TOPOLOGICALLY SIGNIFICANT DERMATOGLYPHIC PATTERNS IN TWINS

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A total of 58 dermatoglyphic characters, consisting of topologically significant pattern elements, i.e., loops and triradii, on palms, soles and fingertips, were tested in a sample of 110 MZ and 111 like-sexed DZ twin pairs. The analysis included homolateral, heterolateral and bilateral concordance rates, the derived H_c *coefficient, coefficients of the within-pair association,* Φ, *derived* χ^2 *intraclass correlation coefficients and heritability estimates based on variances* (h^2) *and correlations* (H_r), *and the variance ratio* F.

A considerable difference was found in respect of "heritability" values between palmar and sole patterns, in that they are the highest for sole loops and triradii and the lowest for most palmar loops. These data are compared with the h^2 *values obtained from family correlations.*

The difficulties in the interpretation of "heritability" estimates based on the material of twins are pointed out and particular attention is drawn to a possibility of the additional bias in twin studies related to a degree of symmetry of the characters investigated.

INTRODUCTION

The purpose of the present study has been to test dermatoglyphic pattern elements, as classified according to the topological method, by means of a within-pair similarity in MZ and DZ twins.

It has been claimed by many of the workers that the twin material is not suitable for estimating heritability, particularly if it is based on a comparison of concordance rates in MZ and DZ twins; for many reasons, which will not be discussed here, it can introduce considerable bias. However, estimates of "heritability" based on twins can be more safely used for the purpose of comparisons between traits and between studies (Allen 1965).

Indeed, the values of "heritability" obtained here, are utilized in particular to compare between dermatoglyphic variables of palms, soles and fingertips, and between methods. The computation included intrapair correlations, which give relatively the best estimate of a within-pair similarity (Allen 1965). For this purpose, a quantitative approach has been applied to apparently non-measurable characters, which were represented directly by the numbers. Some of the results obtained here are also compared with the data from the literature, which are, however, very scarce and usually based on different classification criteria. The heritability values obtained from familial correlations, are also included in a comparison.

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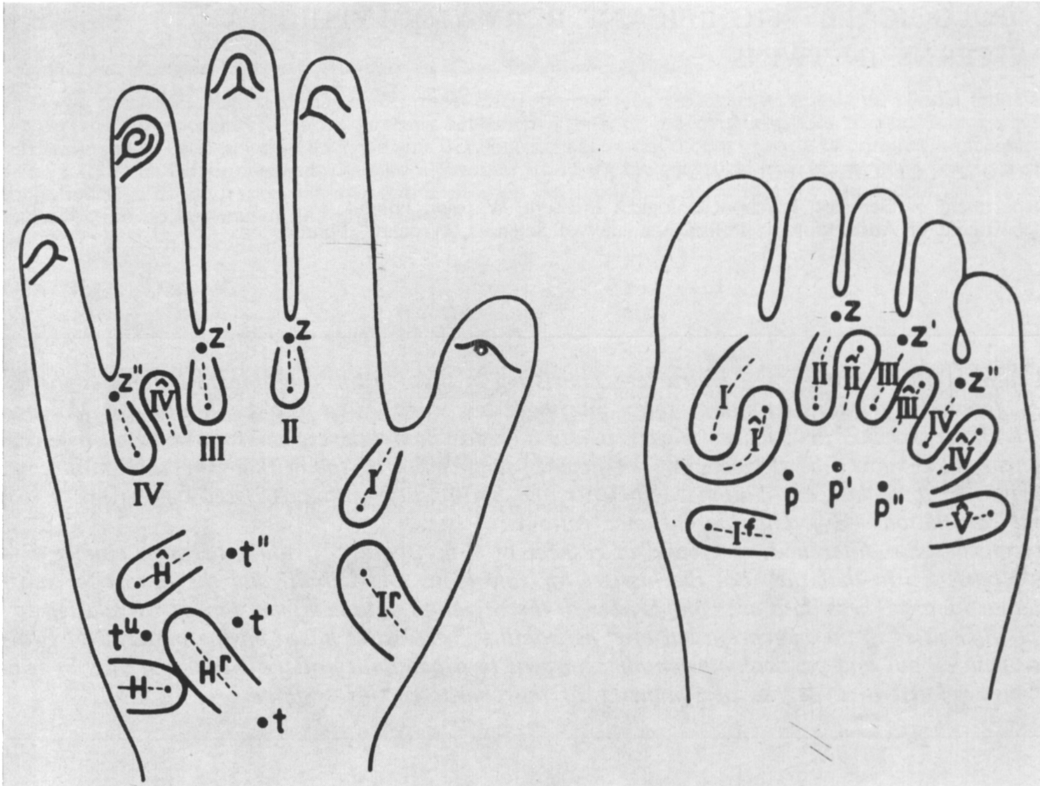

Figure. Schematic illustration of topologically significant dermatoglyphic pattern elements of palm and sole included in this study[1].

MATERIAL AND METHODS

The material for the present study consists of 110 MZ (60 M and 50 F) and 111 like-sexed DZ (62 M and 49 F) twin pairs, collected from schools in the city of Wroclaw.

Zygosity determination was based on the polysymptomatic test of similarity introduced by von Verschuer (1928) and Siemens (1937), which compares a series of morphological characteristics of the skull and face, hair patterns, skin and hair colour, pigmentation and structure of the iris. In addition, in all twin pairs, the following blood groups and other genetic markers have been tested: ABO, MN, Rh (test with anti-C, -c, anti-D and anti-E, -e), Hp, Gc, Gm(a). A total of 74 twin pairs were also tested for Gm(a, x, b, f, 1, 2), PGM, GPT, Ak, Inv, G6PD and AP[2]. In rare cases, in which monozygosity could not be excluded on the basis of blood groups or of the other genetic markers, its probability was estimated, according to the method of Wyslouchowa and Orczykowska-Swiatkowska (1969).

Dermatoglyphic patterns on soles, palms, and fingertips have been classified according to the topological method (see Penrose and Loesch 1969, 1970, and Loesch 1975, respectively). The topologically significant pattern elements, i.e., loops and triradii, which have been included in the present study, are schematically illustrated in the Figure. A few triradii have been left out in some calculations as highly correlated with the

[1] For technical reasons, all symbols with circumphlex mark have been changed in the text into bold face.
[2] All these tests were performed by Dr. Danuta Schlesinger at the Institute of Experimental Therapy and Immunology, Polish Academy of Sciences, Wroclaw.

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corresponding loops, such as: *f*, *e* and t^b palmar triradii, as strictly complementary to the I, I^r and **H** or H^r loops, respectively; *f*, *e* and *h* sole triradii, as complementary to the I, **I** and **V** sole loops, respectively. Similarly, some extremely rare loops, such as **IV** on palms or I^f on soles, have not been included.

For each character, the concordance rates were estimated in MZ and DZ twins, which have also been used for estimating Holzinger's index, $H_c = (c_{MZ} - c_{DZ}) / (100 - c_{DZ})$. The within-pair similarity in MZ and DZ twins have been evaluated by means of the Φ coefficient, calculated in a standard way from the four-fold contingency tables. In order to evaluate statistical significance of a within-pair similarity, the chi square has been derived by the equation: $\chi^2 = N\Phi^2$.

For the purpose of correlational analysis, each pattern element, loop or triradius, included in this study, was represented by a number. If a given character was absent on both palms (or soles), it was scored 0; if it was present on one palm (or sole), it was scored 1; consequently, if any given character occurred, e.g., twice on both palms (or soles), it was scored 4. Patterns on fingers have been summarized in a form of pattern intensity, in turn, for each finger separately (left and right combined), for all ten fingers (PIF), and for the sum of patterns on the ulnar and on the radial side of all fingertips. Pattern intensity index has also been introduced for palmar and sole patterns (PIP and PIS, respectively), as well as the total number of digital triradii (D).

The intraclass correlation coefficients have been computed using Fischer's formula:

$$r(t) = 1/nS^2 \, \Sigma \, [(x_a - \bar{x}) \cdot (x_b - \bar{x})],$$

where: $\bar{x} = 1/2n \, \Sigma \, (x_a + \bar{x}_b)$ is a common mean,

and $S^2 = 1/2n \, [\Sigma \, (x_a - \bar{x})^2 + \Sigma(x_b - \bar{x})^2]$ is a common variance,

with n = number of pairs and x_a, x_b = pair of twins.

The intraclass correlation coefficients and within-pairs mean squares were calculated using the IBM computer. From these, the Holzinger's Hr was calculated, according to the formula:

$$H_r = (r_{MZ} - r_{DZ}) / (1 - r_{DZ}).$$

From the within-pair mean squares, the Dahlberg F coefficient:

$F = V_{DZ}/V_{MZ}$, and the h^2 estimate: $h^2 = (V_{DZ} - V_{MZ})/V_{DZ}$ have also been obtained.

RESULTS AND DISCUSSION

The frequencies of all loops and triradii under study, the concordance rates in MZ and DZ twins and the values of χ^2 for homolateral (Ho), heterolateral (He) and bilateral (L-R) comparisons are presented in Table 1.

The distributions of frequencies of all constituent pattern elements on palms, soles and fingertips already indicate that the estimates based on concordance rates can be informative only in relation to some of these traits. For the characters occurring with extremely high or extremely low frequencies, such as: triradius z on palms, triradius z'' on soles, or radial patterns on fingers III or V, a comparison of the concordance rates in MZ and DZ twins is meaningless and both, the Φ and χ^2 coefficients do not represent the actual within-pair similarity, because the variability of such traits is greatly reduced.

The results of a comparison between homolateral concordance rates in MZ and DZ twins indicate that, for some characters, such as I, II, III^T, H^r palmar loops and triradii t^u, z, and II, **II**, IV, **IV** sole loops and p'' and z'' triradii, the differences are negligeable; however, most of these characters occur with very low frequency. On fingertips, it is rather unexpected to observe that they are small for ulnar patterns on all fingers except for the index. Nevertheless, the χ^2, which is the more accurate measure, is highly significant for all characters (except for triradius t^u) in MZ twins and its value is considerably lower in DZ twins

Table 1. *Concordance within twin pairs and between left and right in respect of all topologically significant pattern elements on palms, soles and fingertips, for sexes combined. Frequencies are given separately for males and females*

Characters	Frequency				Concordance											
	MZ pairs		DZ pairs		Percentage						χ^2					
					MZ pairs			DZ pairs			MZ pairs			DZ pairs		
	M (N=60)	F (N=50)	M (N=62)	F (N=49)	H_o	H_e	L-R	H_o	H_e	L-R	H_o	H_e	L-R	H_o	H_e	L-R
Palms:																
I	6.3	1.0	4.5	6.1	96.4	95.9	95.9	94.6	92.3	93.7	50.9	31.6	44.4	30.7	5.0	15.8
I^r	5.0	1.0	5.6	8.2	98.2	96.8	96.4	91.6	90.1	93.2	109.3	43.6	36.9	19.9	5.8	44.3
II	5.8	2.0	4.0	1.0	95.0	95.0	95.9	95.9	95.9	97.7	23.5	23.5	44.4	0.1	0.1	41.6
III	50.4	41.5	48.0	42.4	78.6	58.6	58.2	68.9	56.8	65.8	72.1	6.3	5.9	31.0	3.6	25.1
III^T	7.1	12.0	10.5	6.7	88.6	85.9	85.9	87.4	85.1	83.8	11.0	0.3	0.3	11.8	0.2	0.0
IV	59.6	54.0	47.6	56.2	82.3	56.4	58.2	64.4	55.9	63.5	46.6	3.2	5.6	18.1	2.9	23.1
H	17.1	8.0	15.3	16.4	90.5	89.1	89.5	77.5	76.1	81.5	69.9	57.0	60.0	0.9	0.1	17.3
H	21.7	31.5	26.6	32.7	82.3	72.7	76.4	68.9	66.7	76.1	59.1	15.3	30.1	11.9	5.9	37.3
H^r	6.7	1.0	1.6	7.2	95.5	93.6	94.5	93.2	94.1	95.0	27.2	1.9	10.8	6.8	18.1	34.7
t	62.1	60.0	67.4	54.6	82.7	78.2	79.1	68.9	67.1	79.7	93.7	64.6	69.2	27.1	21.2	73.1
t′	48.8	39.0	40.3	41.8	78.6	72.7	71.8	61.7	61.7	79.3	69.1	43.1	29.9	0.1	0.1	70.5
t″	5.8	7.5	6.5	12.8	94.5	92.7	94.5	88.3	88.3	95.5	31.2	33.4	64.7	18.1	18.1	116.8
t^u	4.6	3.5	2.8	4.6	94.7	94.1	95.0	95.0	95.9	95.0	2.3	2.3	12.8	3.7	18.3	3.7
Σz	2.1	6.0	4.9	8.2	96.4	95.5	96.4	89.6	89.6	93.2	50.9	27.2	50.9	0.0	0.0	29.5
Soles:																
I	89.6	88.0	88.7	92.4	94.1	90.9	90.9	82.4	82.4	92.8	108.3	62.3	66.2	0.5	0.5	74.5
[illegible]	52.1	46.5	38.7	32.2	87.3	85.9	82.7	63.5	67.1	76.1	119.1	107.6	87.5	9.0	17.0	57.7
III	79.2	61.5	72.2	58.2	89.5	89.1	89.5	66.7	64.9	85.1	123.0	119.0	123.0	13.9	9.7	98.0

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I	**52.1**	**46.5**	**38.7**	**32.2**	**87.3**	**85.9**	**82.7**	**63.5**	**67.1**	**76.1**	**119.1**	**107.6**	**87.5**	**9.0**	**17.0**	**57.7**
III	79.2	61.5	72.2	58.2	89.3	89.1	89.3	66.7	64.9	83.1	123.0	119.0	123.0	13.9	9.7	98.0
III	20.0	8.0	16.9	13.3	91.8	90.5	92.7	81.5	80.2	93.2	93.7	76.3	105.1	17.3	12.4	120.4
IV	23.3	10.5	17.4	16.3	88.6	86.8	85.9	80.2	77.9	89.6	80.9	57.9	55.4	16.3	5.6	83.8
IV	4.2	1.5	4.0	1.0	98.2	98.6	99.1	95.9	96.4	98.2	109.3	184.2	159.9	5.8	22.0	95.9
V	43.3	58.5	38.3	42.4	85.0	77.3	78.6	64.9	66.2	78.4	107.8	65.4	72.2	16.0	19.4	111.7
p+p′	89.2	71.0	80.6	63.7	88.2	86.4	85.0	64.0	58.1	83.3	112.8	98.6	88.6	7.0	0.5	85.6
p″	17.5	6.5	14.9	14.3	88.6	86.8	85.5	83.0	81.5	91.4	50.8	34.7	23.2	22.1	13.0	93.4
z	44.2	34.0	44.0	38.8	88.6	84.1	88.2	72.1	74.8	87.4	130.5	101.2	127.3	39.7	50.8	121.3
z′	21.3	8.0	16.1	11.2	93.2	89.5	91.4	80.6	80.6	92.8	119.1	77.9	97.4	9.3	9.3	111.3
z″	2.9	1.0	1.6	1.0	98.6	97.7	98.6	96.8	96.8	98.6	95.8	41.2	95.8	0.1	0.1	96.6
Fingertips:																
I^{U}	56.7	66.0	53.7	51.5	98.6	98.6	97.7	95.9	94.6	96.4	70.2	70.2	16.5	5.8	0.2	22.0
I^{R}	0.0	0.0	0.0	1.0	81.8	76.4	77.3	58.6	59.5	76.1	82.7	53.9	58.8	6.0	6.7	59.7
II^{U}	31.3	32.5	31.9	27.6	77.3	71.4	68.2	68.0	67.6	76.1	44.4	19.4	11.4	1.3	0.4	20.2
II^{R}	27.5	18.5	13.7	17.9	69.1	61.4	63.2	60.8	55.0	71.6	27.5	7.5	10.8	5.8	0.4	35.3
III^{U}	67.9	76.0	70.6	65.3	94.5	95.0	94.1	92.3	90.1	92.3	64.7	34.3	17.8	37.3	10.2	30.9
III^{R}	2.9	0.5	0.4	2.6	80.5	77.7	76.8	66.7	68.9	83.3	53.7	40.5	37.4	6.0	10.4	99.9
IV^{U}	46.7	55.0	43.6	50.0	98.6	96.4	98.2	97.3	96.4	98.6	33.9	0.1	0.0	0.0	0.1	34.2
IV^{R}	0.0	0.5	0.4	0.0	80.9	67.7	75.5	61.7	59.5	73.4	84.0	27.5	38.5	11.8	7.6	48.4
V^{U}	89.6	90.5	75.8	89.8	99.5	99.1	99.5	99.1	98.6	98.6	1.0	0.0	0.0	0.0	0.0	0.0
V^{R}	0.0	0.0	0.0	0.0	92.7	93.2	92.3	79.3	81.1	91.4	78.1	86.9	81.8	18.0	34.4	101.2

$\chi^2 = 3.8,\ p < 0.05$; $\chi^2 = 5.4,\ p < 0.02$; $\chi^2 = 6.6,\ p < 0.01$; $\chi^2 = 10.8,\ p < 0.001$

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Table 2. *Correlations within twin pairs (coefficients Φ and r) and estimated heritability (H_c, H_r, h^2, F) for all topologically significant pattern elements of palms and soles, for sexes and left and right combined*

Characters	Φ		r		H_c	H_r	h^2	F	h^2 (f) (based on family correlations)[1]
	MZ pairs	DZ pairs	MZ pairs	DZ pairs					
Palms:									
I	0.48*	0.37*	—	—	0.33	—	—	—	—
I^r	0.71*	0.30*	—	—	0.79	—	—	—	—
$I+I^r$	—	—	0.68	0.53	—	0.32	0.52	*2.0956**	0.50
II	0.33*	0.02	0.43	—0.04	—0.22	0.45	0.12	*1.1336*	0.52
III	0.57*	0.37*	0.59	0.39	0.31	0.33	0.37	*1.5780**	0.52
III^T	0.22*	0.23*	—	—	0.10	—	—	—	—
IV	0.46*	0.27*	0.49	0.27	0.50	0.27	0.41	*1.6808**	0.44
H	0.56*	0.06	0.73	0.09	0.58	0.71	0.73	*3.6940**	0.28
H	0.52*	0.23*	0.51	0.33	0.43	0.27	0.29	*1.4132*	0.50
H^r	0.35*	0.18*	0.32	0.31	0.34	0.01	0.22	*1.2751*	0.10
t	0.65*	0.35*	0.74	0.40	0.44	0.56	0.56	*2.2975**	0.60
t′	0.56*	0.02	—	—	0.44	—	—	—	0.40
t″	0.38*	0.29*	—	—	0.53	—	—	—	0.18
t′+t″	—	—	0.76	0.24	—	0.69	0.71	*3.4010**	—
t^b	0.57*	0.23*	—	—	0.50	—	—	—	0.60
t^u	0.10	0.13	—	—	—0.18	—	—	—	—
Σz	0.48	0.00	—	—	0.65	—	—	—	0.08
D	—	—	0.69	0.02	—	0.69	0.71	*3.4812**	—
[illegible]	[illegible]	[illegible]	0.33	0.34	—	0.57	0.65	*2.8509**	0.70
I	0.70*	0.05	0.76	—0.07	0.66	0.77	0.75	*4.0789**	1.50
I	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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D	—	—	0.69	0.02	—	0.69	0.71	*3.4812**	—
PIP	—	—	0.72	0.34	—	0.57	0.65	*2.8509**	0.70
I	0.70*	0.05	0.76	—0.07	0.66	0.77	0.75	*4.0789**	1.50
I	0.74*	0.20*	0.85	0.29	0.65	0.80	0.77	*4.3677**	0.26
II	0.31*	0.06	0.45	—0.09	0.07	0.49	0.34	*1.5245**	0.34
II	0.49*	0.29*	0.60	0.41	0.20	0.32	0.27	*1.3626*	0.00
III	0.75*	0.25*	0.86	0.29	0.68	0.80	0.80	*5.0000**	0.20
III	0.65*	0.28*	0.73	0.25	0.56	0.64	0.65	*2.8943**	—0.02
IV	0.61*	0.27*	0.76	0.29	0.42	0.65	0.66	*2.9741**	0.22
IV	0.71*	0.16	0.73	0.36	0.56	0.58	0.46	*1.8427**	0.40
V	0.70*	0.27*	0.77	0.37	0.57	0.64	0.63	*2.6931**	0.44
e	0.76*	0.22*	—	—	0.69	—	—	—	0.42
f	0.74*	0.01	—	—	0.67	—	—	—	—
p+p′	0.72*	0.18*	0.79	0.06	0.67	0.78	0.76	*4.1059**	~0.64
p″	0.48*	0.32*	0.65	0.34	0.33	0.48	0.61	*2.5435**	0.44
z	0.77*	0.42*	0.82	0.51	0.59	0.64	0.61	*2.5763**	—
z′	0.74*	0.21*	0.78	0.22	0.65	0.72	0.71	*3.4429**	—
z″	0.66*	0.02	0.66	—0.02	0.56	0.66	0.50	*1.9823**	—
Σz	—	—	0.86	0.46	—	0.81	0.72	*3.6195**	0.30
D	—	—	0.33	0.27	—	0.09	0.29	*1.4023**	—
PIS	—	—	0.87	0.30	—	0.82	0.80	*5.0486**	—0.18
Sum of distal loops (palms + soles)	—	—	0.84	0.26	—	0.79	0.75	*4.3563*	—
Sum of proximal loops (palms + soles)	—	—	0.80	0.31	—	0.71	0.68	*3.0951*	—

* $p \leq 0.01$ [1] From Loesch 1974.

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for most characters under study. The MZ-DZ difference is particularly noticeable for sole patterns, mainly for the loops: I, **I** (hallucal), III, **III**, V, for triradii *p*, *p'* (closely associated with the loop III), and for *z* and *z'*, usually occurring in the presence of proximal loops, **III** and **IV**.

At the same time it is clear from the data in Table 1 that MZ-DZ differences in respect of the values of χ^2 are less pronounced for palmar patterns; they are appreciable only for thenar (I^r) and hypothenar (H, **H**) loops and *t*, *t'* and *z* triradii.

The order of magnitude of MZ-DZ differences in respect of concordance seems somewhat intermediate for fingertip patterns. They are particularly small for the ulnar pattern on finger III and none for the ulnar pattern on finger V, but relatively high for the pattern on the thumb and the index finger.

Heterolateral concordance rate is, both in MZ and DZ twins, somewhat lower than the homolateral concordance, particularly for less symmetrical characters, i.e., with low L-R concordance rates.

The H_c values, based on MZ-DZ differences in homolateral concordance rates for all characters, are given in Table 2. Consequently, they are relatively the highest for most sole loops and corresponding triradii, except for loops II, **II** and IV, and are generally lower for the palms, particularly for loops I, II, III, III^T, H^r and for triradius t^u. The H_c values for fingertip patterns (Table 3) are the highest for the thumb and the lowest for fingers II and III.

Table 3. *The within-pair Φ coefficients and estimated heritability*, H_c, *for finger patterns (ulnar and radial components separately, left and right combined), for sexes combined*

Characters		MZ pairs	DZ pairs	H_c
I	U	0.57*	0.16	0.66
	R	0.62*	0.16	0.56
II	U	0.45*	0.08	0.29
	R	0.35*	0.16	0.21
III	U	0.54*	0.41*	0.29
	R	0.49*	0.16	0.41
IV	U	0.39*	0.01	0.48
	R	0.62*	0.23*	0.50
V	U	0.07	0.01	0.44
	R	0.60*	0.29*	0.65

* $p \leq 0.01$

The present results concerning concordance rates in MZ and DZ twins can hardly be compared with any other data from the literature. Brismar (1968), who considered jointly all interdigital loops, as well as patterns on fingers and hallucal loops, obtained results generally consistent with the present data, MZ-DZ differences being largest for hallucal patterns, smallest for interdigital (palmar) patterns and intermediate for fingertip patterns. It should be pointed out, however, that his results were obtained on a small sample of twins. Similarly, Peña et al. (1973), for all digital patterns combined, obtained concordance rates of

77.4% in MZ and 62.9% in DZ twins, resulting in a value of $H_c = 0.39$. Low values for digital patterns were also obtained by Grünberg (1928) and Newman (1930). Also somewhat similarly to the present findings, Peña et al. (1973) observed relatively large MZ-DZ differences in the concordance rate of thenar patterns ($H = 0.69$), whereas their findings disagree with the present data for interdigital loops II ($H = 0.91$), III (0.59) and IV (0.17). Their material was, however, relatively smaller than in this study. The present H_c values for interdigital loop III and for hypothenar patterns are close to the 0.31 and 0.50, respectively, obtained by Rogucka (1971). However, Rogucka's data were based on a sample which included part of the present material. In spite of that, she obtained a lower value (0.32) for loop IV. Her values for thenar patterns are not comparable because of a different classification system.

The recent results obtained by Plato et al. (1976) on large samples of twins, concerned a comparison of MZ-DZ concordance rates for some digital and palmar patterns. Unfortunately, they can be only roughly compared with the present data because the characters were formulated according to the traditional system. For digital patterns, the largest MZ-DZ difference concerned the thumb and the smallest, digit V, which is in agreement with the present data. For palmar patterns, the MZ-DZ differences were noticeable only in the hypothenar and thenar areas, which is also not incompatible with the results obtained here. As concerns sole patterns, the only data on concordance rates in MZ and DZ twins were reported by Wichmann (1952), but they cannot be compared with the present results as the formulation of characters was different.

It seems, however, more interesting to compare the results concerning concordance rates in MZ and DZ twins for all successive pattern elements included here, with the data based on a correlational analysis. The correlation coefficients and derived H_r estimates, as well as the heritability values based on within-pair means squares (h^2, F) for most pattern elements on palms and soles, including pattern intensities, PIP and PIS, are presented in Table 2. The values of Φ are listed as well and it is clear that they are in fair agreement with the corresponding r coefficients, although they are, as a rule, slightly higher than the latter. In the last column of this Table, $h^2(f)$ heritability values computed from familial correlations (Loesch 1974) are also presented for a comparison with heritability estimates, based on twins. The values of r, H_r, h^2 and F for finger pattern intensity on each finger separately, left and right combined, and for all fingers combined, as well as for the total ulnar and total radial pattern, are presented in Table 4.

The results of correlational analysis are mostly in agreement with the data based on concordance rates, although they are more meaningful. Thus, the H_r and F values are generally higher for sole patterns than for palmar patterns (see Table 2). Particularly high heritability estimates have been obtained for sole loops: I, **I**, III, **III**, IV, and **V**, and corresponding triradii, f, e, p, p' and z'. On palms, heritability values of the same order of magnitude have been obtained for the hypothenar loop H with the corresponding t' and t'' triradii and for thenar loops, $I + I^r$, where loop I^r has considerably higher H_c value than loop I; the H_r, h^2 and F values for triradius t are among the highest for palmar patterns.

If all palmar or sole loops are combined into a form of pattern intensity index, heritability values tend to increase, although they do not exceed those obtained for some single pattern elements; the same applies to the sum of distal and the sum of proximal loops on palms and soles combined.

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Table 4. *Within-pair correlations and estimated heritability (H_r, h^2 and F) for finger pattern intensities (left and right and sexes combined)*

Characters	r		H_r	h^2	F
	MZ pairs	DZ pairs			
I	0.77	0.16	0.73	0.76	*4.1374**
II	0.71	0.17	0.66	0.70	*3.3483**
III	0.73	0.27	0.63	0.72	*3.6262**
IV	0.71	0.26	0.61	0.63	*2.7253**
V	0.73	0.35	0.58	0.78	*4.5833**
Total (PIF)	0.91	0.30	0.87	0.90	*10.2864**
Sum of ulnar component	0.50	—0.03	0.52	0.44	*1.8011**
Sum of radial component	0.23	0.01	0.22	0.30	*1.4353**

* $p \leq 0.01$

On the other hand, a discrepancy between the values of correlation coefficients and heritability estimates based on twins and obtained from the family correlations ($h^2(f)$) is obvious for most characters under study. The reason for this is quite obscure. It cannot be accounted for entirely by the fact that correlation coefficients are subject to a considerable chance variation. It may rather be the effect of a considerable bias, introduced by using twin material for estimating " heritability ". The main factors that may largely modify the results based on twins, comprehensively discussed by Allen (1965), can be related, except for sampling biases, to the fact that, in MZ twins, some environmental variance is held constant together with the genotype, which leads to the higher concordance rates and exaggerated heritability values. On the other hand, the estimated within-pair similarity indices may be reduced by hereditary-environmental interaction, leading to genetic differences within one genotype. The heritability estimates obtained from family correlation are also subject to a considerable bias. Besides, in either estimate, between-family environmental variance is ignored.

In a simultaneous study based on the total patterns of palms and soles, some relationship between concordance rate and symmetry of characters has been postulated (Loesch and Swiatkowska 1978), in that the greater symmetry of patterns may be connected with the higher concordance rate in MZ twins. The greater asymmetry of palmar than sole patterns, reported by Loesch and Swiatkowska (1978), and, in particular, the well known asymmetry of the palmar interdigital loops may be in favour of such a hypothesis. A rough comparison of the L-R concordance rates (Table 1) and heritability estimates (Tables 2 and 4) for successive pattern elements on palms and soles is also suggestive of such a relationship. More precise comparisons of the degree of symmetry of individual loops and triradii with their within-pair similarity in MZ twins might considerably help in better understanding some of the peculiarities of the twin material, as applied in genetical analyses.

The values of correlation and " heritability ", H_r, h^2, and F, for patterns on individual fingers (Table 4) are more uniform. However, somewhat similarly to the results based on concordance rates, the values for a thumb are the highest of all fingers. For middle fingers they are relatively lower and the results concerning digit V are not consistent. The values for the finger pattern intensity are, however, much higher than those for sole and palmar pattern intensity, but they are greatly reduced if the ulnar and radial patterns are considered separately.

Differences between males and females in respect of concordance rates and of H and h^2 values are inconsistent and particularly concern patterns with the lowest heritability values. Nevertheless, sexes have been combined on the assumption that the increase in the number of pairs may result in reducing change variation.

CONCLUSIONS

1. Dermatoglyphic pattern elements (loops and triradii) are considerably differentiated in respect of the within-pair similarity in MZ and DZ twins, as well as of the " heritability " estimated from concordance rates, correlation coefficients or variances. The largest MZ-DZ difference in respect of concordance, as well as the highest "heritability" values, are characteristic of sole patterns, while the lowest values have been found for most palmar pattern elements.
2. On the average, the amount of nonhereditary influence is approximately half of the total influence on the formation of single loops (or triradii), but it can be more or less than this. The highest " heritability " values (>0.50) have been obtained for hallucal loops, I and **I**, for distal and proximal sole loops in area III with corresponding triradii p or p' and z', and for distal loop IV. They are also relatively high for patterns on all fingers, particularly on the thumb and for the hypothenar (palmar) distal loop H with corresponding triradii t' or t''. Somewhat lower values, approximating 0.50, have been obtained for thenar loop I^r and the t axial triradius. H_c, H_r, h^2 and F values become slightly higher if all loops are analysed jointly in the form of total pattern intensities on palms or soles, but they are considerably higher only for the total finger-pattern intensity. However, if ulnar or radial aspects of fingers are summed up, these values are greatly reduced, particularly for the radial patterns.
3. The " heritability " estimates based on twin material are incompatible with h^2 values obtained from family correlations for most palmar and sole characters considered in this study. It is probably related to a peculiarity of both twin and family material and indicates that the conclusions concerning the amount of genetic component in the determination of any dermatoglyphic character should be drawn with a particular caution. The results so far obtained for topologically significant patterns indicate that there may be an additional bias in twin studies, related to the degree of asymmetry of any given pattern.
4. A quantitative approach to the apparently nonmeasurable characters has proved of considerable significance in genetical analyses based on twins.

REFERENCES

Allen G. 1965. Twin research: Problems and prospects. In A.G. Steinberg and A.G. Bearn (eds.): Progress in Medical Genetics [pp. 242-269]. New York: Grune and Stratton Inc.

Brismar B. 1968. Dermatoglyphics of twins. Acta Genet. Med. Gemellol., 17: 375-380.

Grünberg H. 1928. Die Vererbung der menschlichen Tastfiguren. Z. Indukt. Abstamm. Vererbungsl., 46: 285-310.

Loesch D. 1974. Genetical studies of sole and palmar dermatoglyphics. Ann. Hum. Genet., 37: 405-420.

Loesch D. 1975. Topological formulation of finger-tip patterns: Comparison of complete and incomplete 21 trisomics with normal subjects. J. Ment. Defic. Res., 19: 121-137.

Loesch D., Swiatkowska Z. 1978. Dermatoglyphic total patterns on palms, finger-tips and soles in twins. Ann. Hum. Biol. (in press).

Newman H.H. 1930. The finger prints of twins. J. Genet., 23: 415-446.

Peña H.F., Salzano F.M., Callegari S.M. 1973. Dermatoglyphics in twins. Acta Genet. Med. Gemmellol., 22: 91-98.

Penrose L.S., Loesch D. 1969. Dermatoglyphic sole patterns: A new attempt at classification. Hum. Biol., 41: 427-448.
Penrose L.S., Loesch D. 1970. Topological classification of palmar dermatoglyphics. J. Ment. Defic. Res., 14: 111-140.
Plato C.C., Schwartz J.T., Wertelecki W. 1976. Dermatoglyphic investigations in twins and siblings. Proc. 1st Int. Congr. Twin Studies, Rome 1974. Acta Genet. Med. Gemellol., 25: 167-173.
Rogucka E., Szczotkowa Z., Szczotka H. 1971. Zroznicowanie i dziedziczenie liczby listewek w przestrzeniach miedzypalcowych na dloniach. Mat. Prace Antropol. (Wroclaw), 81: 159-174.
Siemens H. 1937. Einige Bemerkungen über die Ähnlichtkeitsdiagnose der Eineigkeit. Arch. Rass. Ges. Biol., 31: 211-214.
von Verschuer O. 1928. Die Ähnlichkeitsdiagnose der Eineigkeit von Zwillingen. Anthropologie, 5: 244-248.
Wichmann J.D. 1952. Das Hautleistensystem der Fußsole bei Zwillingen. Z. Morphol. Anthropol., 44: 274-284.
Wyslouchowa B., Orczykowska-Swiatkowska Z. 1969. The diagnosis of twin zygosity on the basis of blood group studies. Acta Med. Pol., 10: 187-196.

RIASSUNTO

Figure Dermatoglifiche Topologicamente Significative in Gemelli

Un insieme di 58 caratteri dermatoglifici, costituiti da figure topologicamente significative, quali anse e triradii, su palme, piante e polpastrelli, sono stati esaminati in un campione di 110 coppie di gemelli MZ e 111 di gemelli DZ dello stesso sesso. L'analisi comprendeva le concordanze omolaterali, eterolaterali e bilaterali, il coefficiente *Hc* derivato, i coefficienti dell'associazione intracoppia, i coefficienti di correlazione intraclasse e le stime di ereditarietà basate su varianze (h^2) e su correlazioni (*Hr*).
Le stime di ereditarietà risultano massime per le anse ed i triradii plantari e minime per la maggior parte delle anse palmari. Questi valori sono raffrontati alle stime ottenute da correlazioni familiari. Vengono sottolineate le difficoltà dell'interpretazione delle stime di ereditarietà basate su materiale gemellare, richiamando l'attenzione sulla possibilità che vi sia qui un'ulteriore fonte di errore relativa al grado di simmetria dei caratteri esaminati.

RÉSUMÉ

Dessins Dermatoglyphiques Topologiquement Significatifs chez les Jumeaux

Un total de 58 traits dermatoglyphiques, constitués par des dessins topologiquement significatifs, tels que boucles et triradii des doigts, des paumes et des plantes, ont été examinés dans un échantillon de 110 couples de jumeaux MZ et 111 de DZ du même sexe. L'analyse comprenait les concordances homolatérales, hétérolatérales et bilatérales, le coefficient *Hc* dérivé, les coefficients de l'association intra-couple, les coefficients de corrélation intraclasse et les estimes d'héritabilité basées sur variances (h^2) et corrélations (*Hr*).
Les estimes d'héritabilité les plus élevées concernent les boucles et les triradii plantaires et les moins élevées les boucles palmaires. Ces valeurs sont rapportées aux estimes dérivées d'analyses familiales. Les difficultés de l'interprétation de ces estimes quant il s'agit d'un matériel gémellaire sont soulignées, à cause d'une possible source additionnelle d'erreur, dans ce cas, en raison du degré de symétrie des traits étudiés.

ZUSAMMENFASSUNG

Topologisch wesentliche Hautleistenfiguren bei Zwillingen

Hendflächen, Fußsohlen und Fingerspitzen einer Mustergruppe bestehend aus 110 EZ- und 111 gleichgeschlechtlichen ZZ-Paaren wurden auf insgesamt 58 Hautleistenmerkmale in Form von wichtigen topologischen Figuren wie Schleifen und Triradien untersucht. Daraus sollten hervorgehen: homo-, hetero- und bilaterale Konkordanzen, der abgeleitete *Hc*-Koeffizient, der Assoziationskoeffizient zwischen den einzelnen Paarlingen, der Korrelationskoeffizient zwischen den verschiedenen Klassen sowie die Erblichkeit aufgrund der Varianzen (h^2) und Korrelationen (*Hr*).
Die Erblichkeit erscheint am größten für die Schleifen und Triradien an der Fußsohle und am geringsten für die meisten Handflächenschleifen. Es erfolgt ein Vergleich zwischen diesen Erhebungen und den Daten aus den Familienkorrelationen. Betont wird, daß die Beurteilung der Erblichkeit bei Zwillingen dadurch erschwert wird, daß der Symmetriegrad der untersuchten Merkmale leicht zu einer weiteren Fehlerquelle wird.

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