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FINGERPRINT PATTERNS AND DISTRIBUTION: INSIGHTS FROM A STUDY ON MEDICAL SCIENCE STUDENTS.

Forensic Medicine

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ABSTRACT

Fingerprints have long been used for identification purposes due to their uniqueness and individuality. This study aimed to analyze the fingerprint patterns of 160 medical students (80 males and 80 females) and to determine if there were any significant differences between genders.

The most common fingerprint pattern observed in the study was the loop pattern (52.75%), followed by the whorl pattern (32.5%) and the arch pattern (12%). The least common pattern was the composite pattern (2.75%). Ulnar loops were the most common type of loop pattern, accounting for 95.56% of all loop patterns.

There were some minor differences in fingerprint patterns between males and females. Males had a slightly higher frequency of whorls (33.75%) than females (31.25%), while females had a slightly higher frequency of arches (12.38%) than males (11.63%). However, these differences were not statistically significant.

The study also found that the distribution of fingerprint patterns varied depending on the finger. For example, the left middle finger had a significantly different distribution of all four fingerprint patterns than the right middle finger.

Overall, the study found that fingerprint patterns are mostly similar between males and females. However, there are some minor differences in the frequency of certain patterns and in the distribution of patterns on different fingers.

KEYWORDS

fingerprints, gender, patterns, identification

INTRODUCTION

Fingerprints are the intricate patterns on the fingertips and thumbs, formed by ridges and furrows.[1] These remarkable features serve two crucial functions: uniqueness and permanence. [2]The probability of two individuals sharing identical fingerprints is incredibly low, estimated at 1 in 64 billion, making them a reliable tool for personal identification.[3]

During fetal development, the unique fingerprint patterns emerge due to the complex interplay of genetic and environmental factors. These factors influence the formation of ridges and their distinctive patterns, ensuring individualization.[4,5] The persistence of these patterns throughout life is another remarkable feature. New skin cells constantly replace old ones, but they seamlessly follow the existing fingerprint pattern, preserving its individuality.

Fingerprints are categorized into four primary types: loops, whorls, arches, and composites. Each type further sub-categorizes based on specific ridge characteristics. The Henry Classification System categorizes fingerprints into eight basic patterns, simplifying identification.[6]

Fingerprint identification relies on the meticulous comparison of minutiae, the subtle details within the ridge patterns. Matching 8 to 16 minutiae confirms a fingerprint's authenticity, making it a highly accurate and infallible technique.[7,8]

Beyond criminal identification, fingerprint analysis has gained recognition in various fields, including anthropology, dysmorphology, and medicine. This remarkable tool continues to evolve, offering new insights into human identity and health.[9]

MATERIALAND METHOD:

This study was conducted at the Department of Forensic Medicine, Maulana Azad Medical College, New Delhi, over a period of one year (2021-2022). It employed a descriptive cross-sectional design and recruited a sample of 160 MBBS students, 80 males and 80 females. The sample size was calculated based on a 95% confidence level and a margin of error of 10%, considering a potential bilateral asymmetry in fingerprint patterns of 20-30%. The study received ethical approval from the Institutional Ethical Committee.

Eligible participants were randomly selected MBBS students from Maulana Azad Medical College. Exclusion criteria included chronic skin diseases, permanent scars or deformities on fingers, missing digits, congenital defects, or additional fingers/webbing/bandages. Fingerprints were recorded using the ink method, with participants washing their hands beforehand to remove any dirt or grease. Impressions were taken for both rolled and plain prints, ensuring careful placement to prevent smudging. Data was collected on participant details, fingerprint patterns (loop, whorl, arch, or composite), shapes, and any oddities.

Statistical analysis was then performed to assess the sequential distribution of fingerprint patterns and their association with sex. Categorical variables are summarized by counts and percentages, while continuous variables are described by their mean and standard deviation. To compare qualitative variables between males and females, the Chi-Square test is used. A p-value less than 0.05 indicates a statistically significant difference. All analyses were conducted using SPSS version 25.0.

RESULT:

A total of 1600 fingerprint samples were analyzed for their patterns. The loop pattern was the most common, accounting for 52.75% (844 samples) of all patterns. Whorls were present in 32.5% (520 samples), arches in 12% (192 samples), and composite patterns in 2.75% (44 samples). This data is summarized in Table 1.

Table 1: Distribution Of Fingerprint Patterns In 1600 Samples

Pattern	Number of Samples	Percentage
Loop	844	52.75%
Whorl	520	32.5%
Arch	192	12%
Composite	44	2.75%

The ulnar loop pattern is most common on the left ring finger, left middle finger, and right middle finger. The radial loop pattern is most

common on the right middle finger and right ring finger. The whorl pattern is most common on the left ring finger, left middle finger, right index finger, and right ring finger. The arch pattern is most common on the left index finger, right index finger, and right middle finger. The composite pattern is most common on the left thumb and right thumb.

The finger wise distribution frequency and percentage of each plain fingerprint pattern in all 160 samples has been shown in table 2, where the loops were in highest number of samples followed by whorls, arch and composite patterns.

Table 2: Frequency Of Fingerprint Patterns In Plain Fingerprints

Pattern (Plain)	LR	LM	RM	RR	LL	LI	RI	RL	LT	RT
Ulnar Loop	73 (45.6%)	88 (55%)	95 (59.4%)	58 (36.3%)	117 (73.1%)	46 (29.4%)	53 (33.1%)	113 (70.6%)	78 (48.4%)	77 (48.1%)
Radial Loop	2 (1.3%)	3 (1.9%)	34 (21.3%)	4 (2.5%)	2 (1.3%)	14 (8.8%)	12 (7.5%)	2 (1.3%)	2 (1.3%)	5 (3.1%)
Whorl	77 (48.1%)	39 (24.4%)	28 (17.5%)	88 (55%)	37 (23.1%)	53 (33.1%)	57 (35.6%)	33 (20.6%)	51 (31.7%)	51 (31.9%)
Arch	7 (4.4%)	27 (16.3%)	3 (1.9%)	8 (5%)	3 (1.9%)	42 (26.3%)	37 (23.1%)	10 (6.3%)	16 (10%)	14 (8.8%)
Composite	1 (0.6%)	4 (2.5%)	1 (0.6%)	2 (1.3%)	1 (0.6%)	4 (2.5%)	1 (0.6%)	2 (1.3%)	13 (8.1%)	13 (8.1%)

LR- left ring finger, LM- left middle finger, RM- right middle finger, RR- right ring finger, LL- left little finger, LI- left index finger, RI- right index finger, RL- right little finger, LT- left thumb, RT- right thumb, F- Frequency, %-percentage

Table 3- Frequency of Fingerprint Patterns in Rolled Fingerprints

Pattern (Rolled)	LR	LM	RM	RR	LL	LI	RI	RL	LT	RT
Ulnar Loop	73 (45.6%)	88 (55%)	95 (59.4%)	58 (36.3%)	117 (73.1%)	46 (29.4%)	53 (33.1%)	113 (70.6%)	78 (48.4%)	77 (48.1%)
Radial Loop	2 (1.3%)	3 (1.9%)	-	4 (2.5%)	2 (1.3%)	14 (8.8%)	12 (7.5%)	2 (1.3%)	2 (1.3%)	5 (3.1%)
Whorl	77 (48.1%)	39 (24.4%)	34 (21.3%)	88 (55%)	37 (23.1%)	53 (33.1%)	57 (35.6%)	33 (20.6%)	51 (31.7%)	51 (31.9%)
Arch	7 (4.4%)	27 (16.3%)	3 (1.9%)	8 (5%)	3 (1.9%)	42 (26.3%)	37 (23.1%)	10 (6.3%)	16 (10%)	14 (8.8%)
Composite	1 (0.6%)	4 (2.5%)	1 (0.6%)	2 (1.3%)	1 (0.6%)	4 (2.5%)	1 (0.6%)	2 (1.3%)	13 (8.1%)	13 (8.1%)

LR- left ring finger, LM- left middle finger, RM- right middle finger, RR- right ring finger, LL- left little finger, LI- left index finger, RI- right index finger, RL- right little finger, LT- left thumb, RT- right thumb, F- Frequency, %-percentage

The finger-wise distribution of rolled patterns, presented in Table 3, although matching the plain patterns in terms of type, necessitated recording both plain and rolled prints for each finger. This redundancy served as a safeguard against potential errors in confirming the pattern type.

Fingerprint Patterns Across Genders

This study explored fingerprint patterns in two groups of 80 individuals each, one male and one female. Table 4 summarizes the distribution of these patterns within each group. Notably, the overall pattern distribution wasn't statistically different between males and females ($p > 0.05$).

Table 4: Fingerprint Pattern Distribution In Males And Females

Fingerprint Pattern	Male (N=80)	Female (N=80)	Total (N=160)
Loop	416 (51.92%)	428 (53.50%)	84 (52.75%)
Whorl	270 (33.75%)	250 (31.25%)	52 (32.50%)
Arch	93 (11.63%)	99 (12.38%)	19 (12.00%)
Composite	21 (2.63%)	23 (2.88%)	44 (2.75%)

Across both genders, loop patterns were the most prevalent, followed by whorls, arches, and lastly, composites. This trend is consistent with broader research on fingerprint patterns.

While a slightly higher percentage of males (6.49%) had radial loop patterns compared to females (4.44%), and females had a slightly higher proportion of ulnar loop patterns (95.56%) compared to males (93.51%), as shown in Table 5, these differences were not statistically significant (p values for both radial and ulnar loops were > 0.05).

Table 5: Distribution Of Loop Patterns

Loop Pattern	Male (N=80)	Female (N=80)	P value
Radial Loop	27 (6.49%)	19 (4.44%)	0.22
Ulnar Loop	389 (93.51%)	409 (95.56%)	0.34
Total	416	428	

This suggests that even though there may be some minor variations in the occurrence of specific loop types between genders, the overall distribution of loop patterns remains statistically similar across both males and females.

Gender Differences In Fingerprint Patterns On Left Middle Fingers

We observed that males and females exhibit distinct patterns on this finger. This difference was not present in other fingers.

Interestingly, the same trend was observed for rolled fingerprints, further solidifying the presence of this difference on the left middle fingers. While the reasons behind this specific finger showing a gender distinction require further investigation, it offers an interesting insight into the potential variability of fingerprint patterns based on sex and body location.

It's important to note that no statistically significant difference was found between males and females in the overall distribution of fingerprint patterns across all fingers (combining data from Table 6). This emphasizes the importance of considering both individual finger analysis and overall patterns when studying fingerprint variations.

Table 6- Gender Wise Distribution Of Fingerprint Patterns In Plain Fingerprints

Pattern	Arch		Composite		Radial Loop		Ulnar Loop		Whorl		P value
Finger	M	F	M	F	M	F	M	F	M	F	
LR	3	4	0	1	0	2	37	36	39	37	0.351
LM	10	16	0	4	4	0	43	44	17	20	0.018
RM	16	12	1	2	0	0	43	49	21	13	0.635
RR	4	5	2	0	2	2	27	32	46	41	0.479
LL	3	1	0	1	1	1	55	64	14	21	0.286
LI	21	21	2	2	6	8	30	19	30	23	0.183
RI	18	18	1	0	8	3	23	29	36	21	0.425
RL	6	4	0	2	2	0	58	53	17	18	0.108
LT	7	9	8	5	0	2	38	40	25	29	0.413
RT	5	9	6	6	4	1	35	43	25	27	0.239

This finding paves the way for further research into the potential biological or environmental factors that might influence fingerprint development and its subtle variations between genders and across different finger locations.

DISCUSSION

Frequency Of Fingerprint Patterns

In our study we find that the loops were in highest number of samples followed by whorls, arch and composite patterns. Our findings correlate with previous research by Narahari & Padmaja [11](2017), and Nithin et al. [12](2009), solidifying the global dominance of ulnar loops and the L > W > A pattern hierarchy. Similar trends were observed by Gangadhar and Rajashekara Reddy[13] (2003) in India and others, suggesting a universal fingerprint code for loop supremacy. Also within the loop family, ulnar loops are more common than radial loops in both men (53.89%) and women (53.89%). These findings aligns with studies conducted by Igbigbi and Msamati[14] (2002) and Jaga and Igbigbi[15] (2008).

Distribution Of Fingerprint Pattern On Digits

Furthermore, the observed pattern frequencies on the right and left hands align with the findings of Narahari et al.[16] (2017). Ulnar loops were most prevalent on both the right (70.6%) and left little fingers (73.1%), while radial loops exhibited higher frequencies on the right (7.5%) and left index fingers (8.8%). The majority of whorls were found on the right (55%) and left ring fingers (48.1%), and the arch pattern dominated on the right (23.1%) and left index fingers (26.3%). Composites were equally distributed and more frequent on both the right and left thumbs (8.1%) . Our findings was similar to the study conducted by Nitin et al[17], it was noted that in the overall subject population, the whorl pattern significantly outnumbered the loop

pattern in both ring fingers, with 45.8% whorl pattern versus 42.4% loop pattern in females and 56.2% whorl versus 30.2% loop pattern in males. The prevalence of the ring whorl pattern was higher in males than females . Huang et al[18] reported that, overall, the loop was the most common fingerprint pattern, with the highest frequency observed on the little fingers. The whorl pattern was predominantly present on the ring fingers of both hands.

Gender Dimorphism In Fingerprint Pattern

We observed that both males and females exhibited the order loop > whorl > arch > composite. Although loops were the most dominant pattern in both sexes (49.26% in males and 50.71% in females. The study noted higher occurrences of radial loops in male prints (6.49%) compared to females (4.44%), while ulnar loops were more prevalent in females (95.56%) than in males (93.51%). These results align with findings from studies by Nithin et al[17] and Shreshtha et al[19], When comparing specific patterns between male and female groups separately, females exhibited a higher percentage of loop patterns (53.5% vs. 31.25% whorls), while males showed a slightly higher occurrence of loops (52% vs. 33.75% whorls). The arch pattern was observed with a frequency of 11.63% in males, whereas composites occurred at 2.63%. Males had a greater frequency of whorls (51.92%) than females (48.07%). The frequency of arches was 48.44% in men and 51.56% in women, and females exhibited a higher number of composite patterns (52.27%) compared to males (47.73%) These findings were corroborated by Nithin et al[17], where a higher frequency of ulnar loop patterns was observed in females, and Ching Cho[20], who found higher whorl frequencies in both males and females.

Contrary to some studies, no gender dimorphism was observed in the digit crest pattern type in the southern Nigerian population of Jaja and Igbigbi et. al.[15]. Despite males and females exhibiting the same distribution pattern in the Hang et al study[21], males had a higher incidence of whorl and compound patterns, while females showed a greater frequency of loop and arch patterns. In line with Gan Shyang Hang[21] and other similar studies.

CONCLUSION

Fingerprints serve as crucial evidence at crime scenes, offering a reliable means of identification due to their constancy and individualistic nature. Despite their unique properties allowing for the differentiation of even identical twins, relatively limited research has explored their potential in gender identification. This study aimed to investigate various fingerprint patterns and their distribution among undergraduate medical science students, emphasizing the most prevalent fingerprint pattern and exploring the relationship between fingerprints and gender. The findings revealed that the ulnar loop was the most frequent pattern in the studied population, and the overall order of occurrence was ulnar loop > whorl > arch > radial loop > composite. No statistically significant differences were observed in the distribution of fingerprint patterns between males and females. However, females exhibited a higher frequency of all studied patterns except for whorls, while males showed a greater frequency of radial loops. Specific fingers displayed distinct patterns, with the left middle finger exhibiting significant differences in distribution between males and females. This study enhances our understanding of fingerprint patterns and their potential applications in gender-related identification.

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