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Decoding the Science of Fingerprints: The Influence of Sex and Blood Group on Dermatoglyphic Traits among Medical Students

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ABSTRACT: ***Background:*** Fingerprint or dermatoglyphics is the study of the patterns of dermal ridges and bridges on the volar surfaces of the fingers, palms, and soles. Fingerprint ridge patterns begin to form between the 12th and 16th weeks of intrauterine life and are fully developed by the 24th week. Fingerprints exhibit a vast range of possible variations, with the probability of two individuals having identical fingerprints estimated at one in sixty-four billion. Even identical twins have distinct fingerprints. ***Materials and methods:*** This descriptive cross-sectional study aimed to explore the relationship between sociodemographic factors (age, gender, blood group and handedness) in medical students through fingerprint analysis. Conducted at North Bengal Medical College, the study included 390 undergraduate students from the 1st to 5th year, selected using census sampling. Inclusion criteria included students willing to participate and provide accurate sociodemographic information. Exclusion criteria included graduate students, those with skin conditions affecting fingerprint analysis, and those who did not consent. Data was collected using a structured questionnaire and fingerprint analysis. Descriptive statistics and the Chi-square test were used for analysis. Ethical approval was obtained from the Institutional Review Board (IRB) before the study. ***Result:*** The sociodemographic profile of 390 medical students revealed a mean age of 21.95 years, with 58% females and 42% males. Most students were right-handed (95.9%), and blood group B+ was the most common (36.7%). Fingerprint analysis showed that whorls were the predominant pattern across all fingers, with variations in distribution by sex and blood group. Significant sex differences were found in fingerprint patterns, with males exhibiting more whorls and females showing higher frequencies of arches and radial loops. Blood group associations were observed for both hands, with B+ and O+ blood groups showing stronger links to whorl patterns. Chi-square tests revealed significant associations between fingerprint patterns and blood groups for both hands ($p < 0.05$), suggesting a genetic correlation between these traits. ***Conclusion:*** In conclusion, this study highlights significant associations between sociodemographic factors, including sex and blood group, and fingerprint patterns in medical students. The findings suggest that fingerprint patterns, particularly whorls, are influenced by genetic factors related to blood groups and sex differences. These results contribute to the understanding of the genetic underpinnings of fingerprint formation and may provide valuable insights for future research in the field of biometrics and genetic traits.

Keywords: Suicide, Elderly Deaths, Cause of Death, Socio-Economic Status, Physical Illness, Mental Illness.

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INTRODUCTION

Fingerprint or dermatoglyphics is the study of the patterns of dermal ridges and bridges on the volar surfaces of the fingers, palms, and soles.[1] The development of fingerprints is influenced by both genetic factors and environmental or accidental factors that create tension during the development process. Fingerprint ridge patterns begin to form between the 12th and 16th weeks of intrauterine life and are fully developed by the 24th week.

Fingerprints exhibit a vast range of possible variations, with the probability of two individuals having identical fingerprints estimated at one in sixty-four billion. Even identical twins have distinct fingerprints. Any disruptions in intrauterine growth that affect the extremities can lead to abnormal fingerprint patterns. These disturbances may arise from either hereditary or environmental factors.[1-5] Fingerprinting is commonly used as an efficient and cost-effective method of identification. The impressions left by fingerprints are referred to as fingerprint patterns. The skin on the fingers is made up of raised areas (ridges) and recessed areas (grooves). Fingerprints are influenced by a variety of factors, including genetic, environmental, and regional factors.[6-8] Individuals can be identified through various features such as their face, height, body shape, gait, voice, and sex. Among these, sex is one of the most significant characteristics for distinguishing individuals. Researchers have explored the use of fingerprints for gender identification, which can be particularly useful for narrowing down suspects.

In recent years, an increasing number of civilian and commercial applications are either utilizing or actively considering fingerprint-based identification. This is due to the availability of affordable and compact solid-state scanners, as well as the technology's proven superior performance in matching compared to other biometric methods.[9] People may show similar variations in their interests, values, desires, and motivations because of systematic differences in how they perceive things and the conclusions they draw. They may also vary in what they excel at and what they enjoy doing the most. The indicator follows this idea and seeks to identify individuals' core preferences for perception and judgment through self-reported reactions, aiming to understand how these preferences interact with one another in their daily lives.[10] Even in monozygotic twins, dermatoglyphics (fingerprints) remain consistent and unique from birth to death. A person's fingerprint serves as a distinct form of identification, being a permanent and individualized trait that is highly detailed and difficult to alter. Similarly, a person's blood type is a biological characteristic that stays the same throughout their life.[11-13] In psychology, one of the most significant efforts has been the measurement of intelligence, which plays a crucial role not only in an individual's life but also in society. Compared to individuals with high IQs, those with low IQs may face difficulties in acquiring, thinking about, and processing new information and knowledge. These individuals may require additional care, education, and medical services, with the need for ongoing support throughout their lives. This is especially true for those with low IQs linked to genetic abnormalities, as they often struggle to achieve personal independence. It is believed that approximately 50% of these challenges have a prenatal origin.[14]

Aims and Objectives

To examine the relationship between sociodemographic factors (age, gender, socioeconomic status, and blood group) and fingerprints in medical students.

MATERIALS AND METHODS

Study Design

This is a descriptive cross-sectional study designed to explore the relationship between sociodemographic factors (age, gender, blood group and handedness) in medical students, through fingerprint analysis. The study was conducted at North Bengal Medical College, located at J.C. Road, Dhanbandhi, Sirajganj. Census sampling was used to include all undergraduate medical students from 1st to 5th years of the college. The study population consisted of 390 undergraduate medical students from the 1st to 5th year of North Bengal Medical College.

Inclusion Criteria

1. Medical students enrolled in the 1st to 5th years at North Bengal Medical College.
2. Students who voluntarily consent to participate in the study.
3. Students who were willing to provide accurate sociodemographic information and undergo fingerprint analysis.

Exclusion Criteria

1. Medical students do not enroll in the undergraduate program (e.g., graduate or postgraduate students).
2. Students who refused to participate or provided incomplete data.
3. Students with any known skin conditions or physical conditions that may interfere with fingerprint analysis.

4. Students who did not provide informed consent.

Data Collection Method

Data was collected using a structured questionnaire, which included questions related to sociodemographic factors (such as age, gender, handedness, and blood group). The fingerprint analysis was performed using a standard method of collecting and analyzing fingerprints. Before data collection began, participants were briefed about the study's objectives and were provided with an informed consent form to sign. The principal investigator then administered the structured questionnaire to all eligible students. Fingerprint patterns were recorded using standardized equipment, and participants were asked to provide their blood group information. The study involved 390 participants, each providing their name, age, and gender. The participants were instructed to clean their hands using tap water and soap, then dry them to remove any dirt. Following this, they were asked to roll their fingertip pads on a forensic fingerprint ink pad, ensuring even ink application on the finger's tip by rolling the thumb towards the body while keeping the other fingers out. The fingerprints were then rolled onto paper from the outside to the inside, capturing the full fingerprint impression (using the ink method by Cummins and Midlo). If any prints were deemed undesirable, the procedure was repeated. The resulting fingerprint patterns were categorized into loops, whorls, arches, or composite forms, using a magnification lens for better clarity. Following data collection, the information underwent a process of scrutiny for accuracy, after which it was compiled and organized. The data were then presented for statistical analysis. A professional data manager conducted statistical analysis using statistical software. Statistical analysis was performed using the χ^2 test and p-value. Data analysis was conducted using SPSS software (version 23). Descriptive statistics, including mean, standard deviations, and frequencies, were used to summarize sociodemographic characteristics and psychological traits. The Chi-square test was applied to examine associations.

RESULTS

The sociodemographic profile of the 390 students in this research reveals several key characteristics. The participants have a mean age of 21.95 years, indicating that the sample primarily consists of young adults. In terms of sex distribution, there is a higher proportion of female students (58%) compared to male students (42%). When considering handedness, the majority of participants (95.9%) are right-handed, with a small percentage (4.1%) being left-handed, and no participants identified as ambidextrous. Blood group distribution shows diversity, with the most common blood group being B+ (36.7%), followed by O+ (24.4%), A+ (20.5%), and AB+ (12.8%). A smaller proportion of students have the blood groups A- (2.3%), B- (0.8%), AB- (0.8%), and O- (1.8%) shown in Table 1.

Table 1: Sociodemographic Pattern of Students

Variables	Frequency n= 390 (%)
Mean age	21.9487
Sex	
Male	146 (42)
Female	226 (58)
Handedness	
Right-handed	374 (95.9)
Left-handed	16 (4.1)
Ambidextrous	0
Blood group	
A+ve	80 (20.5)
A-ve	9 (2.3)
B+ve	143 (36.7)
B-ve	3 (0.8)
AB+ve	50 (12.8)
AB-ve	3 (0.8)
O+ve	95 (24.4)

O-ve	7 (1.8)

The fingerprint patterns observed on both hands of the 390 participants reveal distinct trends across different fingers. For the thumb, whorls were the most common pattern on both the right (62.1%) and left (53.3%) hands, with radial loops more prevalent on the left hand (16.2%) compared to the right (7.9%). The index finger also exhibited a predominance of whorls, with 48.7% on the right and 47.9% on the left, while radial loops were more frequent on the left (16.9%) than on the right (10%). The middle finger displayed a higher percentage of whorls on the left (45.9%) than the right (43.3%), with a notable increase in radial loops on the left hand (22.6%) compared to the right (9.5%). For the ring finger, whorls were again the most common pattern, with 65.9% on the right hand and 61.3% on the left, while radial loops were more pronounced on the left hand (12.8%) compared to the right (6.2%). Lastly, the little finger showed a higher proportion of whorls on the right hand (49.2%) than the left (42.8%), while radial loops were more frequent on the left (25.6%) compared to the right (8.2%) shown in Table 2.

Table 2: Pattern of fingerprints on Both Hands

Finger	Right	Left
Thumb		
Whorls	242 (62.1)	208 (53.3)
Arches	75 (19.2)	72(18.5)
Ulnar loops	23 (5.9)	25(6.4)
Radial loops	31 (7.9)	63(16.2)
Composite	19 (4.9)	22(5.6)
Index finger		
Whorls	190 (48.7)	187 (47.9)
Arches	74 (19)	85 (21.8)
Ulnar loops	65 (16.7)	33 (8.5)
Radial loops	39 (10)	66 (16.9)
Composite	22 (5.6)	19 (4.9)
Middle finger		
Whorls	169 (43.3)	179 (45.9)
Arches	82 (21)	75 (19.2)
Ulnar loops	97 (24.9)	38 (9.7)
Radial loop	37 (9.5)	88 (22.6)
Composite	5 (1.3)	10 (2.6)
Ring finger		
Whorls	252 (65.9)	239 (61.3)
Arches	54 (13.8)	62 (15.9)
Ulnar loops	41 (10.5)	26 (6.9)
Radial loops	24 (6.2)	50 (12.8)
Composite	14 (3.6)	13 (3.3)
Little finger		
Whorls	192 (49.2)	167 (42.8)
Arches	72 (18.5)	62 (15.9)
Ulnar loops	71 (18.2)	31 (7.9)
Radial loops	32 (8.2)	100 (25.6)
Composite	23 (5.9)	30 (7.7)

For the right thumb, males and females predominantly exhibited whorl patterns (121). This difference was highly significant with a chi-square value of 31.701 (p=0.000). Similarly, the left thumb showed a significant difference (chi-square = 16.398, p = 0.003), with males having a greater frequency of whorls (105) and females exhibiting more arches (49) and radial loops (38). On the index fingers, significant

sex differences were also observed. For the right index finger, the distribution of patterns differed significantly (chi-square = 12.145, p = 0.016), with females showing a higher frequency of whorls (99), arches (48), radial loops (27) and composite (18). The left index finger demonstrated a stronger pattern with a chi-square of 31.330 (p=0.000), where females exhibited higher frequencies of arches (47), radial loops (51) and composite patterns (19) compared to males.

Further, the right middle and left middle fingers revealed notable differences in pattern distribution. Males showed a tendency towards left middle finger whorls (94), whereas females exhibited higher counts of radial (61) and ulnar loops (20). The chi-square results were significant (left middle: chi-square = 22.746, p 0.000). The ring and little fingers also presented significant results. Females showed a higher frequency (131) of whorls on the right ring (chi-square = 36.092, p 0.000) and males showed higher frequency (124) on the left ring fingers (chi-square = 25.889, p 0.000). Additionally, for the left little finger, females had a significantly higher frequency of arches (59) and ulnar loops (26) with (chi-square = 62.203, p 0.000) revealed in Table 3.

Table 3: Association Between Sex and Pattern 0f Fingerprints

Fingers	Sex	Whorls	Arches	Ulnar loops	Radial loops	Composite	Chi square	p-value
Right thumb	Male (164)	121	24	13	6	0	31.701	0.000*
	Female (226)	121	51	10	25	19		
Left thumb	Male (164)	105	23	7	25	4	16.398	0.003*
	Female (226)	103	49	18	38	18		
Right index	Male (164)	91	26	31	12	4	12.145	0.016
	Female (226)	99	48	34	27	18		
Left index	Male (164)	92	38	19	15	0	31.330	0.000*
	Female (226)	95	47	14	51	19		
Right middle	Male (164)	83	25	37	19	0	13.507	0.009
	Female (226)	86	57	60	18	5		
Left middle	Male (164)	94	25	18	27	0	22.746	0.000*
	Female (226)	85	50	20	61	10		
Right ring	Male (164)	126	18	5	15	0	36.092	0.000*
	Female (226)	131	36	36	9	14		
Left ring	Male (164)	124	19	7	10	4	25.889	0.000*
	Female (226)	115	43	19	40	9		
Right little	Male (164)	102	20	21	17	4	27.565	0.000*
	Female (226)	90	52	50	15	19		
Left little	Male (164)	91	3	5	55	10	62.203	0.000*
	Female (226)	76	59	26	45	20		

The association between fingerprint patterns and blood groups across the five fingers of the right hand, with significant differences observed for all fingers. Chi-square values ranged from 88.405 to 131.277, with p-values 0.000, indicating a strong statistical association between fingerprint patterns

and blood groups. For the right thumb, individuals with blood group B+ve exhibited the highest frequency of whorls, while A+ve and O+ve groups also showed notable differences in pattern distributions. Similar trends were observed for the right index, middle, ring, and little fingers, where specific blood groups were more strongly associated with particular fingerprint patterns, especially whorls. These findings suggest a significant correlation between blood group and fingerprint pattern distribution, highlighting the potential role of genetic factors in shaping both characteristics revealed in Table 4.

Table 4: Association between fingerprint patterns of right hand with blood group

Finger	fingerprint	A+ve	A-ve	B+ve	B-ve	AB+ve	AB-ve	O+ve	O-ve	Chi square	P-value
Right thumb n=390	Whorls	47	4	89	0	32	3	67	0	110.367	0.000*
	Arches	15	5	13	0	4	0	14	7		
	Ulnar loops	3	0	7	3	6	0	4	0		
	Radial loops	6	0	10	0	5	0	10	0		
	composite	9	0	7	0	3	0	0	0		
Right index n=390	Whorls	23	0	87	0	33	0	43	4	131.277	0.000*
	Arches	35	5	23	3	1	0	7	0		
	Ulnar loops	15	4	18	0	3	3	24	0		
	Radial loops	3	0	11	0	8	0	14	3		
	composite	6	0	4	0	5	0	7	0		
Right middle n=390	Whorls	25	3	72	0	16	3	43	7	98.861	0.000*
	Arches	38	2	19	3	4	0	6	0		
	Ulnar loops	11	4	44	0	12	0	26	0		
	Radial loops	6	0	6	0	8	0	17	0		
	composite	0	0	2	0	0	0	3	0		
Right ring n=390	Whorls	34	7	116	3	18	3	69	7	88.405	0.000*
	Arches	19	2	9	0	10	0	14	0		
	Ulnar loops	15	0	15	0	6	0	5	0		
	Radial loops	6	0	3	0	11	0	4	0		
	composite	6	0	0	0	5	0	3	0		
Right little n=390	Whorls	37	3	71	3	14	0	57	7	97.344	0.000*
	Arches	2	2	35	0	6	3	10	0		
	Ulnar loops	4	4	27	0	19	0	11	0		
	Radial loops	0	0	4	0	11	0	13	0		
	composite	0	0	6	0	0	0	4	0		

The association between fingerprint patterns and blood groups for the left hand, revealing significant associations for most fingers, with p-values consistently below 0.05. For the left thumb, the highest frequency of whorls was seen in individuals with blood group B+ve, with a chi-square value of 117.803 ($p < 0.0001$). Similar patterns were observed for the left index and middle fingers, where whorls were more common among individuals with blood group B+ve and O+ve. However, the left little finger's association was not statistically significant (chi-square = 38.436, $p = 0.090$). Overall, the results suggest that fingerprint patterns, particularly whorls, show significant associations with specific blood groups across most fingers of the left hand, pointing to a potential genetic correlation between these traits shown in Table 5.

Table 5: Association Between Fingerprint Patterns of Left Hand with Blood Group

Finger	fingerprint	A+ve	A-ve	B+ve	B-ve	AB+ve	AB-ve	O+ve	O-ve	Chi square	P-value
Left thumb	Whorls	38	4	90	0	29	0	47	0	117.803	0.000*
n=390	Arches	7	5	23	0	10	0	20	7		
	Ulnar loops	10	0	3	0	8	0	4	0		
	Radial loops	14	0	23	3	0	3	20	0		
	composite	11	0	4	0	3	0	4	0		
Left index	Whorls	30	0	93	0	19	0	41	4	171.057	0.000*
n=390	Arches	22	5	27	0	7	0	24	0		
	Ulnar loops	3	4	4	0	11	0	8	3		
	Radial loops	14	0	19	3	13	0	17	0		
	composite	11	0	0	0	0	3	5	0		
Left middle	Whorls	12	3	84	0	22	3	48	7	116.717	0.000*
n=390	Arches	36	2	16	0	5	0	16	0		
	Ulnar loops	6	4	10	0	11	0	7	0		
	Radial loops	20	0	33	3	12	0	20	0		
	composite	6	0	0	0	0	0	4	0		
Left ring	Whorls	38	7	95	0	27	3	62	7	92.196	0.000*
n=390	Arches	21	2	16	3	5	0	15	0		
	Ulnar loops	0	0	3	0	3	0	14	0		
	Radial loops	0	0	25	0	15	0	4	0		
	composite	0	0	4	0	0	0	0	0		
Left little	Whorls	24	3	67	0	26	3	41	3	38.436	0.090
n=390	Arches	16	2	29	0	6	0	9	0		
	Ulnar loops	7	0	10	0	3	0	11	0		
	Radial loops	24	4	28	3	10	0	27	4		
	composite	9	0	9	0	5	0	7	0		

DISCUSSION

The sociodemographic profile of the 390 students in this study provides valuable insights into the characteristics of the sample population.[5] The mean age of 21.95 years reflects a predominantly young adult group, which is typical for many research studies involving university or college students. The higher proportion of female students (58%) compared to males (42%) aligns with trends seen in many academic settings where females tend to outnumber males. In research by Vishwakarma AK, the sample included a total of 194 medical students, consisting of 107 (55.15%) males and 87 (44.85%) females.[15]

The overwhelming majority being right-handed (95.9%) is consistent with global patterns of handedness, highlighting the natural predominance of right-handed individuals in the population. Approximately 10% of people are left-handed, but it has remained uncertain whether this is associated with changes in brain anatomy.[16] The blood group distribution within the sample is diverse, with B+ being the most common blood group, followed by O+, A+, and AB+. In research by Lyande LB, the most common blood type was O+ (49.5%), followed by A+ (26.3%), B+ (17.2%), and AB+ (5%), B- (1%) and O- (1%).[17]

The analysis of fingerprint patterns across different fingers reveals notable trends in the distribution of whorls and radial loops. Whorls were the most common pattern on both the right and left thumbs, with a higher percentage observed on the right hand (62.1%) compared to the left (53.3%). In research by Kapoor N, a total of 2,900 single-digit fingerprints were collected from 290 participants, and the whorl axis slant was assessed in 743 whorl pattern fingerprints (385 from the right hand and 358 from the left hand). Among the right-hand samples, 81.82% exhibited a slant toward the right, while 80.73% of the left-hand samples showed a slant toward the left.[18]

Radial loops were more prevalent on the left thumb (16.2%) than on the right (7.9%), highlighting lateral variation in pattern distribution. Similar trends were observed on the index and middle fingers, where whorls were dominant on both hands, but radial loops appeared more frequently on the left hand. Specifically, the left middle finger exhibited a marked

increase in radial loops (22.6%) compared to the right hand (9.5%). In research by Taiwo IA, the radial loop was more common, occurring in 51.5% of cases, compared to the ulnar loop at 48.5%.[19] For the ring and little fingers, whorls again dominated, with the left hand showing a higher frequency of radial loops, especially on the little finger (25.6%) compared to the right (8.2%). These findings suggest that while whorls are the most common fingerprint pattern across all fingers, there is a consistent pattern of increased radial loops on the left hand, particularly in the middle and little fingers.

Males predominantly exhibited whorl patterns on the right thumb, right index, and right ring fingers, while females showed higher frequencies of arches and radial loops, particularly on the left thumb and index fingers. These differences were statistically significant, with chi-square values indicating strong associations ($p < 0.05$). Notably, females displayed a higher prevalence of radial and ulnar loops on the middle fingers, while males tended to have more whorls. The left little finger showed a particularly strong distinction, with females having significantly more arches and ulnar loops. These patterns suggest that while whorls are more common in males, females tend to have a greater variety of fingerprint patterns, including arches and loops. In Thai research by Nanakorn S, Males exhibited a higher frequency of radial loops on the index finger (9.1% vs. 9%; $p < 0.001$), whorls on the thumb (39.0% vs. 32.9%; $p < 0.01$) and little finger (34.1% vs. 5.3%; $p < 0.001$), and double whorls on the little finger (6.9% vs. 3.6%; $p < 0.01$). On the other hand, females had a higher frequency of ulnar loops on the little finger (69.0% vs. 57.0%; $p < 0.001$) and thumb (39.3% vs. 32.8%; $p < 0.001$) on their right hands.[20]

Notably, individuals with blood group B+ve exhibited the highest frequency of whorls on the right thumb, and similar trends were observed across the right index, middle, ring, and little fingers, where certain blood groups, particularly B+ve, were more strongly associated with specific patterns, especially whorls. In research by Sudikshya KC, among "B" blood group, the percentile frequency of loops (51.05%) and arches (6.85%) was higher in the Rh-positive blood group compared to the Rh-negative blood group (loops 36.66% and arches 6.67%). However, whorls (56.67%) were more common in the Rh-negative blood group than in the Rh-positive blood group (42.10%).[21]

The analysis of fingerprint patterns and blood groups for the left hand reveals significant associations for most fingers, with p-values consistently below 0.05, indicating strong statistical relevance. Specifically, individuals with blood group B+ve exhibited the highest frequency of whorls on the left thumb, with a chi-square value of 117.803 ($p < 0.0001$). This pattern was similarly observed in the left index and middle fingers, where B+ve and O+ve blood groups were more strongly associated with whorls. These results suggest a consistent correlation between specific blood groups and fingerprint patterns, particularly whorls, across most fingers of the left hand. However, the left little finger did not show a statistically significant association (chi-square = 38.436, $p = 0.090$), suggesting that this relationship may not apply uniformly across all fingers.

Limitations of the Study

This research was carried out in a non-government medical college and hospital of J.C Road, Dhanbandhi, Sirajganj, but not in government medical College Hospitals and outside Sirajganj.

Conflict of Interest: The authors declared that there is no conflict of interest.

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Contributors

SA- Conception, Data acquisition, study design, manuscript writing, final approval and drafting. ABMKH- Conception, study design, and final approval. HRB- Conception, study design, manuscript writing, Data acquisition, final approval and drafting.

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