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DERMATOGLYPHICS IN TWINS

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SUMMARY

The degree of genetic determination of 4 digital and 16 palmar characteristics was investigated in an unselected series of 49 MZ and 51 DZ adult twins. Low indications of heritability were obtained for the qualitative traits, but 6 of the 8 h^2 estimates calculated for the quantitative measurements gave values above 0.70. In general, the results reported here are in agreement with those presented by other authors; however, the correlation coefficients observed for the *A'd* ridge count were lower than those of two other series. All palmar ridge counts seemed to be intercorrelated in a given individual; other expected relationships, however, were not observed. The fingerprints of MZ and DZ twins on the other hand, showed an unexplained difference.

Despite the efforts of many investigators during the last 80 years, the inheritance of dermatoglyphic patterns is still poorly understood. There exists also much more information about fingerprints than for palmar characteristics. Studies designed to tests the correlations between the latter, between them and finger traits, or between dermatoglyphic differences and dissimilarities in other gene markers, are even more scanty. Therefore we decided to investigate these problems as part of a more general project involving an unselected series of monozygotic (MZ) and dizygotic (DZ) twins (Da Rocha et al. 1972, Callegari et al. 1972*a*,*b*).

MATERIALS AND METHODS

Details about the sample, as well as on ascertainment procedures, were given previously in the cited papers. It is sufficient to indicate here that the twins were located primarily in high schools and that almost all of them were Caucasians. Their sex distribution was as follows: MZ, 30 male and 19 female pairs; DZ, 23 male and 28 female pairs. Zygosity determinations were made using blood groups A_1A_2BO, Rh (tests with anti-C, -C^w, -c, -D, -E, -e), MNSs, P, Duffy, and Kell; ABH secretion; and serum haptoglobins. The methods of study were those described by Cummins and Midlo (1961) and Holt (1968).

RESULTS

One of the criticisms that are raised against the twin method is that twins are different from single-borns in a series of characteristics. It is also important that MZ and DZ be as similar as possible in relation to the traits under study. To test this we have compared the distribution of the fingerprints obtained in this investigation with a nontwin sample analyzed

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TABLE I

DISTRIBUTION OF DIGITAL PATTERNS
[N = 49 MZ and 51 DZ twin pairs]

Pattern type	Right hand						Left hand						Two hands	
	I	II	III	IV	V	Total	I	II	III	IV	V	Total	N	%
MZ TWINS														
Arch	2	9	10	6	2	29	4	11	12	7	2	36	65	16
Ulnar loop	57	43	68	50	77	295	52	33	65	54	74	278	573	59
Radial loop	—	7	—	1	—	8	—	9	—	1	—	10	18	2
Whorl	39	39	20	41	19	158	42	45	21	36	22	166	324	33
DZ TWINS														
Arch	—	8	5	2	—	15	1	13	9	3	1	27	42	4
Ulnar loop	60	34	81	51	87	313	74	34	72	61	83	324	637	62
Radial loop	—	18	2	1	—	21	—	17	2	1	—	20	41	4
Whorl	42	42	14	48	15	161	27	38	19	37	18	139	300	30

χ^2 for heterogeneity, MZ vs. DZ: Total distribution: $\chi^2 = 17.4$, 3 *DF*, $P < 0.001$; Finger I: $\chi^2 = 22.3$, 2 *DF*, $P < 0.001$; Finger II: $\chi^2 = 7.5$, 2 *DF*, $P < 0.05$. All other comparisons gave nonsignificant results.

previously in Porto Alegre (Benevides Filho and Salzano 1969, Salzano and Benevides Filho 1973), while the one related to palmar characteristics was compared to other studies in Caucasian populations (Cummins and Midlo 1961). In addition, the frequencies observed among MZ and DZ were examined to check for differences. For only one of 12 qualitative traits (listed in Table II) and one of 8 quantitative measurements (Table III) there were significant departures from previous population samples or differences between the two types of twins. They concern the frequency of digital patterns and the total ridge count. As can be seen in Table I, there are slight but significant differences between MZ and DZ in relation to the distribution of digital patterns, the latter showing more radial loops and less arches than the former. This dissimilarity remains if the analysis is made considering the sexes separately. The variability is mainly due to differences in fingers I and II. A comparison of these values with those obtained among nontwins in Porto Alegre (Benevides Filho and Salzano 1969) indicates that the discrepancy is due to the DZ, which show deviating figures in relation to the two patterns mentioned above. As a consequence, DZ show a significantly less total ridge count when compared to MZ (114.1 ± 54.6; 135.4 ± 67.6, respectively). Since trait frequencies are generally not given in reports concerning twin studies, we could not verify how general our finding is. But we did find significant differences between the distribution of patterns in MZ and DZ in the data of Newman (1930), despite the fact that in this case the deviations were different from ours, being mainly in the frequencies of arches and whorls and located predominantly on fingers II and III.

TABLE II

GENETIC DETERMINATION OF DIGITAL AND PALMAR PATTERNS, MAINLINE ENDINGS, AND POSITION OF TRIRADIUS *t*
[N = 49 MZ and 51 DZ pairs]

Characteristic	% of concordance		*H* (Holzinger)
	MZ	DZ	
Patterns in:			
Digits	77.4	62.9	0.39
Interdigital II	99.0	89.2	0.91
Interdigital III	79.6	50.4	0.59
Interdigital IV	60.2	51.9	0.17
Thenar/Interdigital I	91.8	73.5	0.69
Hypothenar	61.2	48.0	0.25
Mainline endings			
Line A	58.1	47.1	0.21
Line B	48.9	34.3	0.22
Line C	52.0	31.3	0.30
Line D	63.2	39.2	0.39
Line T	84.7	82.6	0.12
Position of *t*	73.5	59.8	0.33

$$H = \frac{\text{Concordance in MZ} - \text{Concordance in DZ}}{1 - \text{Concordance in DZ}}$$

The degree of concordance observed among the twins in relation to digital patterns and 11 qualitative palmar characteristics, as well as estimates of the degree of genetic determination for these traits, are given in Table II. The difference in concordance for digital patterns is not very high in MZ and DZ (77.4% and 62.9% respectively), leading to a low *H* value (0.39). Similar results were obtained by Grüneberg (1928), Newman (1930), and Parisi and Di Bacco (1968). As for the presence of patterns in the palmar areas, the influence of heredity seems to be highest in interdigital area II and lowest in interdigital IV. The position of mainline endings and of triradius *t* does not seem to be highly affected by genetic factors, all *H* values being lower than 0.40. Not much data are available in the literature to check our findings. The results of Meyer-Heydenhagen (1934) are not strictly comparable to ours. Those of Yamashita (1960) agree with some of those reported here, the same being true for the data of Glanville (1965*b*) and Brodar (1971-72).

Our results concerning 3 digital and 5 palmar quantitative characteristics are presented in Table III. As can be seen, the h^2 estimates concerning TRC, URC, and RRC, are very similar. The two latter measurements were taken due to unpublished observations of Pereira

TABLE III

GENETIC DETERMINATION OF DIGITAL AND PALMAR QUANTITATIVE CHARACTERISTICS

Characteristic	Zygosity	No. of pairs	Variance		r	h^2	F
			Between	Within			
TRC	MZ	49	4564	131	0.94	0.87	8.2***
	DZ	50	2984	1084	0.47		
URC	MZ	49	4285	213	0.91	0.80	5.0***
	DZ	50	2948	1068	0.47		
RRC	MZ	49	3885	124	0.94	0.88	8.6***
	DZ	50	2308	1066	0.36		
ab count	MZ	49	294	37	0.77	0.71	3.4**
	DZ	50	207	128	0.23		
bc count	MZ	48	177	28	0.72	0.70	3.3**
	DZ	45	202	94	0.36		
cd count	MZ	48	334	54	0.72	0.66	3.0**
	DZ	45	253	161	0.22		
A'd count	MZ	48	746	139	0.68	0.64	2.8**
	DZ	47	709	389	0.29		
Angle *atd*	MZ	45	487	39	0.85	0.84	5.6***
	DZ	46	368	219	0.30		

TRC = Total ridge count; URC = Ulnar ridge count; RRC = Radial ridge count.

$h^2 = \dfrac{Vw\text{DZ} - Vw\text{MZ}}{Vw\text{DZ}}$, where Vw = variance within pairs.

da Silva and Krieger, who suggested that URC, unlike the two other measurements which are probably conditioned by polygenes, might be determined to a large extent by only one pair of genes. No significant differences appear, however, in relation to the degree of genetic determination of these 3 counts, a result also obtained by Beiguelman and Pinto Jr. (1971). Our data for TRC, on the other hand, do not differ from those of previous authors (Bonnevie 1924, Newman 1930, Fukuoka 1937, Holt 1957, Lamy et al. 1957, Parisi and Di Bacco 1968, Roitman and Lipovetzkaya 1969, Beiguelman 1970); as a matter of fact, it is remarkable how the estimates of genetic determination for this characteristic agree closely in populations as diverse as those that were investigated in these studies.

As for the palmar traits indicated in Table III, the h^2 values varied from 0.64 (*A'd*) to 0.84 (*atd* angle); those for the *ab*, *bc*, and *cd* counts, clustered around 0.70. All F ratios were

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TABLE IV

CORRELATION COEFFICIENTS BETWEEN DIGITAL AND PALMAR CHARACTERISTICS

	ab	*bc*	*cd*	*A'd*	*atd*
TRC	0.13	0.10	0.01	— 0.08	— 0.06
ab		0.36*	0.50***	0.46***	— 0.03
bc			0.42**	0.31*	0.19
cd				0.18	0.02
A'd					0.0002

TABLE V

CORRELATION COEFFICIENTS BETWEEN BLOOD-GROUP ANTIGENIC DISSIMILARITIES AND DIFFERENCES IN THE *atd* ANGLE, DIGITAL AND PALMAR COUNTS

TRC	— 0.22	*cd*	0.31*
ab	0.10	*A'd*	— 0.24
bc	— 0.22	*atd*	0.21

statistically highly significant. Previous investigations on these characteristics are not numerous. Glanville (1965*b*) used for his analyses the total interdigital pattern ridge count (*ab* + *bc* + *cd*) and introduced some correction factors so that his results are not strictly comparable to ours. For *ab* there are those of Fang (1950), Beiguelman (1970), and Rogucka et al. (1971); the latter authors also studied the ridges between *bc* and *cd*. Glanville (1965*a*) and Beiguelman (1971) investigated the heritability of *A'd*, while Penrose (1954) presented data on the *atd* angle. In a general way our estimates about the genetic determination of these traits are of the same order of magnitude as those obtained by these researchers, with the exception of the one related to the *A'd* count. In the latter case the correlation coefficients we observed for MZ and DZ (0.68 and 0.29) were lower than those calculated by Glanville (1965*a* - 0.94 and 0.39) and Beiguelman (1971 - MZ: 0.92-0.94; DZ: 0.40-0.54).

To what extent are the several traits listed in Table III correlated among themselves? Data concerning this question are presented in Table IV. As expected, no correlation was observed between TRC and the palmar characteristics. On the other hand, all palmar counts proved to be intercorrelated, indicating a common factor responsible for their determination; this conclusion is supported by the similar h^2 values obtained independently for them (Table III) The *atd* angle did not show any correlation with the other palmar characteristics, suggesting that it measures mainly the position of triradius *t* on the palm, the distance *ad* not having much influence on it.

If we suppose that the blood groups used for the zygosity determinations, on the one hand, and the digital and palmar characteristics, on the other, furnish an unbiased estimate of the genotypes of the DZ twins studied, we could expect some correlation between the differences found among them in blood group antigens and those seen in the dermatoglyphic traits. Data concerning this point are shown in Table V. Only one of the 6 correlation coefficients calculated was significantly different from zero; the wide dispersion of the values observed (from — 0.24 to 0.31), however, suggests the absence of any discernible relationship.

DISCUSSION

The differences in the frequencies of digital patterns and in TRC that we observed between MZ and DZ in our series and that of Newman (1930) are curious and should be verified in other samples. Since the causes that lead to these two types of twins are different, the same being true to some extent with their intrauterine conditions, it is not unreasonable to suppose that factors present there may influence their dermatoglyphics, leading to pattern diversity. But the results should be confirmed in other studies before further elaboration is made about the possible causes for these discrepancies.

We observed a clear dichotomy in the behavior of the qualitative and quantitative characteristics studied. The former yielded in general low indications of heritability, the opposite being true for the latter, in which 6 of the 8 h^2 values were above 0.70. This is probably due to the fact that the quantitative traits reflect the pattern of variation of these characteristics and their underlying factors in a better way; but it is possible that questions related to the subjectivity of some of the qualitative classifications may also influence these calculations, leading to a higher nongenetic « noise » among them.

The great majority of our estimates of genetic determination for the characteristics studied agree with those of other investigators (the exception being the *A'd* ridge count). This suggests that the genetic and environmental factors responsible for these traits do not differ much from population to population.

The observed intercorrelations and similar h^2 values encountered between all palmar ridge counts are interesting, pointing to a major factor common to them. Embryological studies may be necessary to determine its exact nature. On the other hand, some expected correlations failed, like the one between the *atd* angle and the *ad* ridge counts; or between the former and the presence of patterns in the hypothenar area: since the occurrence of 10 of the 12 observed patterns in this region would lead to an additional triradius or to a distal displacement of *t*, we would expect more similarity between the estimates of genetic determination for these two traits. It should be mentioned that we are aware of the relative value of *H* (as defined here) as an indicator of this determination (Cavalli-Sforza and Bodmer 1971). We used it for comparative purposes only and because it has been calculated in other series. But the low percentage of concordance for the presence of patterns in the hypothenar area for both MZ and DZ twins in our series is in itself an indication for the occurrence there of nongenetic influencing factors.

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RIASSUNTO

È stato studiato il grado di determinazione genetica di 4 caratteri digitali e 16 palmari in un campione casuale di 49 coppie MZ e 51 DZ adulte. Per i caratteri qualitativi sono state ottenute basse indicazioni di ereditarietà ma 6 delle 8 stime di h^2 calcolate per i caratteri quantitativi hanno dato valori superiori a 0.70. In generale, i risultati concordano con quelli riportati da altri autori. Tuttavia, i coefficienti di correlazione ottenuti per il conteggio *A'd* risultano inferiori a quelli di altri due campioni. Tutti i conteggi palmari sono apparsi essere intercorrelati, ma non sono state osservate altre correlazioni attese. D'altra parte, le impronte digitali di gemelli MZ e DZ hanno presentato una inspiegabile differenza.

RÉSUMÉ

Le degré de détermination génétique de 4 caractères digitaux et 16 palmaires a été étudié dans un échantillon non sélectionné de 49 couples MZ et 51 DZ adultes. Alors que pour les caractères qualitatifs le conditionnement héréditaire est résulté limité, 6 des 8 estimes de h^2 calculées pour les caractères quantitatifs ont donné des valeurs plus élevées de 0.70. En général, ces résultats sont en accord avec ce qui a été rapporté par d'autres auteurs. Toutefois, les coefficients de corrélation obtenus pour le compte *A'd* sont moins élevés par rapports à deux autres séries. Tous les comptes palmaires ont présenté une intercorrélation, mais d'autres corrélations attendues n'ont pas été observées. De l'autre côté, les empreintes digitales des jumeaux MZ et DZ ont présenté une différence inexplicable.

ZUSAMMENFASSUNG

An einer auslesefreien Erwachsenengruppe von 49 EZ und 51 ZZ wurde die Erbbedingtheit von 4 Finger- und 16 Handflächenmerkmalen untersucht. Während die Erblichkeit für die qualitativen Merkmale niedrige Werte ergab, wiesen 6 der 8 h^2 Schätzungen für die quantitativen Merkmale Werte über 0.70 auf. Im allgemeinen stimmen die Ergebnisse mit denen anderer Verfasser überein. Allerdings zeigten sich die Korrelationskoeffizienten für die Zählung von *A'd* niedriger als bei zwei anderen Gruppen. Es scheint, dass alle Handflächenzählungen miteinander verbunden sind, aber es werden keine anderen Beziehungen beobachtet. Andererseits zeigte sich ein unerklärlicher Unterschied bei den Fingerabdrücken von EZ und ZZ.

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