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Original Research Article

A study on digital dermatoglyphics among indigenous Assamese populations of Assam

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ABSTRACT

Background: Dermatoglyphic patterns are among the most distinctive and reliable features of the human body. Their uniqueness plays a vital role in forensic investigations, as no two individuals have identical fingerprints. These patterns also reflect racial, ethnic, and gender differences and can assist in diagnosing certain congenital disorders.
Methods: The present study was conducted on 222 students from indigenous Assamese populations, aged 18–22 years, to examine the frequency distribution of fingerprint patterns, identify the most and least prevalent types, and assess inter- and intra-population variations. Fingerprint impressions of both hands were collected and classified using Henry's classification system. Additionally, pattern intensity index, Dankmeijer's index, and Furuhata's index were calculated.
Results: The results showed that loops were the most common pattern in both males (58.89%) and females (62.8%). In males, whorls (24.63%) were the second most common, while in females, composites (20.88%) ranked second. Arches were the least common in both sexes—2.41% in males and 7.19% in females. Significant sex-based differences were observed in the distribution of whorls and composites. Among the indices, the pattern intensity index (10.76) and Furuhata's index (41.82) were higher in males, while Dankmeijer's index was higher in females (78.84).
Conclusions: The study identifies loops as the most common fingerprint pattern and arches as the least common.

Keywords: Digital dermatoglyphics, Dermatoglyphic pattern indices, Indigenous Assamese populations, Assam, India

INTRODUCTION

Dermatoglyphics refers to the scientific study of fingerprints and ridge characteristics, which enable efficient classification and examination. The development of these ridges begins along the basement membrane and becomes visible in histological foetal preparations between the 12th and 16th weeks of embryonic development, with formation typically completed by the 14th week.[1,2] Once formed, these ridge patterns remain unchanged throughout an individual's life, unless altered by injury or decomposition after death.

The dermatoglyphics pattern is one of the most interesting, reliable, and unique features of the human body. No two fingerprints are exactly alike. Consequently, the study of dermatoglyphics plays a crucial role in suspect identification or elimination in criminal investigations, establishing its importance not only in forensic science but also in medicine, biological anthropology, ethnology and population genetics.

Dermatoglyphic patterns have been shown to exhibit considerable variation among different populations and ethnic groups. These patterns not only reflect genetic and racial distinctions but also assist in individual identification and gender differentiation.

Given this wide applicability, dermatoglyphic analysis has become a valuable tool in forensic investigations. When a fingerprint is found at a crime scene, the primary step is pattern classification, which can help narrow the suspect pool by excluding individuals with differing fingerprint patterns. Matching minutiae becomes a secondary step in

the identification process. This classification-based approach helps reduce the workload of investigators by enabling early-stage suspect filtering.

In addition to forensic applications, dermatoglyphics research also plays a crucial role in detecting hereditary abnormalities by revealing predispositions to various congenital and genetic disorders.[3,4] Specific dermatoglyphic features such as an increased prevalence of arches and a single transverse palmar crease are indicative of chromosomal anomalies like Patau syndrome.[5,6] Similarly, Turner syndrome often presents with a dominant pattern of whorls while a lower A-B ridge count has been correlated with schizophrenia.[7,8]

Over the years, various researchers have explored the distribution of fingerprint patterns across diverse various populations and ethnic groups. In line with this, the present study was conducted to determine the frequency distribution of different fingerprint patterns, identify the most and least predominant types, and investigate the presence of any statistically significant gender differences within the studied population.

METHODS

The present study was a cross-sectional study conducted on a total of 222 students (108 males and 114 females) from North Gauhati College, Assam, India, belonging to indigenous Assamese populations, namely Koch Rajbongshi, Kalita, Yogi, Kaibartta, and Brahmin communities. The participants were aged between 18 and 22 years. Data collection was carried out in the Physical Anthropology Laboratory of North Gauhati College, Assam. Prior to participation, all students were informed about the purpose and nature of the study, and data were collected only from those who voluntarily agreed to participate as subjects.

Participants with any history of chronic illness, physical deformities, recent injuries, or visible abnormalities affecting the palmar surface of the hand were excluded to ensure data reliability and consistency.

Before fingerprint collection, subjects were instructed to wash and thoroughly dry their hands. After a waiting period of five minutes, they were guided step-by-step to provide rolled finger impressions. Thumb impression ink (Kores India) was evenly spread on a glass slab using a cotton roller. With arms relaxed, participants were asked to roll their fingertips over the ink slab and then carefully, slowly, and sequentially press them onto the designated spaces of a standard 10-digit fingerprint identification form. Care was taken to avoid any external pressure during the process to prevent smudging. All fingerprints were obtained only in the respective spaces provided on the form.

The fingerprint impressions thus obtained were classified by using Henry's classification system. The prints were categorized into the following major types and subtypes: arches, loops, whorls, and composites.

Arch patterns are the simplest form, where ridges flow continuously from one side of the finger to the other without forming loops or backward turns. These patterns generally lack a delta and are further divided into two types: plain arch, where ridges flow smoothly, and tented arch, which features a sharp up-thrust or spike at the center. Loop patterns are the most common and are characterized by one or more ridges entering from one side of the impression, recurving, and exiting on or near the same side. Loops contain one delta and are divided into ulnar loops (opening toward the little finger) and radial loops (opening toward the thumb). Whorl patterns consist of ridges that form at least one complete circuit and always contain two or more deltas. They can be classified into concentric whorls, where ridges form circular rings, and spiral whorls, where ridges spiral around the core in a clockwise or anticlockwise direction. Composite patterns are combinations of two or more different fingerprint types and include central pocket loops (containing a smaller pocket within a loop), twin loops (a double loop pattern formed by two loops overlapping or surrounding each other), lateral pocket loops (ridges arising from each core open toward the opposite margin of the finger), and accidental whorls (representing a combination of two or more of the above configurations).

Three pattern indices *viz.* pattern intensity index, arch/whorl index of Dankmeijer, and whorl/loop index of Furuhata were calculated as follows.[9-12]

$$Pattern\ intensity\ index = (2 \times \%\ whorl + \%\ loop) \div 2$$

$$Arch/whorl\ index\ of\ Dankmeijer = (\%\ arches \div \%\ whorl) \times 100$$

$$Whorl/loop\ index\ of\ Furuhata = (\%\ whorl \div \%\ of\ loop) \times 100$$

The t-test was performed to assess statistically significant gender differences in fingerprint pattern distribution. A p value of <0.05 was considered statistically significant.

RESULTS

The present study comprises 2220 finger prints from 222 students (male-108 and female-114) belongs to indigenous Assamese population (Koch Rajbongshi, Kalita, Yogi, Kaibartta, Brahmin) of age group 18 to 22 years. The findings reveal that loops are the most prevalent fingerprint pattern in both males (58.89%) and females (62.81%). Among males, the second most common pattern is whorl (24.63%), whereas in females, it is the composite pattern (20.88%). The arch pattern shows the lowest frequency in both sexes, with 2.41% in males and 7.19% in females (Tables 1 and 2).

Table 1: Digit wise distribution of finger print patterns in male.

Finger print patterns	Left hand										Right hand										Both hand		Grand total	
	Little		Ring		Middle		Index		Thumb		Little		Ring		Middle		Index		Thumb					
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Arch																								
Plain	5	4.63	1	0.93	1	0.93	1	0.93	2	1.85	1	0.93	1	0.93	1	0.93	2	1.85	0	0	15	1.39	26	2.41
Tented	2	1.85	0	0.00	2	1.85	5	4.63	0	0.00	0	0.00	0	0.00	0	0.00	2	1.85	0	0	11	1.02		
Loop																								
Radial	3	2.78	1	0.93	1	0.93	8	7.41	0	0.00	1	0.93	1	0.93	1	0.93	6	5.56	1	0.93	23	2.13	636	58.89
Ulnar	71	65.74	56	51.85	66	61.11	53	49.07	62	57.41	76	70.37	46	42.59	75	69.44	55	50.93	33	30.56	613	56.76		
Whorl																								
Concentric	5	4.63	5	4.63	5	4.63	3	2.78	6	5.56	5	4.63	12	11.11	4	3.70	8	7.41	14	12.96	67	6.20	266	24.63
Spiral	9	8.33	30	27.78	17	15.74	24	22.22	11	10.19	12	11.11	34	31.48	16	14.81	23	21.30	43	39.81	199	18.43		
Composite																								
Central pocket	9	8.33	12	11.11	9	8.33	7	6.48	5	4.63	13	12.04	12	11.11	8	7.41	6	5.56	4	3.70	85	7.87	152	14.07
Laterial pocket	2	1.85	0	0.00	0	0.00	1	0.93	2	1.85	0	0.00	1	0.93	0	0.00	1	0.93	1	0.93	8	0.74		
Twinned	2	1.85	3	2.78	7	6.48	6	5.56	18	16.67	0	0.00	1	0.93	2	1.85	5	4.63	11	10.19	55	5.09		
Accidental	0	0	0	0.00	0	0.00	0	0.00	2	1.85	0	0.00	0	0.00	1	0.93	0	0.00	1	0.93	4	0.37		
Total	108	100	108	100	108	100	108	100	108	100	108	100	108	100	108	100	108	100	108	100	1080	100	1080	100

Table 2: Digit wise distribution of finger print patterns in female.

Finger print patterns	Left hand										Right hand										Both hand		Grand total	
	Little		Ring		Middle		Index		Thumb		Little		Ring		Middle		Index		Thumb					
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Arch																								
Plain	6	5.26	4	3.51	8	7.02	8	7.02	6	5.26	2	1.75	2	1.75	0	0.00	4	3.51	2	1.75	42	3.68	82	7.19
Tented	0	0.00	4	3.51	4	3.51	10	8.77	8	7.02	2	1.75	0	0.00	0	0.00	8	7.02	4	3.51	40	3.51		
Loop																								
Radial	2	1.75	0	0.00	0	0.00	2	1.75	2	1.75	2	1.75	2	1.75	2	1.75	0	0.00	0	0.00	12	1.05	716	62.81
Ulnar	80	70.18	52	45.61	82	71.93	62	54.39	56	49.12	86	75.44	54	47.37	98	85.96	72	63.16	62	54.39	704	61.75		
Whorl																								
Concentric	6	5.26	0	0.00	2	1.75	4	3.51	24	21.05	0	0.00	4	3.51	0	0.00	0	0.00	14	12.28	54	4.74	104	9.12
Spiral	2	1.75	8	7.02	4	3.51	4	3.51	2	1.75	4	3.51	10	8.77	6	5.26	6	5.26	4	3.51	50	4.39		
Composite																								

Continued.

Finger print patterns	Left hand										Right hand										Both hand		Grand total	
	Little		Ring		Middle		Index		Thumb		Little		Ring		Middle		Index		Thumb					
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Central pocket	6	5.26	24	21.05	6	5.26	14	12.28	10	8.77	4	3.51	22	19.30	8	7.02	16	14.04	18	15.79	128	11.23		
Laterial pocket	11	9.65	20	17.54	7	6.14	10	8.77	4	3.51	13	11.40	20	17.54	0	0.00	8	7.02	8	7.02	101	8.86	238	20.88
Twinned	0	0.00	2	1.75	0	0.00	0	0.00	2	1.75	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	0.35		
Accidental	1	0.88	0	0.00	1	0.88	0	0.00	0	0.00	1	0.88	0	0.00	0	0.00	0	0.00	2	1.75	5	0.44		
Total	114	100	114	100	114	100	114	100	114	100	114	100	114	100	114	100	114	100	114	100	1140	100	1140	100

Table 3: Frequency of digital dermatoglyphic patterns of fingers in descending order.

Pattern	Sex	Hand	Order
Arch	M	Right	II(3.70%)> III/IV/V (0.93%)> I (0%)
	M	Left	V(6.48%)> II(5.56%)> III(2.78%)> I(1.85%)> IV(0.93%)
	F	Right	II(15.8%)> I(12.3%)> III(10.5%)> IV(7.92%)> V(5.26%)
	F	Left	II(10.5%)> I(5.26%)> V(3.51%)> IV(1.75%)> III(0%)
Loop	M	Right	IV(70.37%)> I(58.89%)> III(56.48%)> V(43.52%)> II(31.48%)
	M	Left	V(68.52%)> III(62.04%)> I(57.41%)> II(56.48%)> IV(52.78%)
	F	Right	III(87.7%)> V(77.2%)> II(63.2%)> I(54.4%)> IV(49.1%)
	F	Left	V/III(71.9%)> II(56.1%)> I(50.9%)> IV(45.6%)
Whorl	M	Right	I(53.8%)> IV(42.6%)> II(28.7%)> III(18.5%)> V(15.7%)
	F	Left	IV(32.4%)> II(25%)> III(20.4%)> I(15.7%)> V(13%)
	F	Right	I(15.8%)> IV(12.3%)> II/III(5.26%)> V(3.51%)
	F	Left	I(22.8%)> II/IV/V(7.02%)> III(5.26%)
Composite	M	Right	I(25%)> III(14.8%)> IV(13.9%)> II(13%)> V(12%)
	M	Left	I(15.7%)> IV(13%)> V(12%)> II(11.1%)> III(10.2%)
	F	Right	IV(36.8%)> I(24.6)> II(21.1%)> V(15.8%)> III(7.02%)
	F	Left	IV(40.4%)> II(21.1%)> V(15.8%)> I(14%)> III(12.3%)

The sub-classification of fingerprint patterns reveals that the loop pattern is the most frequently observed type, with the ulnar loop being more dominant than the radial loop in both males and females. Regarding gender differences, the prevalence of the ulnar loop is higher in females (61.75%) compared to males (56.76%) (Tables 1 and 2).

The whorl pattern is observed more frequently in males (24.63%) compared to females (9.12%). Among males, the spiral whorl type is more prevalent (18.43%), whereas in females, the concentric whorl type is slightly more common (4.74%). The composite pattern is more frequently seen in females (20.88%) than in males (14.07%). Within the composite category, the central is the most common subtype in both males (7.87%) and females (11.23%), followed by the twin loop (5.09%), lateral pocket loop (0.74%), and accidental loop (0.37%) in males, and the lateral pocket loop (8.86%), accidental loop (0.44%), and twine loop (0.35%) in females. The arch pattern also shows a higher prevalence in females (7.19%) than in males (2.41%), with the plain arch type being the most common subtype in both males (1.39%) and females (3.68%) (Tables 1 and 2).

The decreasing order of digital dermatoglyphic pattern types reveals that the arch pattern shows the highest prevalence in the index finger of both hands in females (right: 15.8%, left: 10.5%) and in the right index finger of males (3.70%). Similarly, the whorl pattern is most frequently observed in the thumb of both hands in females (left: 22.8%, right: 15.8%) and particularly in the right thumb of males (53.8%). Notably, the frequency of whorl in the right thumb of males represents the highest occurrence among all digit types.

The loop pattern is most prevalent in the middle finger of females (87.7%). In females, the highest loop frequencies are observed in the middle of the right hand (87.7%) and the middle and little fingers (71.9%) of the left hand. In contrast, among males, the ring finger of the right hand (70.37%) and the little finger of the left hand (68.52%) exhibit the highest loop pattern frequencies.

The composite pattern is more commonly found in the thumb of males (right: 25%, left: 15.7%) and in the ring finger of females (left: 40.4%, right: 36.8%) (Table 3).

The analysis of various dermatoglyphic indices in the present study reveals that the values of the pattern intensity index (10.76) and Furuhata index (41.82) are higher in male. In contrast, the Dankmeijer's index is found to be higher in females (78.84) (Table 4).

The statistical analysis of fingerprint patterns reveals that, except for the arch pattern (p=0.5645), there is a significant difference between males and females in the distribution of loop (p=0.016739), whorl (p=0.00001), and composite (p=0.0000) patterns.

Table 4: Distribution of finger print pattern indices in Indian populations.

Population	Gender	Pattern intensity index	Dank-meijer's index	Furuh-ata's index
Present study	Male	10.76	9.78	41.82
	Female	8.11	78.84	14.52
	M+ F	9.44	44.31	28.17
Rengma Nagas of Nagaland (India)[17]	Male	1.54	0.14	
	Female	1.56	3.34	
	M+ F	0.47	1.47	
Dhimals of North Bengal[18]	Male	15.24	4.98	130.7
	Female	14.86	3.13	104.07
	M+ F	15.05	4.1	116.49
Muslims (Central India)[19]	Male	10.87	12.42	53.80
	Female	10.38	19.15	57.77
	M+ F	10.63	15.79	55.72
Rajputs (India)[14]	Male	14.70	4.08	100
	Female	15.00	3.41	118
	M+ F	14.85	3.73	109

Table 5: Distribution of finger print patterns in various populations of India.

Population	Gender	Pattern intensity index	Dankme-ijer's index	Furu-hata's index
Present study	Male	10.76	9.78	41.82
	Female	8.11	78.84	14.52
	M+ F	9.44	44.31	28.17
Rengma Nagas of Nagaland (India)[17]	Male	1.54	0.14	
	Female	1.56	3.34	
	M+ F	0.47	1.47	
Dhimals of North Bengal[18]	Male	15.24	4.98	130.7
	Female	14.86	3.13	104.07
	M+ F	15.05	4.1	116.49
Muslims (Central India)[19]	Male	10.87	12.42	53.80
	Female	10.38	19.15	57.77
	M+ F	10.63	15.79	55.72
Rajputs (India)[14]	Male	14.70	4.08	100
	Female	15.00	3.41	118
	M+ F	14.85	3.73	109

DISCUSSION

In the present study, a total of 2,220 finger prints were collected and classified using Henry's classification system. The analysis revealed that loops are the most common fingerprint pattern, while arches are the least frequent. When compared with findings from other Indian populations using the major classification categories (Loop, Whorl, and Arch), the results show similarities with populations such as South Indians, Rajputs, Rarhi

Brahmins, and the Danguri Tharu of Uttar Pradesh, all of which also reported loops as the most prevalent pattern.[13-16]

However, contrasting results have been observed among the Rengma Naga of Nagaland and the Dhimals of North Bengal where whorls were reported as the most common pattern, followed by loops and arches in both males and females.[17,18]

The pattern intensity index, Dankmeijer's index, and Furuhata's index are important dermatoglyphic measures with significant biological and forensic relevance. The Pattern Intensity Index reflects the overall complexity of fingerprint patterns by assigning values to arches, loops, and whorls. A higher index indicates a greater presence of genetically complex patterns, making it useful in population genetics for studying hereditary influences and genetic diversity. Dankmeijer's Index compares the frequency of the simplest (arches) and more complex (whorls) patterns, helping to reveal inter-population variation and evolutionary trends. It provides insight into the genetic background of different ethnic groups. Furuhata's index, which measures the balance between whorls and loops, is particularly informative in comparing genetic traits across populations. These indices assist forensic experts in classifying population affinity, supporting criminal investigations and personal identification when other data are lacking. They are also valuable in anthropological and biometric studies, helping track migration patterns, genetic drift, and admixture.

In the present study, three dermatoglyphic indices - pattern intensity index, Dankmeijer's index and Furuhata's index were also calculated and compared with earlier research on Indian populations. The pattern intensity index in this study aligns with the findings among the Dhimals of West Bengal and the Muslims of Central India, where males showed higher values than females.[18.19] However, populations such as the Rengma Naga and Rajputs showed slightly differing results.[14,17]

Regarding Dankmeijer's index, the current findings are consistent with those of the Rengma Naga and the Muslims of Central India, which also showed a higher index in females.[17,19] For Furuhata's index the present study aligns only with the Dhimals of North Bangal.[19]

CONCLUSION

The present study highlights significant variations in fingerprint pattern distribution and dermatoglyphic indices among the indigenous Assamese populations. Loops emerged as the most dominant pattern, while arches were the least common, consistent with findings from several other Indian populations. However, notable deviations were observed when compared with groups such as the Rengma Naga and Dhimals, underscoring the influence of ethnic and regional diversity on dermatoglyphic traits.

The analysis of pattern indices further reinforces gender-based differences, with males showing higher values for the pattern intensity and Furuhata's indices, and females exhibiting a higher Dankmeijer's index. These results not only support earlier findings in select Indian communities but also contribute new comparative data for the Assamese populations.

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