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Comparisons of Dermatoglyphic Patterns in Monochorionic and Dichorionic Monozygotic Twins

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INTRODUCTION

There are marked differences in the variability of dermatoglyphic patterns within dizygotic (DZ) and monozygotic (MZ) twins, and dermatoglyphic patterns may be used to help discriminate MZ and DZ twins [1, 2].

Approximately two-thirds of identical twin pairs have monochorionic (MC) placentas and the remainder dichorionic (DC) placentas [3]. The dichorionic-monozygotic (DC-MZ) twins arise from division at an earlier stage than the monochorionic-monozygotic (MC-MZ) twins [3]. Previous studies found associations between placental type and newborn hematocrit [4], birthweight [5], IgG levels [6], intelligence [7], and newborn [8, 9] as well as adult [10] plasma cholesterol. The cholesterol findings are of particular interest because they arose from the initial observation that the total variance of cholesterol in MZ twins was smaller than DZ twins [11–13] and the subsequent finding that the within DC-MZ mean square was more than five times the size of the within MC-MZ mean square [9]. In a previous study from our laboratory [14], it was noted that 21 of 71 dermatoglyphic variables also had different total variances ($P < .05$) for DZ and MZ twins, and a preliminary report [15] revealed evidence for differences between MC-MZ and DC-MZ twins. As dermatoglyphic patterns are formed by the 20th week of gestation and are known to be influenced by in utero events, we have continued to investigate the dermatoglyphic differences between MC-MZ and DC-MZ twins.

MATERIALS AND METHODS

Dermatoglyphics were taken on 108 pairs of MZ twins of known placenta type. The number of chorions was established by gross and microscopic examination of fetal membranes. Zygosity was confirmed by typing like-sexed pairs for at least 10 polymorphic blood group systems, and any dichorionic set with identical results was further eliminated if genetic assistants, the parents of the young twins, or the adult twins themselves believed that they were not identical. These

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precautions were taken because any errors in zygosity determination would place DZ twins in the DC-MZ class. There were 34 sets (20 monochorionic, 14 dichorionic) from the McMaster University twin panel. These adult twins had placental types ascertained between 1935 and 1951 by Dr. I. A. Uchida and the late Dr. N. F. Walker. There were 74 sets (50 monochorionic and 24 dichorionic) from the Indiana University newborn twin panel. Of the 70 MC-MZ pairs, 32 were male and 38 were female, and in the 38 DC-MZ pairs, 17 were male and 21 were female.

Prints were taken using the Faurot (New York) inkless method. In addition, for ridge counts of the younger Indiana twins, the Hollister (Chicago) ink pad procedure was used. The 84 dermatoglyphic variables examined include: *sole* (16)—hallucal, interdigital II, III, IV, and hypothenar areas, plantar pattern intensity [16], big toe pattern, and ridge count; *palm* (26)—thenar/interdigital I, interdigital II, III, IV, and hypothenar patterns, *a-b* ridge count, *atd* angle, percent distal deviation of the axial *t*, (*t*, *t*,', or *t*") after Walker [17], palmar pattern intensity [18], mainline index, palmar crease anomalies, and a variable for absent or extra palmar triradii; and *fingers* (42)—radial counts, ulnar counts, pattern type, ridge count (larger of radial or ulnar count), total ridge count, and ridge count diversity [19]. All pattern type variables were quantitated by methods previously reported [14]. (For more information concerning pattern type and pattern areas, see Penrose [20] or Cummins and Midlo [21].)

STATISTICAL METHODS

The analysis of variance model used is presented in table 1. The notation of Christian et al. [22] was extended to include comparisons of MC-MZ and DC-MZ twins. Variance and covariance components containing genetic influences are assumed to be equal for the two chorion types ($\sigma_a^2, \sigma_d^2, \sigma_i^2, \sigma_{ge}$), but allowance is made for disparate environmental variances and covariances for MC-MZ and DC-MZ twins.

The means of MC-MZ and DC-MZ twins were first compared by the t' test proposed by Christian and Norton [23] for testing the differences between means of MZ and DZ twins. Two-tailed F tests were used to test the differences between the within-pair and among-pair mean squares for the two twin types, with the larger mean square as the numerator and the probability twice that shown in the usual F tables. The total variances of the twin types were compared using the two-tailed F' test previously proposed to test the difference between total variances of MZ and DZ twins substituting MC-MZ and DC-MZ for MZ and DZ twin types [22].

RESULTS

Of the 84 variables studied only five had significant differences between the means of MC-MZ and DC-MZ twins ($P < .05$). All of these variables were related to placement of the most distal axial triradius (left and right axial triradius, left and right percent distance and right *atd* angle), and in all instances the MC-MZ mean was larger than the DC-MZ mean. The remaining variable in this group (left *atd* angle) also had a greater MC-MZ mean, but not significantly so ($P = .17$).

Table 2 lists the variables and related variables for which there was evidence for differences in the within-pair analysis of variance for MC-MZ and DC-MZ twins. The within-pair test should provide the most sensitive test of differences in variances of the two twin types. Of the 84 variables studied, 19 had significant ($P < .05$) differences between the within-pair mean squares with the DC-MZ within-pair mean square larger in 11 and the MC-MZ within-pair mean square larger in eight of these comparisons.

The DC-MZ within-pair variation was larger for both the left plantar interdigital III pattern and left plantar hypothenar area. A similar trend on the right foot was noted for the former, but not the latter.

TABLE 1

ANALYSIS OF VARIANCE MODEL FOR MONOCHORIONIC AND DICHORIONIC TWINS

Source of Variation	Degrees of Freedom	Mean Squares	Expected Value of Mean Square
Monochorionic MZ Twins:			
Among pairs	n_{MC}^{-1}	M_{AMC}	$2\sigma_a^2 + 2\sigma_d^2 + 2\sigma_i^2 + \sigma_{eMC}^2 + 4\sigma_{ge} + C_{MC}$
Within pairs	n_{MC}	M_{WMC}	$\sigma_{eMC}^2 \quad - C_{MC}$
Dichorionic MZ Twins:			
Among pairs	n_{DC}^{-1}	M_{ADC}	$2\sigma_a^2 + 2\sigma_d^2 + 2\sigma_i^2 + \sigma_{eDC}^2 + 4\sigma_{ge} + C_{DC}$
Within pairs	n_{DC}	M_{WDC}	$\sigma_{eDC}^2 \quad - C_{DC}$

NOTE.—n_{MC} and n_{DC} = no. of MC-MZ pairs and DC-MZ pairs, respectively; σ_a^2 = variance component due to additive genetic effects; σ_d^2 = variance component due to dominant genetic effects; σ_i^2 = variance component due to epistatic genetic effects; σ_{ge} = covariance between genetic and environmental effects; σ_{eMC}^2 and σ_{eDC}^2 = environmental variance components for monochorionic and dichorionic twins, respectively; and C_{MC} and C_{DC} = covariance among environmental effects between pairs of MC- and DC-MZ twins, respectively.

TABLE 2

ANALYSIS OF VARIANCE FOR DERMATOGLYPHIC TRAITS WITH EVIDENCE FOR DIFFERENCES BETWEEN MC-MZ AND DC-MZ TWINS

VARIABLE	MC-MZ TWINS			DC-MZ TWINS			SIGNIFICANCE TESTS*		
	No.	M_{AMC}	M_{WMC}	No.	M_{ADC}	M_{WDC}	Within Pair	Among Pair	Total Variance
Plantar Variables:									
1. Interdigital III (L)	66	0.59	0.08	36	0.62	0.19	DC .00	DC .84	DC .43
Interdigital III (R)	66	0.45	0.11	35	0.57	0.17	DC .15	DC .42	DC .25
2. Hypothenar (L)	35	0.23	0.06	20	0.24	0.13	DC .04	DC .96	DC .48
Hypothenar (R)	29	0.31	0.09	18	0.36	0.08	MC .96	DC .68	DC .71
Palmar Variables:									
1. Axial triradius (L)	70	0.87	0.11	38	0.52	0.42	DC .00	MC .08	MC .84
Axial triradius (R)	70	1.02	0.21	38	0.66	0.19	MC .66	MC .16	MC .13
Percent distance (L)	70	240.92	17.67	38	141.17	73.04	DC .00	MC .08	MC .43
Percent distance (R)	70	296.10	36.89	38	164.00	39.50	DC .78	MC .05	MC .05
atd angle (L)	70	231.02	17.98	38	157.94	65.76	DC .00	MC .20	MC .66
atd angle (R)	70	261.04	25.29	38	146.93	28.57	DC .64	MC .06	MC .06
2. Hypothenar (L)	70	0.52	0.09	38	0.44	0.16	DC .06	MC .58	MC .93
Hypothenar (R)	70	0.54	0.08	38	0.33	0.17	DC .00	MC .10	MC .36
3. Simian crease (L)	70	0.015	0.016	38	0.031	0.020	DC .45	DC .01	DC .02
Simian crease (R)	70	0.004	0.004	38	0.026	0.013	DC .00	DC .00	DC .00
4. Miscellaneous (L)	70	0.044	0.006	38	0.048	0.020	DC .00	DC .74	DC .20
Miscellaneous (R)	70	0.028	0.015	38	0.045	0.020	DC .28	DC .08	DC .05
5. Thenar/IDI (L)	70	0.39	0.12	38	0.56	0.04	MC .00	DC .20	DC .52
Thenar/IDI (R)	70	0.04	0.04	38	0.46	0.07	DC .12	DC .00	DC .00

TABLE 2 (CONTINUED)

Variable	MC-MZ Twins			DC-MZ Twins			Significance Tests*		
	No.	M_{AMC}	M_{WMC}	No.	M_{ADC}	M_{WDC}	Within Pair	Among Pair	Total Variance
Finger Variables:									
1. Middle ridge count (L)	69	67.54	6.38	38	57.65	11.14	DC .04	MC .60	MC .79
Middle ridge count (R)	69	56.96	5.96	37	37.09	8.07	DC .28	MC .16	MC .20
Middle radial count (L)	69	62.99	6.57	37	55.89	10.77	DC .08	MC .70	MC .88
Middle radial count (R)	69	60.17	5.76	37	38.82	9.86	DC .05	MC .16	MC .24
2. Index radial count (L)	69	76.12	9.50	38	57.55	17.25	DC .03	MC .36	MC .59
Index radial count (R)	70	77.36	9.12	37	53.18	20.93	DC .00	MC .22	MC .53
3. Little pattern (L)	70	0.18	0.02	38	0.07	0.02	MC .99	MC .00	MC .00
Little pattern (R)	70	0.21	0.03	38	0.15	0.01	MC .04	MC .22	MC .15
4. Thumb pattern (L)	70	0.43	0.06	38	0.34	0.07	DC .56	MC .42	MC .47
Thumb pattern (R)	70	0.33	0.09	38	0.39	0.04	MC .02	DC .56	DC .88
Thumb ulnar count (L)	69	70.55	10.16	36	145.95	13.88	DC .26	DC .01	DC .01
Thumb ulnar count (R)	68	95.96	15.85	37	127.48	14.96	MC .86	DC .32	DC .33
5. Thumb ridge count (L)	69	64.66	5.79	37	91.44	3.93	MC .20	DC .22	DC .25
Thumb ridge count (R)	68	58.10	8.56	38	71.63	3.88	MC .01	DC .45	DC .62
Thumb radial count (L)	70	63.02	5.75	38	64.71	4.53	MC .42	DC .60	DC .96
Thumb radial count (R)	69	58.76	8.22	38	71.52	3.29	MC .00	DC .48	DC .66
6. Ring pattern (L)	70	0.47	0.07	38	0.29	0.03	MC .01	MC .12	MC .07
Ring pattern (R)	70	0.43	0.11	38	0.37	0.05	MC .02	MC .62	MC .34
7. Total Ridge Count	64	3972.15	88.40	36	3355.16	44.85	MC .03	MC .60	MC .57

* The two F tests (within-pair and among-pair) and the F' test (total variance) are all two-tailed tests. The chorion type providing the numerator (larger) mean square or sum of mean squares is listed with the probability. Sample sizes vary for different variables due to incomplete sets of prints.

The palmar variables displaying significantly larger dichorionic within-pair variability can be condensed into four areas. The first area related to positioning of the most distal axial triradius (*atd* angle, percent distal deviation, and position of the axial *t* as *t*, *t'*, or *t''*). In this sample of twins, there were striking differences between the twin types for these related variables on the left hands but not the right. The second area with apparent within-pair differences is the hypothenar pattern, both of which had larger within DC-MZ pair variation than within MC-MZ pairs with the right significant ($P < .01$) but the left just missing significance ($P = .06$). Thirdly, the right simian crease pattern had significantly more within DC-MZ pair variability ($P < .01$) but the left did not ($P = .45$). The fourth area is the left miscellaneous variable which records the ulnar triradii, parathenar patterns, and absent digital triradii.

Two groups of finger patterns were more variable within DC-MZ than MC-MZ twins. The left middle finger ridge count had a significantly larger DC-MZ within-pair mean square ($P = .04$) but not the right ($P = .28$). On the index fingers, both left and right radial ridge counts were significant ($P < .05$). On the palm, only the left thenar/interdigital I pattern had significantly larger within MC-MZ mean square than within DC-MZ mean square ($P < .01$) with no evidence for this difference on the right palm. There was evidence for greater within-pair variability of MC-MZ twins than DC-MZ twins for several finger variables including total ridge count ($P = .03$), right thumb pattern ($P = .02$), right thumb radial ($P < .01$) and ridge counts ($P < .01$), right little finger pattern ($P = .04$), and left ($P < .01$) and right ($P = .02$) ring finger patterns.

DISCUSSION

The variables with significant differences between the within-pair mean squares for MC-MZ and DC-MZ twins could represent chance deviations, unique properties of the sample of twins chosen, or true biological differences. The findings could be attributed to two situations: (1) different environmental variance components, and (2) a different environmental covariance for the two types of twins. For the first situation, the twin type with the larger within-pair mean square would be expected to have a larger among-pair mean square and total variance than the other twin type. In the second case, the twin type with the larger within-pair mean square would be expected to have a smaller among-pair mean square and no difference in total variance when compared to the other twin type. The among-pair mean squares and estimates of total variance (within + among mean squares) are much larger than the within-pair mean squares and therefore would be expected to have correspondingly greater sampling variances. Examination of the 19 variables with significant differences between the within-pair mean squares reveals that only one (right simian crease) has a significant difference ($P < .05$) for either the among-pair mean squares or estimates of total variance.

The asymmetry of findings is of interest. Of the 19 variables with significant within-pair differences, only four are left-right pairs. This finding could represent marked laterality of effects, but it seems more likely to reflect the instability of the mean squares due to relatively small numbers of twin pairs.

Penrose [24] has shown in correlation studies of relatives that the *atd* angle is genetically influenced but with considerable environmental alteration and that the large number of disorders with characteristic positioning of the axial triradius attests to its frequent modification by both genetic and environmental influences. In addition, the *atd* angle has been employed by several groups of investigators [25–27] searching for asymmetry as an indication of hereditary predisposition to cleft lip and palate. It is assumed the genetic predisposition lowers the developmental stability and allows environmental insults to be more expressive, and a secondary effect of the loss of the genes buffering against environmental shocks is an increase in *atd* angle asymmetry. That the DC-MZ twins have larger within-pair mean squares indicates that perhaps some feature specific to the dichorionic twinning process also results in more asymmetry between members of the dichorionic set or conversely more symmetry among the monochorionic pairs, while the larger mean of the axial triradius variables in MC-MZ pairs points to the axial triradius also being more distally located in MC-MZ pairs.

Previously we reported that the thumb pattern and ridge counts displayed nonsignificant genetic variance in comparison of MZ and DZ twins [14] and a greater total variance in DZ twins for these variables. Subsequently, we found that the thumb variables were among the best discriminators between MZ and DZ twins [2]. Since the mean squares within MC-MZ twins for these thumb variables are in general larger than those within DC-MZ twins, the observed reduction in total variance of MZ twins in all probability reflects the smaller environmental variance affecting the thumb ridge counts in DC-MZ twins.

An analogous story has been found with regards to plasma cholesterol. First, a significantly larger total variance was found in DZ twins compared to MZ twins [11–13]; then a significant difference in the within-pair mean squares in plasma cholesterol was found between monochorionic and dichorionic MZ twins [8–10]. For the cholesterol data, the DC-MZ within-pair mean squares were larger, while in the thumb variables the MC-MZ twins had the larger mean squares.

SUMMARY

The data presented here indicate that different influences affect dermatoglyphic pattern development in MC-MZ and DC-MZ twins. Only five of 84 variables had significant mean differences but their clustering suggested a real difference in mean placement of the *atd* angle. Nineteen of 84 variables had significantly different within-pair mean squares for the two twin types. Larger numbers of twins will be required to obtain accurate estimates of the magnitude of the dermatoglyphic differences between MC-MZ and DC-MZ twins.

Studies of dermatoglyphics in MC-MZ and DC-MZ twins are important to the understanding of factors which influence early embryonic development and when better documented may provide a mechanism for retrospectively diagnosing placental type of MZ twins.

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