Institute of Experimental Morphology, Pathology and Anthropology with Museum
Bulgarian Anatomical Society

Acta morphologica et anthropologica, 22
Sofia ● 2015

Qualitative Dermatoglyphic Traits in Twins

I. Maslarski

Department of Human Anatomy, Histology and Pathology, Medical Faculty, University of Sofia St. Kliment Ohridski, Bulgaria

Palm and finger prints are an important element of the Twin Method, whereby we use both qualitative and quantitative indicators. It has been established with the qualitative indicators that the papillary image refers to polygenic hereditary characteristics, and that they are to be detected more easily than the quantitative ones. The main place in the study is the dermatoglyphic morphology of the hands, represented in two groups: monozygotic twins (MZ) and dizygotic twins (DZ). The material of the study included palm prints of both hands of 21 pairs of MZ twins and 22 pairs of DZ twins. Fingerprints and palms were obtained by a standard method. The Twin Method researches differences in MZ and DZ twins, using the "Similarity Method". Quantitative indicators demonstrate a relationship with zygosity, concerning the left and right hand.

Key words: monozygotic twins, dizygotic twins, twin method, total ridge count, ridge count triradii.

Introduction

The Twin Method appeared due to the necessity of juxtaposing the genetic predisposition and the influence of one's environment. Already in 1875, Francis Galton [6] had made a series of experiments with twins to establish the extent of influence in environmental and genetic factors. He had prepared hundreds of questionnaires addressed to parents of the twins in order to achieve his goal and to understand the power of heredity. Nowadays, we can rely on findings from other disciplines, such as morphology, genetics and psychology, to explore the above-mentioned discourse and for our analysis to be more authentic.

Palm and finger prints are an important element of the Twin Method, whereby we use both qualitative and quantitative indicators. It has been established with the qualitative indicators that the papillary image refers to polygenic hereditary characteristics and that they are to be detected more easily than the quantitative ones (**Fig. 1**). The application and the development of the Twin Method, as well as of the finger-palm prints, leads to the advance of the following disciplines: medical genetics (used to establish a relationship between changed in skin relief and hereditary chromosomal diseases, as well as to determine the zygosity of twins), ethnic anthropology (used to establish a common origin of two separate groups of a population) and criminology (used to solve debatable questions, such as paternity rejection or identification of an individual).

Particularities of fingerprints have been noticed ever since the Ancient times The Chinese, for example, used their fingerprints instead of a stamp when validating docu-

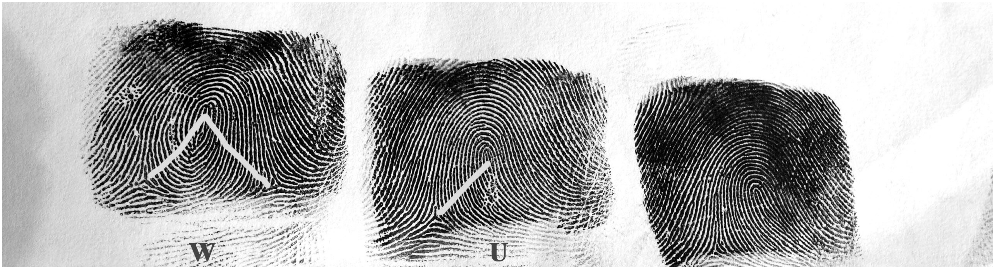

Fig. 1. Ridge count triradii of the fingers, W – whorl; U – ulnar loop; Line – ridge count triradii

ments. The use of friction ridge skin as a signature in China, Japan, India, and possibly in other states prior to European discovery is thus well documented. The German doctor and anatomist C. A. Mayer wrote: "Although the arrangement of skin ridges is never duplicated in two persons, never the less the similarities are closer among some individuals. In other, the differences are marked, yet in spite of their peculiarities of arrangement all have a certain likeness" (Cummins and Midlo, 1943), [3]. Mayer was the first to write that friction ridge skin is unique.

The birth of dermatoglyphics was possible thanks to works of Galton, Herschel (1880) [8] and Faulds [4], which researched fingerprints of people and primates. They establish the individuality and uniqueness of the images, as well as the possibility of human identification using finger-palm prints [5]. A few years later, Kallman (1885) made the first dermatoglyphic description of a foot. Following his example, a series of scientists continued studying the foot dermatoglyphics (Hepburn 1893, 1895; Wielder, 1904, 1913, 1916, 1922). Cummins and Middlo (1943), [3] publish two important monographs: about the skin relief in primates (1942) and about general dermatoglyphics (1943). Bansal (1968), [1] reports the bilateral symmetry, measuring the distance between the triradii of the third and the fourth finger.

The literature review demonstrates that twin research has not been extensive, perhaps due to the difficulty of obtaining anthropological material. The majority of twin research is based on physical development of twins and on causes for multiple pregnancies (J. Bertrand Petit, A. Marin, 1988). Imaizumi (1987), [9] and co-authors make a series of experiments on the influence of parents' age and the birth sequence on a multiple pregnancy. They establish that with parents' age increase, the chance of twin birth is higher.

Materials and Methods

The main place in the study is the dermatoglyphic morphology of the hands, represented in two groups: monozygotic twins (MZ) and dizygotic twins (DZ). The material of the study included palm prints of both hands of 21 pairs of MZ twins and 22 pairs of DZ twins. Most data was collected in the area surrounding the town of Shumen, Bulgaria. Fingerprints and palms were obtained by a standard method. Fingerprinting was done by covering the hand palmar surface with topographic ink, and by using a glass plate and a roller. The recording of fingerprinting was done in a passive way, as the researcher helped with the data collection. A rotary tool was used to cover palms and fingers, always starting from the 1st finger on the right hand and finishing with the 5th finger on the left hand. Palmar surface was greased with topographic ink and fingerprints were left on a white sheet of paper, placed on a convex cylindrical surface. Such method provided an accurate print of the palmar surface, including the central part of the palm. The establishment of dermatoglyphic differences was performed with the aid of a binocular loupe.

Results and Discussion

Every developing trait depends both on hereditary and environmental factors. The goal of the Twin Method is to establish the relative role of both in the variability of different traits. This method is used in medicine when studying the hereditary predisposition to specific diseases (Down syndrome, cerebral gigantism, diabetes, schizophrenia, chromosomal abnormalities and others).

The Twin Method study differences in monozygotic (MZ) and dizygotic (DZ) twins, using the "Similarity Method". MZ twins are juxtaposed with DZ twins of the same gender, while taking into account that all differences in MZ twins are a product of external factors and in DZ twins – partly due to genetic factors and partly because of environmental ones. When taking heredity into account, one must determine the type of zygosity in twin research with great accuracy.

Two MZ embryos have the same hereditary potential, but develop as two independent individuals. They have the same gender, the same blood group and the same serum factors. This applies to many other hereditary physical traits. When it comes to intrauterine development, there are a couple of conditions, which can lead to differences in MZ twins. The exact time of zygote division is of great importance. We distinguish three ways of zygote division, depending on the time of its occurrence.

• MZ I (dichorionic diamniotic) – the separation happens between 0 to 3 days after fertilization. MZ I type occurs approximately 28.3%).

• MZ II (monochorionic diamniotic) – the separation happens during the developed morula stage (from day 4-5 to day 7 after fertilization). This type of separation is the most typical for the monozygotic twins (about 70%).

• MZ III (monochorionic monoamniotic) – the separation takes place after the 7th day following fertilization, which is when the embryo of the internal membranes (amnion) is already formed and the process of division stopped. MZ III type occurs rarely (1.2%).

The so called 'Siamese twins' are of great interest, as they do not have the possibility of full zygote division and remain connate to different extents. This takes place if the division starts after the 9th day post-fertilization.

Qualitative dermatoglyphic results shown that the ridge count between the four finger triradii has been defined: "a-b", "b-c" and "c-d" separately on each hand, the total ridge count (TRC) for both hands and the total ridge count. When there was an extra triradius, we also took into account the finger triradius "a" or "d".

The size of the "atd" angle has been measured by connecting finger triradii "a", "t" and "d" with two straight lines, and reported using an octant and a protractor. If extra triradii "a1" and "d1" existed, we also noted the most radial and most ulnar triradii. If extra axis triradii existed, we noted the most distal triradii.

When comparing the finger ridge quantity, we observed the following patterns. MZ twins with highest values have a unique IV finger on the left hand in both groups (I born twins – 15.55%; II born twins – 16.45%). We observed a high degree of similarity in the researched trait distribution also in the rest of the fingers (**Table 1**). The distribution of this trait in DZ twins is quite different. The highest ridge quantity was observed on the 1st finger of right hand in the group of 1st born twins. As a whole, this trait is characterized with higher values in the group of 1st born DZ twins and in both types of group twins (**Table 2**).

Table 1. Quantitative indicators of the monozygotic twins (MZ)

Index	Birth order	N	$\bar{x}$ (μ_x) mean value	Standard deviation S.	Sample standard deviation Sx	Variance (V)
TRC a-d	I	22	190.2727	45.1571	9.6275	23.73
	II	22	187.8636	43.1115	9.1914	22.94
TRC I-V	I	22	132.5	32.9657	7.0283	24.87
	II	22	135.4091	33.3262	7.1052	24.61
∑ RT I-V dex	I	22	66.5455	15.6714	3.3412	23.55
	II	22	67.4545	17.1012	3.6460	25.35
∑ RT I-V sin	I	22	65.9545	18.9246	4.0347	28.69
	II	22	67.9545	17.3356	3.6960	25.59
∑ RT d-a dex	I	22	97.4545	19.2965	4.1140	19.79
	II	22	98.2727	17.7635	3.7872	18.07
∑ RT d-a sin	I	22	96.2273	19.3364	4.1225	20.10
	II	22	99.7273	13.2564	2.8263	13.30
RT d-c dex	I	22	33.2273	10.2443	2.1841	30.82
	II	22	36	7.6158	1.6237	21.14
RT d-c sin	I	22	31.5	10.5413	2.2474	33.46
	II	22	33.5455	8.3821	1.7871	24.89
RT c-b dex	I	22	26.8182	7.9560	1.6962	29.68
	II	22	27.3636	5.2513	1.1196	19.19
RT c-b sin	I	22	25.7727	7.5589	1.6116	29.33
	II	22	27.5909	4.7675	1.0164	17.29
RT b-a dex	I	22	38.0909	4.5136	0.9623	11.84
	II	22	37.7273	4.7927	1.0218	12.72
RT b-a sin	I	22	38.9545	5.5419	1.1815	14.22
	II	22	38.4091	6.5659	1.3998	17.08
RT I dex	I	22	14.227	6.5096	1.3878	45.75
	II	22	15.1364	6.5268	1.3915	43.13

RT I sin	I	22	14.8182	5.5689	1.1873	37.52
	II	22	15.2273	4.6284	0.9868	30.33
RT II dex	I	22	13.2273	3.6506	0.7783	27.58
	II	22	12.7273	4.4420	0.9470	34.88
RT II sin	I	22	10.9545	6.0826	1.2968	55.52
	II	22	11.2273	5.8386	1.2448	52.00
RT III dex	I	22	12.0909	4.5660	0.9735	37.76
	II	22	12.7727	5.2001	1.1087	40.71
RT III sin	I	22	12.1818	5.6285	1.2000	46.21
	II	22	12.5	4.0679	0.8673	32.54
RT IV dex	I	22	14.6818	4.2693	0.9102	29.08
	II	22	14.8182	4.6867	0.9992	31.63
RT IV sin	I	22	15.5455	4.8573	1.0356	31.24
	II	22	16.4545	3.5821	0.7637	21.77
RT V dex	I	22	12.2273	4.6284	0.9868	37.85
	II	22	12.1364	4.6629	0.9941	38.39
RT V sin	I	22	12.7727	4.5558	0.9713	35.71
	II	22	13	4.6188	0.9847	35.53
< atd dex	I	22	46.1818	6.5001	1.3858	14.07
	II	22	47.0909	6.7040	1.4293	14.24
< atd sin	I	22	46.2273	7.4446	1.5872	16.10
	II	22	47.0455	7.9491	1.6948	16.90

TRC – total ridge count
RT – ridge count triradii
dex – right
sin – left

Table 2. Quantitative indicators of the dizygotic twins (DZ)

Index	Birth order	N	$\bar{x}$ (μ_x) mean value	Standard deviation S.	Sample standard deviation Sx	Variance (V)
TRC a-d	I	21	199.7619	22.7638	4.9675	11.36
	II	21	192.0952	34.8782	7.6111	18.16
TRC I-V	I	21	138.9048	31.9467	6.9713	23.00
	II	21	122.8095	47.0836	10.2745	38.34
∑ RT I-V dex	I	21	69.1429	16.6201	3.6268	24.04
	II	21	63.6190	22.9945	5.0178	36.14
∑ RT I-V sin	I	21	69.7619	17.0555	3.7218	24.45
	II	21	59.1905	25.3882	5.5402	42.90
∑ RT d-a dex	I	21	101.0952	12.8876	2.8123	12.75
	II	21	94.8571	23.5803	5.1456	26.97
∑ RT d-a sin	I	21	103.3333	11.2665	2.4585	11.00
	II	21	101.4286	18.6884	4.0781	18.43
RT d-c dex	I	21	35.5238	6.5316	1.4253	18.38
	II	21	35.5238	4.7076	1.0273	13.26
RT d-c sin	I	21	35.2857	5.5690	1.2153	15.79
	II	21	34.0952	11.2067	2.4455	32.87
RT c-b dex	I	21	25.5238	5.6800	1.2395	22.26
	II	21	26.5714	6.6225	1.4451	24.91
RT c-b sin	I	21	26.1905	4.3545	0.9502	16.61
	II	21	26.3810	8.0838	1.7640	30.63
RT b-a dex	I	21	39.4286	7.0041	1.5284	17.75
	II	21	38.4286	4.8946	1.0681	12.72
RT b-a sin	I	21	41.8571	6.5596	1.4314	15.67
	II	21	40.3333	4.6940	1.0243	11.65
RT I dex	I	21	15.7619	5.2240	1.1400	33.12
	II	21	16.4762	4.5345	0.9895	27.50

RT I sin	I	21	14.8095	4.8023	1.0479	32.41
	II	21	13.5238	4.8334	1.0547	35.72
RT II dex	I	21	12.0000	6.3246	1.3801	52.67
	II	21	11.5238	6.0052	1.3104	52.10
RT II sin	I	21	12.3333	6.6508	1.4513	53.94
	II	21	10.4762	6.4158	1.4000	61.24
RT III dex	I	21	13.0000	4.4159	0.9636	33.97
	II	21	10.4762	5.9213	1.2921	56.52
RT III sin	I	21	13.9048	5.3843	1.1749	38.72
	II	21	10.6667	7.3643	1.6070	68.98
RT IV dex	I	21	15.1905	4.4229	0.9652	29.12
	II	21	13.1905	6.2500	1.3639	47.38
RT IV sin	I	21	15.6667	3.5963	0.7848	22.92
	II	21	13.0952	7.2726	1.5870	55.88
RT V dex	I	21	13.2381	4.7001	1.0256	35.50
	II	21	12.2381	6.2202	1.3574	50.82
RT V sin	I	21	13.0476	4.3986	0.9599	33.71
	II	21	11.4286	6.1284	1.3373	53.62
< atd dex	I	21	45.9524	7.2696	1.5864	15.82
	II	21	42.4286	13.0674	2.8515	20.16
< atd sin	I	21	45.3810	7.6972	1.6797	16.96
	II	21	45.8095	8.6811	1.8944	18.95

TRC – total ridge count
sin – left
RT – ridge count triradii
dex – right

There have not been established any differences in ridge count distribution in interdigital fields neither in the MZ and DZ twins comparison, nor in the order of birth comparison. The highest ridge quantity for the entire excerption was observed in the field d-a, with the second highest observed in the field b-a, and the lowest – in c-b.

The average value of the total ridge count (TRC) is highest in I-born twins group (138.90%) and lowest in II-born DZ twins group (122.81%). This trait in MZ twins was almost identical for both I-born and II-born twins (I-born – 132.5%, II-born – 135.41%). When comparing the total ridge count trait, the difference is minimal in I-born and II-born MZ twins (2.41%). The two DZ twin groups show a bigger difference (7.67%). The highest total ridge count is observed in I-born twins (199.76%) and the lowest – in II-born MZ twins (187.86%).

When comparing the maximal values of the angle atd, we have not observed any significant differences between the two researched groups. The highest maximal value of the angle has been reported in II-born MZ twins in both hands, while the lowest maximal value was observed on the right hand in II-born DZ twins (**Tables 1, 2**).

The analysis of connections and dependencies in MZ twins demonstrates that all researched quantitative indicators (ridge count of interdigital triradii (RT), ridge quantity of finger phalanges (RT – I-V), total right count and the angle atd) are distributed normally (**Tables 1, 2**). By performing Levene's test, we also established that all indicators are over 0.05% (first order error) and, subsequently, there is no connection between the indicators and the I-born and II-born MZ twins (T-test).

We have performed the same test for DZ twins, and the results are similar and show the expected distribution, with the exception of the indicator RT III dex (Kolmogorov-Smirnov test). A non-parametrical test for this indicator demonstrates lack of a relationship with the relevant groups of I-born and II-born DZ twins. The indicators RT d-c sin, RT c-b sin, RT III sin and RT IV sin in Levene's test reject the null hypothesis. Despite the existing relationship, it is not statistically significant, because the null hypothesis may not be rejected in a T-test. The calculated extent of the relationship is under 0.3, i.e. the difference between the two researched groups is very weak with these indicators in mind.

The comparison of groups as a whole, MZ on the one hand, and DZ on the other, demonstrates that, on average, all indicators have a normal distribution (Kolmogorov-Smirnov test). Levene's test confirms the null hypothesis, which is rejected only by the RT d-c dex indicator (T test). Only with this indicator is it possible to search for a difference between MZ and DZ twins, but the calculated effect is minimal.

The second variant in researching MZ and DZ twins as an median difference between I-born and II-born twins was more successful. The distribution of indicators TRC a-d, TRC I-V, ∑ RT I-V dex at sin, ∑ RT d-a dex. et sin., RT d-c dex, RT I dex, RT II dex, RT V dex. < atd dex. is not normal. For these indicators we used Mann Whitney's non-parametrical test. The above-mentioned indicators, with the exception of RT d-c dex, RT I dex., ∑ RT d-a sin, RT V dex. < atd dex., demonstrate the existence of a connection in twin zygosity.

Parametrical indicators are investigated with Levene's test and T-test. With Levene's test we found that the following indicators have a connection with zygosity: RT b-a dex., RT I sin, RT III sin, RT IV dex et sin. The aforementioned indicators reject the null hypothesis in the T-test. Significant values are the sum of 1-5 phalanges ridges on the left hand (0.67%) and the TRC of finger phalanges. The least significant value is possessed by the indicators ∑ RT d-a dex and TRC a-d. The most significant individual indicator was the ridge count of the 5^{th} finger phalanx on the left hand.

Conclusion

Based on the current research and after analysing the results, the following conclusions can be made:

1. MZ twins with highest values in finger ridge quantity have a unique IV finger on the left hand in both groups (I born twins – 15.55%; II born twins – 16.45%). The highest ridge quantity in DZ was observed on the 1st finger of the right hand in the group of I-born twins;

2. Quantitative indicators demonstrate a relationship with zygosity, concerning the left and right hands are as following: five indicators on the left hand (∑ RT I-V sin, RT I sin, RT III sin, RT IV sin, RT V sin), five indicators on the right hand (∑ RT I-V dex., ∑ RT d-a dex., RT b-a dex., RT II dex., RT IV dex.) and two total indicators (TRC a-d, TRC I-V);

3. The distribution of indicators TRC a-d, TRC I-V, ∑ RT I-V dex at sin, ∑ RT d-a dex. et sin., RT d-c dex, RT I dex, RT II dex, RT V dex. < atd dex. is not normal;

4. The significant individual indicator was the ridge count of the 5th finger phalanx on the left hand.

References

1. **Bansal, I. J. S.** Palmar dermatoglyphics in maharashtrians in India. – Acta geneticae medicae et gemellologiae, **14**(4), 1965, 431-437.
2. **Boklage, C.** Race, zygosity and mortality among twins: interaction of myth and method. – Acta geneticae medicae et gemellologiae, **6**(3), 1987, 275-288.
3. **Cummins, H., C. Midlo.** Finger prints, palms and soles: an introduction to dermatoglyphics. New York, Dover Publications, 1961, 319.
4. **Faulds, H.** Guide to Finger-print Identification. Hanley, Wood, Mitchell & Co Ltd, 1905, 75.
5. **Fournier, N., H. Ross.** Sex, ancestral, and pattern type variation of fingerprint minutiae: A forensic perspective on anthropological dermatoglyphics. – J. Am. Phys. Anthrop., **158**(3), 2015, 78-84.
6. **Galton, F.** The history of twins, as a criterion of the relative powers of nature and nurture. – Fraser's Magazine, **12**, 1875, 566-576.
7. **Hepburn, D.** The Papillary Ridges of the Hands and Feet of Monkeys and Men. – Royal Dublin Society, 1895, 538.
8. **Herschel, W. J.** The Origin of Finger-Printing. Oxford University Press, London, 1916.
9. **Imaizumi, Y.** Infant mortality rates in single, twin and triplet births, and influencing factors in Japan. – Paediatric and perinatal epidemiology, **15**(4), 2001, 346-351.

Corresponding author:
Maslarski, Ivan Ilkov
Tel.: +359-882-000-809
e-mail: maslarsky@gmail.com