

DERMATOGLYPHIC PATTERNS AMONG STUDENTS IN NORTH MACEDONIA

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Abstract

Introduction: Dermatoglyphics is a scientific discipline that studies the epidermal ridge patterns present on the palmar surfaces of the hands, the toes and the plantar surfaces of the feet.

Aim. An analysis of individual dermatoglyphic characteristics in healthy medical students of Macedonian and Albanian ethnicity was conducted.

Material and methods: The study included 234 healthy students; palm prints were obtained and dermatoglyphic parameters were read, classified and compared with data reported in the dermatoglyphic literature. Imprinting was done by the Cummins and Midlo ink method. The reading and classification of dermatoglyphic patterns were performed according to Henry's system.

Results: Ulnar loops were the most prevalent patterns, followed by circular, arcuate and complex patterns, which were present in a small percentage in both genders; radial loop was present only on the second finger in both genders. There were differences on the right hand for the second, fourth and fifth finger, and on the left hand for the third, fourth and fifth finger between males and females. Also, significant differences were found in the third and fourth interdigital spaces and hypothenar area. The triradii distribution formula in females was: $a > b > d > c > t$; whereas in males it was: $a > t > b > c = d$. Additional triradii were rare in both genders. The atd angle was within the range of 32°-55° in females and 33°-50° in males, most often 40° in both groups.

Conclusion: This population-based study have shown similarities and differences in the prevalence of some dermatoglyphic features in males and females among healthy students.

Keywords: dermatoglyphics, palm prints, genders

Introduction

The skin on the palmar surface of the hands and the plantar surface of the feet is characterized by the presence of sweat glands and the absence of hair and sebaceous glands. The sweat glands open onto the epidermal ridges (*cristae superficiales*), which are separated from each other by shallow furrows (*sulci cutanei*). Due to the abundance of sensitive nerve endings, these epidermal ridges are also called tactile ridges^[1,2]. The secretion from the sweat glands located at the top of the ridges leaves an oily impression of the corresponding patterns on any touched surface. Chance impressions (fingerprints) can be patent (visible), transferred

from the fingers via ink, blood, or paint; plastic, impressed into substances like wax or clay; or latent (invisible), especially those left on smooth surfaces, which can be made visible when necessary using various techniques such as dusting with appropriate powder. The powder particles adhere to the fatty residues; these visualized prints are then lifted with adhesive tape and photographed. Every individual possesses a unique fingerprint, which serves as a method of identification^[3]. The traces seen in a fingerprint appear as lines known as papillary lines. The flow of these papillary lines is generally parallel; however, in certain topographical fields, the flow is non-parallel, creating characteristic patterns. The morphological characteristics of the skin are studied by a specific scientific discipline - dermatoglyphics (*derma*-skin, *gliphe*-carving). The term was proposed by Cummins and Midlo and accepted by the American Association of Anatomists^[4].

To obtain a visible fingerprint, the fingertips are inked and pressed on paper. The most common pattern is the loop, which every individual has on at least some part of their skin. Within the boundaries of each print are individual characteristics known as minutiae (ridge details), of which there are at least 100 per finger; positive identification is based on the matching of a subset of these^[5].



Fig. 1. Fingerprint.

Figure 1. illustrates:

- Sweat glands appearing as tiny white dots along the ridge;
- Points where ridges split into two branches (bifurcation or fork);
- Ridge ending;
- A ridge splitting into two and then reuniting (enclosure or lake);
- Delta (triradius) - a point where ridges from three different directions meet at angles of approximately 120 degrees (noted in text as 90 degrees);
- Independent ridge (short ridge)^[5].

The characteristics responsible for the uniqueness of fingerprints were studied and named after the British anthropologist Francis Galton.

The skin relief of the fingers forms during fetal development, between the 5th and 15th weeks of gestation. On the surface of the fingers, palms, and soles, small volar pads first develop. These pads expand, and small ridges develop upon them with openings for the glandular excretory ducts (pores) along the center, separated by furrows. Blood vessels and subsequently nerves enter these pads. Guided by a genetically determined morphological blueprint influenced by environmental factors during growth, the papillary ridges are aligned to form shapes we call dermatoglyphic patterns^[7].

Dermatoglyphics also include the triradii (a, b, c, d, t, t', t'') present on the topographical regions of the hand: the thenar and first interdigital space, the second, third, and fourth interdigital spaces, and the hypothenar area. The topographical regions used to

determine the presence of dermatoglyphics are shown in Figure 2, while the calculation of the atd angle is measured between the a, d, and t triradii, which is a quantitative characteristic of dermatoglyphics.

Dermatoglyphic patterns are classified as: whorls (W), loops (L), arches (A), double loops (Wd) - illustrated in Figure 3, as well as lateral pocket loops (Wlpl), central pocket loops (Wcpl), and accidental patterns (Wacc). Whorls can further be divided into concentric, elliptical, or spiral (Wc, Ws, We), while loops can be radial or ulnar (L-r, L-u), as well as distal or proximal (L-d, L-p), depending on the orientation of the loop [4,5].

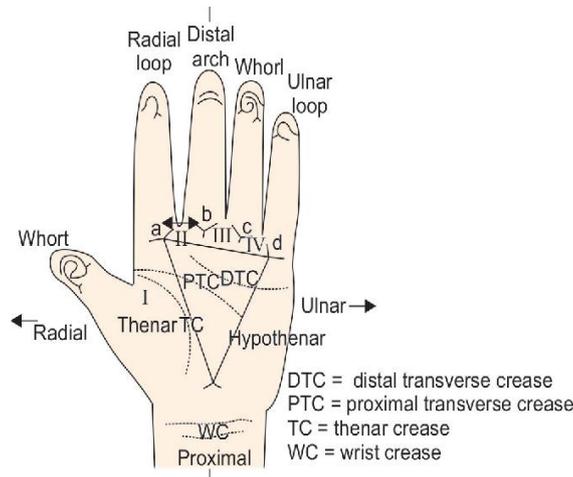


Fig. 2. The topographical regions used to determine the presence of dermatoglyphics.

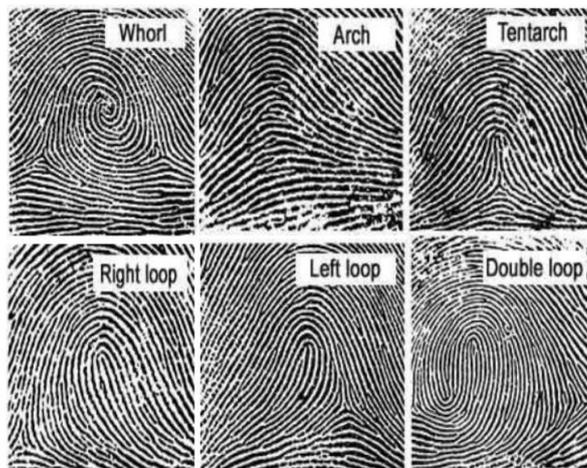


Fig. 3. Dermatoglyphic patterns.

Population-based dermatoglyphic studies examine the variability of patterns within a healthy population. These studies establish the necessary descriptive and comparative foundations that contribute to a better understanding of the humans. Dermatoglyphic traits are utilized to uncover population characteristics and affinities, as well as similarities and differences between various races. Wilder (1925), one of the pioneers of population-based dermatoglyphic research, pointed out that certain traits are characteristic of one race in a higher percentage compared to another. He emphasized that these traits hold ethnic significance if a sufficient sample is taken—at least one hundred subjects from a single ethnic group^[8,9].

Regarding population dermatoglyphic research of the palm, nearly all geographical regions of the world are well-represented with results in numerous publications. India and Europe have the highest number of published papers on the dermatoglyphic characteristics of

their populations, followed by population studies from Asia, Africa, America, and Australia. Many papers conduct comparative analyses between peoples living within the borders of a single continent, as well as between different ethnic groups.

The results of dermatoglyphics or patterns formed by the epidermal ridges are utilized across various sciences and scientific disciplines, including biology, anthropology, genetics, criminology, forensic medicine, and other medical branches^[10].

For a new idea to be integrated into medical practice, it must be medically justified, rational, and clinically adequate. The applicative significance of dermatoglyphic research is based on the following:

Unchanged: From birth until the end of life, dermatoglyphics remain unchanged in appearance, increasing only in width.

Uniqueness: No two individuals possess the same dermatoglyphic phenotype, not even monozygotic (identical) twins. Despite extensive research, no two identical fingerprints have ever been found. Consequently, they are of exceptional importance for human identification in forensic medicine^[11,12].

The rationality lies in the fact that fingerprinting and dermatoglyphic analysis represent one of the most non-invasive, cost-effective, rapid, and painless methods. Their application requires only a certain knowledge of dermatoglyphics.

Material and methods

A dermatoglyphic population-based study was conducted at the Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, N. Macedonia. The sample for this study consisted of 234 subjects, aged 18 and 19 years. A total of 468 palmar prints was obtained from both, the right and the left hands. Dermatoglyphic patterns were classified and analyzed.

Participants were of Macedonian and Albanian ethnicity, with each group comprising a varying number of male and female individuals. The study included students who voluntarily signed an informed consent form for participation in scientific research. National affiliation and the absence of diseases were determined through a survey.

The primary exclusion criteria were: refusal to provide consent, the presence of systemic diseases and skin alterations that prevented the clear acquisition of prints.

The collected prints are kept in secure storage at the Institute of Anatomy at the Faculty of Medicine in Skopje, and are used exclusively for scientific research purposes.

The study was conducted after obtaining the necessary approvals from:

- The Ethics Committee of the Faculty of Medicine, Ss. Cyril and Methodius University in Skopje.
- The Agency for the Protection of Personal Data in North Macedonia.

Methodology^[4,6]

Fingerprint and palmar prints were obtained according to the method of Cummins and Midlo.

Classification of dermatoglyphic patterns was conducted using the Henry's system.

Carpal-axial triradii of the palms were identified.

Atd angles of the palms were measured.

The collected data were statistically analyzed and are presented in tables.

Results

The obtained results are presented and explained in the tables.

The percentage of Macedonians and Albanians, female to male ratio and age (18-19 years) are shown in Table 1.

Table 1. Baseline participants' characteristics (N = 234)

Participants' characteristics	n (%)
Nationality	
Albanians	36 (15.4)
Macedonians	198 (84.6)
Age (years)	
18	144 (61.5)
19	90 (38.5)
Gender	
Female	153 (65.4)
Male	81 (34.6)

Note. Values are presented as frequency (percentage).

Table 2. Fingerprint patterns by gender for right-hand fingers (n, % within pattern)

Fingerprint pattern	I		II		III		IV		V	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
A	8 (100.0)	0 (0.0)	29 (72.5)	11 (27.5)	19 (65.5)	10 (34.5)	14 (73.7)	5 (26.3)	16 (72.7)	6 (27.3)
L-u	83 (65.9)	43 (34.1)	48 (65.3)	25 (34.7)	89 (64.5)	49 (35.5)	61 (61.6)	38 (38.4)	102 (61.8)	63 (38.2)
L-r			14 (36.8)	24 (63.2)	0 (0.0)	4 (100.0)	1 (100.0)	0 (0.0)		
Wacc	1 (100.0)	0 (0.0)								
Wc	33 (57.9)	24 (42.1)	42 (72.4)	16 (27.6)	22 (73.3)	8 (26.7)	40 (76.9)	12 (23.1)	24 (75.0)	8 (25.0)
Wcpl					1 (100.0)	0 (0.0)	1 (100.0)	0 (0.0)		
Wd	13 (56.5)	10 (43.5)	5 (100.0)	0 (0.0)	8 (57.1)	6 (42.9)	1 (14.3)	6 (85.7)	0 (0.0)	3 (100.0)
We	11 (73.3)	4 (26.7)	9 (64.3)	5 (35.7)	13 (81.2)	3 (18.8)	34 (65.4)	18 (34.6)	11 (100.0)	0 (0.0)
Wlpl	2 (100.0)	0 (0.0)	1 (100.0)	0 (0.0)						
Ws	2 (100.0)	0 (0.0)	5 (100.0)	0 (0.0)	1 (50.0)	1 (50.0)	1 (33.3)	2 (66.7)	0 (0.0)	1 (100.0)
Pearson χ^2 (df), p	9.525 (7), p = 0.217		22.200 (8), p = 0.005		11.380 (7), p = 0.123		14.754 (7), p = 0.039		16.138 (5), p = 0.006	

Note. Values are n (% within fingerprint pattern for the given finger).

Pearson χ^2 : there was statistically significant association for II (p = 0.005), IV (p = 0.039) and V (p = 0.006); there was no association for I (p = 0.217) and III (p = 0.123)

Table 2 displays the percentage of fingerprint patterns by gender for right-hand fingers. Ulnar loops were the most frequent pattern, followed by concentric and elliptical whorls; radial loops were present only on the second digit; complex patterns were rare except for the double loops, mostly on the first finger. The Pearson chi-square (χ^2) test revealed a statistically significant association between gender and dermatoglyphic patterns on the second (p=0.005), fourth (p= 0.039), and fifth (p=0.006) fingers. No significant association was observed for the first (p=0.217) and third (p=0.123) fingers.

The percentage of fingerprint patterns by gender for the fingers on the left-hand are shown in Table 3.

Ulnar loops were the most prevalent pattern, followed by concentric and elliptical whorls; radial loops were present only on the second digit; complex patterns were rare except for the double loops, mostly on the first finger. The Pearson chi-square (χ^2) test revealed a statistically significant association between gender and dermatoglyphic patterns on the third L ($p=0.004$), the fourth L ($p =0.001$) and the fifth L ($p<0.001$). No significant association was observed for the first L ($p=0.391$) and the second L ($p=0.111$).

Table 3. Fingerprint patterns by gender for left-hand fingers (n, % within pattern)

Fingerprint pattern	I		II		III		IV		V	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
A	12(75.0)	4(25.0)	30(62.5)	18 (37.5)	25 (67.6)	12 (32.4)	20 (64.5)	11 (35.5)	18 (94.7)	1 (5.3)
L-u	78 (61.4)	50 (38.6)	46 (69.7)	20 (30.3)	83 (60.6)	54 (39.4)	59 (53.2)	52 (46.8)	100 (59.5)	68 (40.5)
L-r			14 (56.0)	11 (44.0)	0 (0.0)	4 (100.0)	1 (100.0)	0 (0.0)		
Wacc	1 (100.0)	0 (0.0)								
Wc	25 (62.5)	15 (37.5)	39 (78.0)	11 (22.0)	26 (89.7)	3 (10.3)	45 (78.9)	12 (21.1)	24 (75.0)	8 (25.0)
Wcpl										
Wd	26 (72.2)	10 (27.8)	9 (42.9)	12 (57.1)	7 (77.8)	2 (22.2)	5 (50.0)	5 (50.0)	0 (0.0)	3 (100.0)
We	8 (80.0)	2 (20.0)	13 (65.0)	7 (35.0)	12 (70.6)	5 (29.4)	22 (95.7)	1 (4.3)	10 (100.0)	0 (0.0)
Wlpl										
Ws	3 (100.0)	0 (0.0)	2 (50.0)	2 (50.0)	0 (0.0)	1 (100.0)	1 (100.0)	0 (0.0)	1 (50.0)	1 (50.0)
Pearson χ^2 (df), p	7.378 (7), p = 0.391		10.336 (6), p = 0.111		19.279 (6), p = 0.004		23.395 (6), p = 0.001		22.259 (5), p < 0.001	

Note. Values are n (% within fingerprint pattern for the given finger).

Pearson χ^2 – there was statistically significant association for the III_L ($p = 0.004$), IV_L ($p = 0.001$) and V_L ($p < 0.001$); no significant association was observed for the I_L ($p = 0.391$) and II_L ($p = 0.111$) finger.

Table 4. Triradii distribution by gender (n, % within category)

Triradi	R hand		Pearson χ^2 (df), p	L hand		Pearson χ^2 (df), p
	Female	Male		Female	Male	
a	152 (65.8)	79(34.2)	1.379 (1), p = 0.240	147(65.0)	79(35.0)	0.338 (1), p = 0.561
b	143 (66.8)	71(33.2)	2.287 (1), p = 0.130	141(65.9)	73(34.1)	0.280 (1), p = 0.597
c	130 (65.0)	70(35.0)	0.566 (1), p = 0.753	123(64.1)	69(35.9)	0.826 (1), p = 0.363
D	139 (66.5)	70(33.5)	1.089 (1), p = 0.297	144(64.9)	78(35.1)	0.517 (1), p = 0.472

Note. Values are n (% within triradius category for the given variable).

Table 5. t-tr patterns by gender (n, % within category)

Category	t-tr. _R		t-tr. _L	
	Female	Male	Female	Male
absent	11(64.7)	6(35.3)	9(52.9)	8(47.1)
t	125(63.5)	72(36.5)	133(65.2)	71(34.8)
t,t'	14(100.0)	0(0.0)	6(100.0)	0 (0.0)
t'	3(100.0)	0(0.0)	5(100.0)	0(0.0)
t''	0(0.0)	3(100.0)	0(0.0)	2(100.0)
Pearson χ^2	14.995 (4),		10.768 (4),	
(df),	p = 0.005		p = 0.029	
p				

4 and 5 present data on palmar triradii: the formula in females was: a > b > c > d > t, whereas in males it was: a > b > t > c=d. Additional triradii were rare in both genders.

Table 6. Palmar patterns (interdigital/hypothenar) on the right hand by gender (n, % within category)

Palmar Areas	Pattern	Female Count (%)	Male Count (%)	p-value
I Interdig.	Abs.	152(65.8%)	79(34.2%)	0.115
II Interdig.	L-d	14(63.6%)	8(36.4%)	0.756
III Interdig.	Abs	120(72.7%)	45(27.3%)	<0.001
IV Interdig.	L-d	31(100.0%)	0(0.0%)	<0.001
Hypothenar	Abs.	132(68.8%)	60(31.2%)	0.010

The Pearson χ^2 analysis confirmed that while some areas (I and II interdigital) were relatively with the same patterns among genders, the III, IV, and hypothenar areas were key markers for gender differentiation.

III Interdigital Area (p<0.001): A highly significant statistical difference was observed. The W (Whorl) pattern was present in the male group but entirely absent among the females in this sample.

IV Interdigital Area (p<0.001): This region represented the most striking gender-based difference. The L-d (Loop distal) pattern was identified in 31 female participants, whereas it was not recorded (0.0) among male participants (Table 6).

Hypothenar (p=0.010): This area also demonstrated significant differentiation. Patterns such as the A (Arch) appeared exclusively in males, while the L-u (Loop ulnar) was significantly more frequent in females.

I and II Interdigital Areas: The differences in these regions were not statistically significant (p=0.115 and p=0.756, respectively), suggesting that these areas shared similar dermatoglyphic characteristics in genders (Table 7).

Table 7. Palmar patterns (interdigital/hypothenar) on the left hand by gender (n, % within category)

Palmar Areas	Pattern	Female Count (%)	Male Count (%)	p-value
I Interdig.	Abs.	153(65.7%)	80(34.3%)	0.168
II Interdig.	L-d	6(42.9%)	8(57.1%)	0.068
III Interdig.	Abs.	126(70.8%)	52(29.2%)	0.002*
IV Interdig.	L-d	24(100.0%)	0(0.0%)	<0.001*
Hypothenar	Abs.	137(68.5%)	63(31.5%)	0.011*

The Pearson χ^2 analysis confirmed that some areas were relatively with the same patterns among genders.

Strict gender dimorphism was found in the fourth interdigital space: just like the right hand, the L-d pattern on the left hand was found only in females (100%), making it a powerful gender discriminator in our group of participants.

Increased complexity in hypothenar area: the p-value of 0.011 reflects a significant difference, with females exhibiting a wider variety of rare loops (L-p and L-u) compared to males.

Significant difference was also found in the third interdigital space: the left hand showed a very high statistical significance ($p = 0.002$) for the ratio of pattern absence.

Table 8. Descriptive statistics for the atd angle in female participants

Variable	Min.	Max.	M	SD
Atd-angle_R	32.0	55.0	41.007	3.78
Atd-angle_L	32.0	55.0	40.821	3.65

Table 9. Descriptive statistics for the atd angle in male participants

Variable	Min.	Max.	M	SD
Atd-angle_R	35.00	50.00	41.06	3.81
Atd-angle_L	33.00	50.00	39.96	3.85

Tables 8 and 9 present the values for the atd angle; in females the angle ranged between 32° and 55° and in males it ranged between 33° and 50°. No significant difference between genders was observed.

Discussion

Numerous studies from various parts of the world involving different population groups have been published; we will discuss and compare our findings with some relevant studies.

Some studies on the Chinese population have observed an increased frequency of whorls and arches, whereas in the British population, a decrease in whorls and an increase in arches have been noted. In several studies, females exhibit narrower ridges, a higher frequency of arches, and fewer whorls, which aligns with our findings. Females also show a high frequency of hypothenar patterns and patterns in the fourth interdigital spaces; in our study males had more patterns in the hypothenar area.

Caucasian and Native American groups in the USA have shown a higher frequency of patterns in the hypothenar area. African populations and populations from Mongolia exhibited the highest frequency of patterns in the fourth interdigital space. Regarding the thenar area and first interdigital space, patterns are most prevalent among Americans; in the second interdigital space, they are most frequent among individuals of the Black race; and in the third interdigital space, among Europeans - findings that correspond with our results^[13,14].

Results from an Indian population study (2025) were consistent with our findings: loops were the most common pattern in both males (58.89%) and females (62.8%). In males, whorls (24.63%) were the second most frequent pattern, and similarly, in females, whorls (20.88%) held the second position. Arches were the least prevalent pattern in both genders: 2.41% in males and 7.19% in females^[15]. Data from Northeast Indian populations also showed that the most common pattern was the loop (males: 64.33%; females: 75.00%), followed by whorls (males: 31.00%; females: 21.33%), and finally arches (males: 4.67%; females: 3.66%), which is consistent with our study. No significant gender differences were found in pattern types. The Pattern Intensity Index (P.I.I.), Dankmeijer's Index (D.I.), and Furuhashi's Index (F.I.) were 14.08, 12.60, and 96.06, respectively^[16].

In a study from Australia, fingerprints of 114 Aboriginal men and 90 women were analyzed. Whorls were more frequent in males (56.7%) than in females (51.2%), while loops

were less frequent in males (42.6%) than in females (47.0%). The P.I.I. showed a higher value in males (15.60) than in females (14.94). Bimanual differences in both genders were not statistically significant regarding pattern occurrence on the right and left hands. The incidence of true symmetry on homologous fingers was 74.0% in males and 77.3% in females^[17].

A study of 200 male and 200 female healthy volunteers from an ethnic group in Nigeria was conducted to determine digital dermatoglyphic traits. Ulnar loops were the most dominant digital pattern, occurring more in females (50.1%) than in males (39.6%), followed by whorls (42.9%) in males, arches (31.1%) in females, and radial loops (2.1%) in males, which is in line with our results. Gender differences between some patterns were statistically significant detected with chi-square tests. The P.I.I. was higher in males (15.13) than in females (11.88)^[18].

Extensive research has also been conducted for populations in the Balkans^[10] and Europe. In some studies, males tend to have a higher frequency of whorls, while females demonstrate a higher frequency of ulnar loops. In most studies, loops are the most prevalent pattern, followed by whorls, while arches are the least present – findings that align with our study. In studies involving European, Bulgarian, and Russian populations, the P.I.I. showed minor differences between genders, for e.g. 12.74 in males and 12.03 in females. In the Russian population, P.I.I. values were reported as 13.14 and 12.56 for males and females, respectively^[19].

A cross-sectional quantitative study was conducted in the King Faisal University, Saudi Arabia. A total of 122 participants were selected using systematic or stratified random sampling. Dermatoglyphic data were collected using digital biometric scanners. Ridge counts, pattern types, atd angles, and palmar crease morphology were analyzed. Data were analyzed with descriptive statistics, chi-square tests, t-tests and correlation analyses. Statistical significance was set at $p < 0.05$. Loops were the most frequent dermatoglyphic pattern (60.7%), followed by whorls (28.7%) and arches (10.6%), which is in agreement with our results. Atd angles were $45.0^\circ \pm 4.5$ ($p = 0.031$)^[20].

Conclusion

Dermatoglyphic patterns are strongly influenced by genetic polymorphisms and prenatal biochemical factors, highlighting their potential as non-invasive biomarkers for forensic and genetic profiling. Multifactorial nature of dermatoglyphic development support their utility in biomedical and forensic applications.

During medical education, dermatoglyphics and the study of epidermal ridges that form different patterns are addressed only briefly; therefore, it is our hope that the publication of the results of this study will contribute to the regional anthropometric database, popularization and further development of dermatoglyphic research.

Conflict of interest statement. None declared.

References

1. Gilman S. Joint position sense and vibration sense: anatomical organization and assessment. *J of Neurolog Neurosurg and Psychiatry* 2002; 73(5): 473-477. doi: 10.1136/jnnp.73.5.473.
2. Babler WJ. Embryological development of epidermal ridges and their configurations. 1991; 27(2): 95-112. PMID: 1786361.
3. Tuthill Harold FCIS. Individualization: Principles and procedures in Criminalistics, Lightning Powder Company. Inc salem Oreg 1994: 1-15.
4. Cummnis H, Midlo C. Palmar and plantar epidermal ridge configurations (dermatoglyphics) in European-Americans. *Am J Phys Anthropol* 1926; 9: 471-502. <https://doi.org/10.1002/ajpa.1330090422>Digital Object Identifier (DOI)

5. Gutiérrez E, Galera V, Martínez JM, Alonso C. Biological variability of the minutiae in the fingerprints of a sample of the Spanish population. *Forensic Sci Int* 2007; 172(2-3): 98-105. doi: 10.1016/j.forsciint.2006.12.013.
6. Cummins H, Midlo C. "Finger prints, Palms and Soles" An introduction to dermatoglyphics New York: Dover Publications, 1961.
7. Mathew L, Hegde AM, Rai K. Dermatoglyphic peculiarities in children with oral clefts. *J Indian Soc Pedod Prev Dent* 2005; 23(4): 179-182. doi: 10.4103/0970-4388.19005.
8. Wilder HH. Racial differences in palm and sole configuration. *Am Anthropol* 1904; 6: 244-292.
9. Wilder HH. Palm and Sole studies. *Biol Bull* 1916; 30: 135-172 и 211-252.
10. Kumbhani HK. Dermatoglyphics: A Review. *Anthropologist Special* 2007; 3: 285-95.
11. Almirall J, Furton Kenneth G. Trends in forensic science education: expansion and increased accountability. *Anal Bioanal Chem* 2003; 376(8): 1156-1159. doi: 10.1007/s00216-003-1891-1894.
12. McRoberts AL. Nature Never Repeats Itself. *The Print* 1996; 12(5): 1-3.
13. Bhat GM. Dermatoglyphics: in health and disease - a review. *Int J Res Med Sci* 2014; 2(1): 31-37. doi: 10.5455/2320-6012.ijrms20140207
14. Uchida IA, Patau K, Smith DW. Dermal pattern of 18 and D1 trisomies. *Am J of Human Genetics* 1996; 14(4); 345-352. PMID: 13995080.
15. Boruah A. A study on digital dermatoglyphics among indigenous Assamese populations of Assam. *International Journal of Research in Medical Sciences* 2025; 13(8): 3259-3265. doi: <https://doi.org/10.18203/2320-6012.ijrms20252392>.
16. Dorjee B, Das S, Mondal N, Sen J. Dermatoglyphic variation among the Limboo of Sikkim, India. *J of Compar Human Biol-HOMO* 2015; 66(5): 455-470. doi: 10.1016/j.jchb.2015. 02.010.
17. Ching Choo. Finger Dermatoglyphics of Australian Aborigines in the Northern Territory of Australia. *Korean J Biol Sci* 2000; 4(1): 91-94.
18. Ekanem E, Eluwa M, Udoaffah G, Ekanem T, Akpantah A. Digital Dermatoglyphic Patterns Of Annang Ethnic Group In Akwa Ibom State Of Nigeria. *The Internet Journal of Biological Anthropology* 2008 ;Vol 3: (1): 1-4.
19. Sheil HG, Shmidt HD, Baltova S, Djodjevic D, Vulpe C, Efremovska LJ. Dermatoglyphic studies in Eastern and South-Eastern Europe. *Anthropologischer Anzeiger* 2006; 63(4): 393-399. PMID: 16402589.
20. Ayesha Pervez, Ayub F, et al. Biochemical and Genetic Determinants of Dermatoglyphic Patterns: An Anatomical Basis for Forensic and Genetic Profiling. 2025; ISSN: 0513-4870, Vol. 60 (04).