RESEARCH PAPER

Sex Identification Using Fingerprint Patterns: A Study on an Egyptian Sample

Wafaa S. Shama[1*], Abdelmoty M. Kabbash[1], Tawfeek M. Eldekin[1], Marwa M. Shahin[1], Nadia E. Helal[1]

[1]Forensic Medicine and Clinical Toxicology Department, Faculty of Medicine, Tanta University, Egypt.
[*]Corresponding author: Wafaa S. Shama, Forensic Medicine and Clinical Toxicology department, Faculty of Medicine, 6th floor, Tanta University, Medical Colleges Complex, Al-Geesh Street, Tanta 31527, Egypt.
Email: wafaa.shama@med.tanta.edu.eg. Telephone number: +201115469644. ORCID: https://orcid.org/0000-0003-3215-1498
Co-authors
emails: abdelmoaty.kamal@med.tanta.edu.eg, tawfeek.eldaken@med.tanta.edu.eg, marwa.shahin@med.tanta.edu.eg , nadia.helal@med.tanta.edu.eg

ABSTRACT

Background: Fingerprints provide positive identification because they are unique and permanent throughout life. Their easy availability and less sophisticated techniques make them a convenient tool for personal identification. Determination of sex is important in both forensic and anthropological identification because it narrows the search for identity by excluding half of the population.

Materials and Methods: This study analyzed fingerprint patterns of 200 Egyptian volunteers (100 males and 100 females). Fingerprints of the ten fingers were collected by rolling the finger bulb on an ink-smeared plate and then placing it on a sheet of white paper. Fingerprints were classified according to Galton's classification (loop, whorl or arch).

Results: The Fingerprint pattern distribution between both hands in males and females demonstrated that there were no statistically significant differences in all fingers except for the index finger in males as the right index finger showed significantly more whorl patterns and fewer loop patterns than the left, whereas arch patterns were more frequent on the left side. The loop pattern was observed more frequently in females while whorl was predominant in males in right hand, left hand and both hands. The distribution of fingerprint patterns between males and females showed no statistically significant differences in all fingers ($P > 0.05$), except for the right index finger, which showed a significant difference. Univariate logistic regression models were performed to predict female sex from loop pattern and male sex from whorl pattern of right index finger with an accuracy of 68.0% and 60.5% respectively. The models were a good fit for predicting sex, as indicated by a non-significant difference between predicted and observed sex.

Conclusion: Fingerprint pattern distribution in the right index finger is effective tool for sex identification.

Key words: Sex identification, Fingerprint, Pattern.

How to cite this article: Shama WS, Kabbash AM, Eldekin TM, Shahin MM, Helal NE. Sex Identification Using Fingerprint Patterns: A Study on an Egyptian Sample. Int J Drug Deliv Technol. 2026;16(19s): 84-92. DOI: 10.25258/ijddt.16.19s.10

Introduction

Identification of a person is an essential task in forensic medicine, and it means the determination of the individuality of a person. It can be either partial (incomplete) or absolute (complete). Incomplete identification reveals certain details about a person, such as ethnicity, age, and sex. While complete identification provides a conclusive determination of a person's identity **(Yaacob et al., 2022, Kumar et al., 2023).**

The most important parameter in identification is the fingerprints, which often provide the positive identification of an individual or suspect because they are unique, permanent, and remain constant throughout life until death **(Chukwumah, 2020).** Furthermore, the easy availability and less sophisticated techniques involved in fingerprint analysis make it a convenient tool for forensic pathologists or anthropologists in personal identification. Fingerprints can be obtained from a decomposed body if the palmar skin is present, and they can be transported to different countries in cases involving internationally operating criminals **(Sreekumar et al., 2023).**

Fingerprint structural features are commonly categorized into two main types: pattern types and minutiae. The pattern area consists of ridges, cores, and deltas, and is enclosed by type lines. The core represents the center of the fingerprint pattern, while the delta is the point formed by the meeting of three different ridge fields. The type of fingerprint pattern also depends on the number of deltas present. Type lines are defined as the two innermost ridges that initially run parallel, then diverge, and enclose or tend to enclose the pattern area **(Kumar, 2021).**

Human fingerprints are characterized by various ridge patterns classified as loops, whorls, and arches, each having unique characteristics with respect to a reference point called the delta. These patterns constitute approximately 60–65%, 30–35%, and 5% of all fingerprints, respectively **(Gutierez et al., 2012, Wijerathne et al., 2013).**

Determination of sex is important in both forensic and anthropological identification because it reduces the search for identity by excluding half of the population **(Baban and Mohammad, 2023).** Although sex identification using novel methods such as DNA analysis is highly reliable, sex prediction from fingerprints has also been found to be a reliable, cheaper, easier, and less time-consuming method **(Sánchez-Andrés et al., 2018).** Several studies have suggested that sex can be identified using fingerprints **(Mishra and Jain, 2022).** In addition to being an important biological characteristic of the human body, fingerprints contain abundant information related to sex **(Qi et al., 2021).** Moreover, previous studies have indicated a possible association between fingerprint pattern distribution, blood groups, and sex **(Vankara et al., 2021).** Fingerprints possess features that can be used to determine the sex of individuals, such as pattern type and ridge density. The possibility of sex differentiation using fingerprints has been attributed to the observation that females tend to have finer epidermal ridge details, whereas males tend to have coarser ridge details **(Taduran et al., 2016).**

Materials and Methods:

Ethical consideration:

The study was conducted following approval by the Research Ethics Committee of the Faculty of Medicine, Tanta University**.** Written informed consent was obtained from each participant after clarifying the aim of the study. Confidentiality of the data was maintained by assigning a code to each contributor.

Study design:

A cross-sectional study was carried out on 200 adult Egyptian volunteers (100 males and 100 females). For each participant, demographic data, including age and sex, were recorded.

Inclusion criteria:

Any healthy adult Egyptian person, either male or female, aged 18 to 40 years.

Exclusion criteria:

- Idiopathic absence of fingerprints.
- Any physical abnormality of hands and fingers due to amputation, burn, fracture, congenital deformity or deformity due to any surgical procedure.
- Presence of major dermatological injuries or diseases affecting fingerprints (scars, mechanical abrasion, leprosy, laceration, irritant contact dermatitis, dyshidrotic dermatitis, atopic eczema, psoriasis, or chemotherapy).
- Any abnormalities detected during the examination of fingerprints were excluded.

Materials:

1- Ink (from the Egyptian Ministry of Interior)**.**
2- Soap.
3- Dry towel.
4- White paper (size A4).

Analysis parameter:

Fingerprints from all ten fingers were collected after the hands had been washed with soap and thoroughly dried. The fingertips were rolled on an ink-coated plate and then transferred onto a sheet of white paper. Care was taken to avoid applying excessive pressure during both the inking and recording processes **(Nithin et al., 2009).** Qualitative fingerprint analysis was performed by classifying the patterns into loops, whorls, and arches according to Galton's classification. In loop patterns, the ridge enters from one side, extends toward the center, curves backward, and exits on the same side. Whorl patterns are characterized by circular or spiral ridge formations at the center. In arch patterns, the ridges enter from one side and exit on the opposite side. These fingerprint patterns are further distinguished by the number of deltas, which represent the central point of a triangular junction formed by three ridge systems. Arches lack a delta, loops contain one delta, and whorls have two deltas **(Ahmed et al., 2011; Vankara et al., 2021). Figures [1,2,3]** belong to participants in this study.

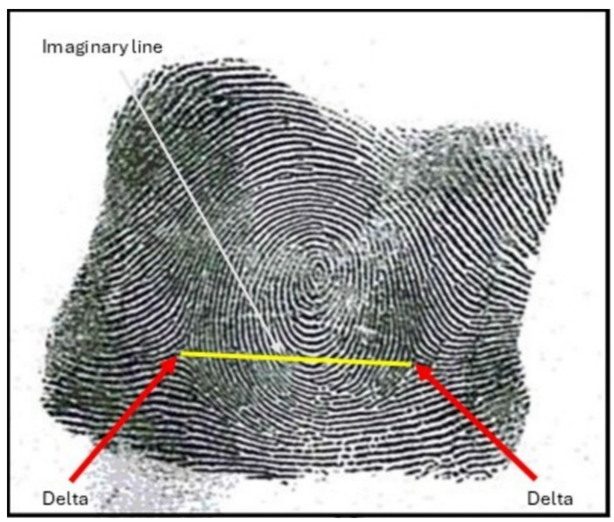

Figure 1: Whorl pattern (the imaginary line connecting the two deltas)

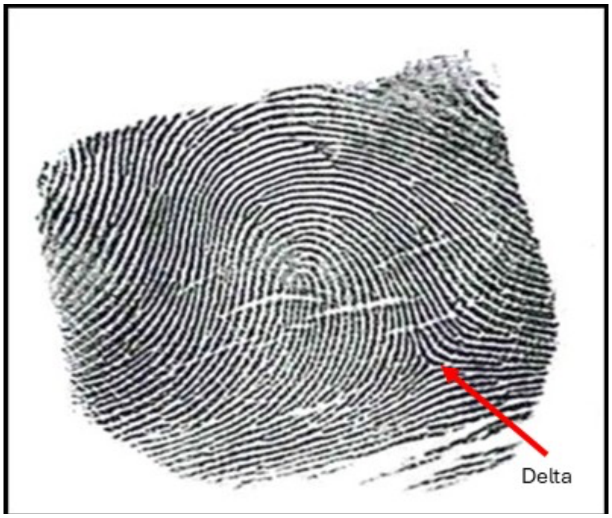

Figure 2: Loop pattern

Figure 3: Arch pattern.

Reliability and reproducibility of fingerprint pattern analysis method:

Fingerprint patterns were analyzed by two independent examiners. To assess intra-rater reliability, the first examiner repeated the pattern classification for a randomly selected sample of 30 participants after a two-week interval. To evaluate inter-rater reliability, both examiners independently performed the pattern classification on the same sample of 30 participants. Agreement between measurements was assessed using Cohen's kappa statistical method, as shown in the Results section **(Table 2).**

Statistical analysis:

All study data were tabulated and analyzed by the statistical package for the social sciences software program, IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, N.Y., USA).

- **Descriptive statistics**: Categorical data were presented as numbers and percentages.
- **Inferential statistics**: Comparisons of the fingerprint pattern categorical variable were done between the right and left sides using the McNemar test, then between the male and female groups using the Pearson chi-square test.
- **Sex prediction statistics:**

For the fingerprint pattern, only two univariable regression models were developed for the whorl or loop patterns of the right index finger. $P < 0.05$ was considered statistically significant.

Regression model results: Significant p-value for the model: The model can significantly predict sex. Significant p-values of the predictors in the multivariable model mean a significant contribution of the variables to the model (for sex prediction).Hosmer and Leme show test: A non-significant ($p > 0.05$) result means that the differences between observed and expected proportions of sex are non-significant, indicating that the model is a good fit, and vice versa. Beta coefficients: Express the amount of change in the probability of sex prediction for every unit increase or decrease in the studied predictor (measurement), according to the sign of the beta coefficient.

- **Intra-rater and Inter-rater reliability testing:**

Intra-rater and inter-rater reliability of fingerprint pattern assessment were evaluated using Cohen's Kappa statistics. According to Cohen's interpretation, Kappa values ≤0 indicate no agreement; 0.01–0.20 indicate none to slight agreement; 0.21–0.40 indicate fair agreement; 0.41–0.60 indicate moderate agreement; 0.61–0.80 indicate substantial agreement; 0.81–0.90 indicate very good agreement; and 0.91–1.00 indicate excellent agreement.

Results

I-Demographic data:

The ages of both male and female participants ranged from 18 to 40 years. No statistically significant difference in age was observed between the two groups, as shown in **Table (1).**

Table (1): Distribution of age and sex in the studied participants (N=200)

		Sex			
		Male	Female	t	p-value
Age, years	Minimum	18.0	18.0	1.787	0.075
	Maximum	40.0	40.0		
	Mean	24.9	26.5		
	SD	5.6	6.3		

*Significant at p <0.05, t: student's t test, SD: standard deviation, N: number.

II-Intra-rater and Inter-rater reliability testing:

Tables (2) demonstrated intra-rater and inter-rater agreements of pattern. Pattern had excellent intra-rater and inter-rater agreement in all ten fingers (kappa > 0.81).

Table (2): Intra-rater and Inter-rater reliability testing of fingerprint patterns (N=30)

Pattern	Intra-rater reliability		Inter-rater reliability	
	Kappa statistic	95% CI	Kappa statistic	95% CI
Right little	1.0	1.0-1.0	1.0	1.0-1.0
Right ring	1.0	1.0-1.0	0.821	0.980-1.00
Right middle	1.0	1.0-1.0	0.948	0.857-1.0
Right index	0.956	0.872-1.0	0.968	0.908-1.0
Right thumb	1.0	1.0-1.0	1.0	1.0-1.0
Left little	1.0	1.0-1.0	1.0	1.0-1.0
Left ring	0.940	0.822-1.00	1.0	1.0-1.0
Left middle	1.0	1.0-1.0	0.843	0.872-.932
Left index	0.963	0.895-1.0	1.0	1.0-1.0
Left thumb	0.898	0.771-1	1.0	1.0-1.0

N: number, CI: confidence interval, %: percentage.

III- Pattern:

In the right hand, the loop pattern was observed more in females (57.6%) compared to males (46.6%), while the whorl pattern was higher in males (48.8%) than in females (37%). The arch pattern showed minimal differences, with 4.6% in males and 5.4% in females with no statistically significant difference between both groups **(P = 0.240).** In the left hand, females showed a higher frequency of the loop pattern (54%) compared to males (47.8%). Conversely, the whorl pattern was more common in males (45.2%) than in females (39.6%). The arch pattern was found in 7% of males and 6.4% of females with no statistically significant difference between both groups **(P = 0.679).** Regarding both hands, the loop pattern was more prevalent in females (55.8%) than males (47.2%). The whorl pattern was slightly higher in males (47%) compared to females (38.3%), while the arch pattern showed minimal variation, with 5.8% in males and 5.9% in females with no statistically significant difference between both groups **(P = 0.447)** as shown in **Table (3).**

Table (3): Comparison between males and females regarding the fingerprint pattern distribution on the right and left hands and both hands (N=200)

	Male N=100		Female N=100		X^2	P-Value
	N	%	N	%		
Right hand						
Loop	233	46.6	288	57.6	2.848	0.240
whorl	244	48.8	185	37.0		
Arch	23	4.6	27	5.4		
Left hand						
Loop	239	47.8	270	54.0	0.774	0.679
whorl	226	45.2	198	39.6		
Arch	35	7.0	32	6.4		
Both hands						
Loop	472	47.2	558	55.8	1.606	0.447
whorl	470	47.0	383	38.3		
Arch	58	5.8	59	5.9		

*Significant at p <0.05, X^2: Chi square goodness of fit test, N: number, %: percentage.

Regarding the distribution of patterns in the right and left hands for both males and females, there were no statistically significant differences in all fingers **(P > 0.05)** except for the index finger in males, which showed a significant difference between both hands **(P = 0.016).**

Regarding the index finger, the fingerprint pattern in males showed significantly more whorl patterns (58%) in right hand compared to the left hand (45%), however the loop patterns were significantly lower in the right index fingers than left ones (32% and 40% respectively). The least frequent patterns were the arches, which showed significantly higher incidence in left fingers compared to the right side (15% and 10% respectively) as shown in **Table (4).**

Table (4): Finger wise distribution of fingerprint pattern in the right and left hands (N=200)

		Right hand		Left hand		McNemar test	
		N	%	N	%	Test statistic	P-Value
Males							
Little finger	Loop	69	69.0 %	58	58.0 %	7.263	0.064
	Whorl	29	29.0 %	39	39.0 %		
	Arch	2	2.0 %	3	3.0 %		
Ring finge	Whorl	69	69.0 %	59	59.0 %	6.00	0.112

r	Loop	29	29.0%	36	36.0%		
	Arch	2	2.0%	5	5.0%		
Middle finger	Loop	64	64.0%	61	61.0%	2.733	0.255
	Whorl	31	31.0%	30	30.0%		
	Arch	5	5.0%	9	9.0%		
Index finger	Whorl	58	58.0%	45	45.0%	10.33	0.016*
	Loop	32	32.0%	40	40.0%		
	Arch	10	10.0%	15	15.0%		
Thumb	Whorl	56	56.0%	53	53.0%	0.529	0.467
	Loop	41	41.0%	44	44.0%		
	Arch	3	3.0%	3	3.0%		
Females							
Little finger	Loop	75	75.0%	69	69.0%	1.524	0.467
	Whorl	22	22.0%	27	27.0%		
	Arch	3	3.0%	4	4.0%		
Ring finger	Whorl	54	54.0%	56	56.0%	0.515	0.773
	Loop	43	43.0%	40	40.0%		
	Arch	3	3.0%	4	4.0%		
Middle finger	Loop	70	70.0%	68	68.0%	1.743	0.627
	Whorl	19	19.0%	23	23.0%		
	Arch	11	11.0%	9	9.0%		
Index finger	Loop	55	55.0%	51	51.0%	1.672	0.643
	Whorl	37	37.0%	39	39.0%		
	Arch	8	8.0%	10	10.0%		
Thumb	Whorl	53	53.0%	53	53.0%	3.048	0.384
	Loop	45	45.0%	42	42.0%		
	Arch	2	2.0%	5	5.0%		

*Significant at p<0.05, N: number, %: percentage.

Table (5) demonstrated that the distribution of fingerprint patterns of males and females showed no statistically significant differences in all fingers (**P > 0.05**), except for the right index finger, which showed a significant difference (**P = 0.004**).

Regarding the right index finger; in males, the whorl pattern was the most dominant pattern with significantly more occurrence (58%) in males compared to females (37%), followed by the loop pattern which was conversely more abundant among females (55%) than males (32%). The least patterns were the arches with slight however significant difference between males (10%) than females (8%).

Table (5): Pattern wise distribution of fingerprints in males and females (N=200)

		Males N=100		**Females N=100**		**Fisher-Freeman-Halton Exact & Chi-Square tests**	
		N	**%**	**N**	**%**	**Test statistic**	**P-value**
Right little	Whorl	29	29.0%	22	22.0%	Exact=1.469	0.576
	Loop	69	69.0%	75	75.0%		
	Arch	2	2.0%	3	3.0%		
Right ring	Whorl	69	69.0%	54	54.0%	Exact=4.794	0.107
	Loop	29	29.0%	43	43.0%		
	Arch	2	2.0%	3	3.0%		
Right middle	Whorl	31	31.0%	19	19.0%	X^2=5.399	0.067
	Loop	64	64.0%	70	70.0%		
	Arch	5	5.0%	11	11.0%		
Right index	Whorl	58	**58.0%**	37	37.0%	X^2=10.945	0.004*
	Loop	32	32.0%	55	**55.0%**		
	Arch	10	10.0%	8	8.0%		
Right	W	56	56.	5	53.	Exact=0	0.7

thumb	horl		0%	3	0%	.530	89
	Loop	41	41.0%	45	45.0%		
	Arch	3	3.0%	2	2.0%		
Left little	Whorl	39	39.0%	27	27.0%	Exact=3.312	0.213
	Loop	58	58.0%	69	69.0%		
	Arch	3	3.0%	4	4.0%		
Left ring	Whorl	59	59.0%	56	56.0%	Exact=0.449	0.828
	Loop	36	36.0%	40	40.0%		
	Arch	5	5.0%	4	4.0%		
Left middle	Whorl	30	30.0%	23	23.0%	X^2=1.304	0.521
	Loop	61	61.0%	68	68.0%		
	Arch	9	9.0%	9	9.0%		
Left index	Whorl	45	45.0%	39	39.0%	X^2=2.758	0.252
	Loop	40	40.0%	51	51.0%		
	Arch	15	15.0%	10	10.0%		
Left thumb	Whorl	53	53.0%	53	53.0%	Exact=0.563	0.801
	Loop	44	44.0%	42	42.0%		
	Arch	3	3.0%	5	5.0%		

*Significant at p <0.05, X^2: Chi square goodness of fit test, N: number, %: percentage.

Table (6) demonstrated that whorl pattern of the right index finger was a significant predictor of male sex **(P=0.003)**. The presence of the whorl pattern increased the odds of predicting male sex by 2.351 (odds ratio: 2.351; CI: 1.333–4.149). The whorl pattern of the right index finger could classify sex with an accuracy of 60.5%. The model was a good fit for predicting sex, as indicated by a non-significant difference between predicted and observed sex (Hosmer and Lemeshow test =0.058).

- **The equation for determining male sex from whorl pattern of right index finger:**

Logit (p)= -0.405+ (0.855 x whorl pattern of right index finger)
Presence of whorl pattern=1
Absence of whorl pattern=0

Logit (p) can be transformed to the probability of being male by the following formula:

$$P = \frac{1}{1 + e^{-logit\,(p)}}$$

Table (6): Univariate binary logistic regression analysis model for predicting male sex depending on whorl pattern of the right index finger (N=200)

	Beta coefficient	P-Value	Odds ratio	95% CI for odds ratio	Accuracy	HLT	P-value
Whorl of right index finger	0.855	0.003*	2.351	1.333-4.149	60.5%	0.058	0.003*
Constant	-0.405	0.042*	0.677	------			

*Significant at p <0.05, N: number, CI: confidence interval, HLT: Hosmer and Lemeshow test, %: percentage.

As shown in **Table (7)**, the loop pattern of the right index finger was a significant predictor of female sex **(P<0.001).** The presence of the loop pattern increased the odds of predicting female sex by 2.597 (odds ratio: 2.597; CI: 1.460–4.620). The loop pattern of the right index finger could classify sex with an accuracy of 68.0%. The model was a good fit for predicting sex, as indicated by a non-significant difference between predicted and observed sex (Hosmer and Lemeshow test =0.071).

- **The equation for determining female sex from loop pattern of right index finger:**

Logit (p)= -0.413+ (0.952 x loop pattern of right index finger)
Presence of loop pattern=1
Absence of loop pattern=0

Logit (p) can be transformed to the probability of being female by the following formula:

$$P = \frac{1}{1 + e^{-logit\,(p)}}$$

Table (7): Univariate binary logistic regression analysis model for predicting female sex depending on loop pattern of the right index finger (N=200)

	Beta coefficient	P-Value	Odds ratio	95 % CI for odds ratio	Accuracy	HLT	P-value
Loop of right index finger	0.952	0.001*	2.597	1.460-4.620	68.0 %	0.071	<0.001*
Constant	-0.413	0.032*	0.662				

*Significant at p <0.05, N: number, CI: confidence interval, HLT: Hosmer and Lemeshow test, %: percentage.

Discussion

Sex identification is one of the most important parameters for distinguishing individuals **(Shrestha and Malla, 2019).** Additionally, using fingerprints for sex prediction can help reduce the number of potential suspects. The probability that two individuals have identical fingerprints is approximately one in 64 billion **(Gupta and Singh, 2024).**

Concerning the comparison between males and females regarding distribution of patterns on the right and left hands, the frequency of the loop pattern was found to be higher in females, whereas whorl patterns were more common in males. The arch pattern showed minimal differences between the two groups. Additionally, there were no statistically significant differences between males and females regarding patterns distribution on the right and left hands. These results are consistent with those reported by **Ujaddughe et al. (2015)** and **Chukwumah (2020),** who found that the distribution of fingerprint patterns on the right and left hands between males and females was not statistically significant.

Regarding the comparison between males and females in fingerprint pattern distribution on both hands, the loop pattern was more prevalent in females than in males. The whorl pattern was higher in males compared to females, while the arch pattern showed minimal variation between the two groups. These results are in agreement with the findings of **Koura et al. (2022), Kc et al. (2018), and Ghaffar (2024),** who conducted studies on Egyptian, Nepalese, and Saudi Arabian participants, respectively. Similar findings were also reported in studies conducted by **Deshpande et al. (2024)** in India, **Omuruka et al. (2017)** in Nigeria, **Shrestha et al. (2019)** in Nepal, and **Al Habsi et al. (2023)** in Oman. In contrast, **Zeeshan et al. (2024)** in Pakistan reported that loops and whorls were more frequent in females than in males. This difference may be attributed to the unequal sample size between the two groups (102 males and 192 females).

In the present study, there was no statistically significant difference between the two groups regarding the distribution of fingerprint patterns on both hands. These results are in agreement with the findings of **George and Yassa (2018)** and **Koura et al. (2022)** in their studies on Egyptian participants, **Ghaffar (2024)** on the Saudi population, **Iqbal et al. (2024)** in Pakistan, **Rastogi et al. (2023)** in India, and **Chaudhary et al. (2017)** in Nepal. On the contrary, **Sreekumar et al. (2023)**, in a study conducted on Indian participants, found a statistically significant association between fingerprint pattern distribution and sex. Additionally, **Hamad et al. (2021),** in a study conducted in Iraq, reported a significant association between sex and fingerprint pattern distribution

Concerning the finger-wise distribution of fingerprint patterns on the right and left hands, there were no statistically significant differences in all fingers except for the index finger in males, which showed a significant difference between the two hands. On the other hand, **Singh et al. (2024)** in India reported that the difference in patterns distribution between the right and left hands was not statistically significant in both males and females. Additionally, there were no statistically significant differences between the two hands regarding fingerprint pattern distribution for each finger.

As regards the pattern-wise distribution of fingerprints in males and females in the present study, the distribution of patterns showed no statistically significant differences in all fingers, except for the right index finger, which demonstrated a significant difference between the two groups. Regarding the right index finger, the whorl pattern was the most dominant in males, with a significantly higher occurrence compared to females. Conversely, the loop pattern was more prevalent among females than males. The least common pattern was the arch, which showed a slight but statistically significant difference between males and females. These results are consistent with another Egyptian study conducted by **Koura et al. (2022).** In their study, they observed that there was a statistically significant difference between males and females regarding the right index finger. Males had a higher percentage of whorl and arch patterns, whereas females exhibited a higher frequency of loop patterns. In contrast, **Chukwumah (2020),** in a study conducted on Nigerian students, reported that there was no significant association between patterns distribution and sex with respect to each finger.

According to the best of our available knowledge, this current study is the first to use univariate binary regression analysis models to predict male sex based on whorl pattern of the right index finger and female sex based on loop pattern of the right index finger.

The results indicated that the whorl pattern of the right index finger was a significant predictor of male sex, with an accuracy of 60.5%.

- **The equation for determining male sex from whorl pattern of the right index finger:**

Logit (p)= -0.405+ (0.855 x whorl pattern of right index finger)

Logit (p) can be transformed to the probability of being male by the following formula:

$$P = \frac{1}{1 + e^{-logit\,(p)}}$$

Additionally, the results revealed that the loop pattern of the right index finger was a significant predictor of female sex, with an accuracy of 68%.

- **The equation for determining female sex from loop pattern of the right index finger:**

Logit (p)= -0.413+ (0.952 x loop pattern of right index finger)

Logit (p) can be transformed to the probability of being female by the following formula:

$$P = \frac{1}{1 + e^{-logit\,(p)}}$$

The differences between the results of the current study and those of other studies could be attributed to variations in sample size, geographical location, and the ethnic background of the participants **(Raj et al., 2024).** Moreover, differences in the distribution of fingerprint patterns between males and females have been reported in several studies. Therefore, sexual dimorphism in fingerprint patterns may be attributed to differences in heritability and developmental variations between the sexes **(Shrestha and Malla, 2019).** Additionally, the distribution of fingerprint patterns varies among different populations, emphasizing the role of genetic factors **(Varma et al., 2023).**

Conclusion

The difference in fingerprint pattern distribution between males and females was not statistically significant. However, there was a statistically significant difference in the distribution of fingerprint patterns on individual fingers particularly the right index finger.

References

- Ahmed, Z. A., Abdelrahman, A. A. and Salah, M. A.2011. Impact of gender and race on fingerprint recognition system in Egyptians versus Malaysians. Mansoura Journal of Forensic Medicine and Clinical Toxicology, 19(2):93-106.
- Al Habsi, T., Al Khabori, H., Al Qasmi, S., Al Habsi, T., Al Mushaiqri, M., Das, S. and Sirasanagandla, S.R. 2023. The association between fingerprint patterns and blood groups in the Omani population. Arab Gulf Journal of Scientific Research, 41(3): 283-292.
- Baban, M.T.A. and Mohammad, D.N.2023. The accuracy of sex identification using CBCT morphometric measurements of the mandible, with different machine-learning algorithms—a retrospective study. Diagnostics, 13(14):2342.
- Chaudhary, S., Deuja, S., Alam, M., Karmacharya, P. and Mondal, M. 2017. Fingerprints as an alternative method to determine ABO and Rh blood groups. Journal of Nepal Medical Association, 56(208): 426–431.
- Chukwumah, A.L.2020. Gender prediction from the primary fingerprint pattern-a study among medical students in Ambrose Alli University, Ekpoma. Biomedical Journal of Scientific & Technical Research, 29(1):22100-22104.
- Deshpande, S.M., Choudhari, S., Kavle, P., Patil, A., Kale, P. and Korde, S. 2024. Gender identification by fingerprint pattern and salivary blood group antigen expression: a Forensic approach. Cureus, 16(3): e56324.
- George, S.M. and Yassa, H.A.2018. Sexual dimorphism in fingerprint pattern: a tool for sex identification. Zagazig Journal of Forensic Medicine and Toxicology, 16(1):1-9.
- Ghaffar, U.B. 2024. Palmar dermatoglyphic pattern in relation to blood group and gender in Saudi population. Journal of Pharmacy and Bioallied Sciences, 16(S 3), S2172-S2175.
- Gupta, A. and Singh, B.K. 2024. Fingerprint-based prediction of gender: an important tool in criminal investigation. Journal of Indian Academy of Forensic Medicine, 46(2): 224-226.
- Gutierez, S.B., Lucenario, J.L.S. and Yebes, M.J.T.2012. Dermatoglyphic studies among the Dumagat-Remontado tribal population of the Philippines. Journal of Anthropology, 2012(1): 812128.
- Hamad, Z.A., Salih, H.R. and Ali, L.K.2021. Identification of relationships between fingerprint patterns and gender in Koya, Kurdistan Region, Iraq. Polytechnic Journal, 11(2): 65-68.
- Iqbal, F., Alam, N., Yasmin, R.S., Khattak, M.A., Farid, N. and Aziz, I. 2024. Pattern of fingerprints and its association with gender among medical students of Peshawar Medical College: fingerprint patterns and gender association. Pakistan Journal of Health Sciences, 5 (6) :114-117.
- Kc, S., Maharjan, N., Adhikari, N. and Shrestha, P.2018. Qualitative analysis of primary fingerprint pattern in different blood group and gender in Nepalese. Anatomy Research International, 2018(1): 2848974.
- Koura, S.M., Abdel-Rahman, R.H. and Emam, N.M.2022. Role of fingerprints patterns and ABO/Rh blood groups in sex dimorphism among Egyptian population. Mansoura Journal of Forensic Medicine and Clinical Toxicology, 30(2): 1-17.

- Kumar, D.R., Jatti, V.B. and Patil, A.2023. Determination of gender by palatal rugae print. Journal of Indian Academy of Forensic Medicine, 45(1): 4-6.
- Kumar, M.S.2021. Dermatoglyphic pattern configurations:a review. International Journal of Dentistry and Oral Science, 8(6): 2816-2827.
- Mishra, A. and Jain, S. 2022. A review on identification of gender using fingerprints. International Journal of Health Sciences, 6(S2):9624-9634.
- Nithin, M.D., Balaraj, B.M., Manjunatha, B. and Mestri, S.C. 2009. Study of fingerprint classification and their gender distribution among South Indian population. Journal of Forensic and Legal Medicine, 16(8): 460-463.
- Omuruka, T.C., Paul, C.W. and Paul, J.N. 2017. Relationship between fingerprint patterns and gender among Port Harcourt residents, Rivers State, Nigeria. International Journal of Pharma Research and Health Sciences, 5(6): 1935-1938.
- Qi, Y., Li, Y., Lin, H., Chen, J. and Lei, H. 2021. Research on gender-related fingerprint features. arXiv preprint arXiv:2108.08233.
- Raj, Y., Munisekhar, M.S., Shylaja, S., Bhavani, S.N., Ramanand, O.V. and Reddy, S. 2024. Role and reliability of cheiloscopy, rugoscopy and dactyloscopy in gender identification. Oral and Maxillofacial Pathology Journal ,15 (2):210-215.
- Rastogi, A., Bashar, M.A., Sheikh, N.A. and BASHAR, M.A. 2023. Relation of primary fingerprint patterns with gender and blood group: a dermatoglyphic study from a tertiary care institute in Eastern India. Cureus, 15(5): e38459.
- Sánchez-Andrés, A., Barea, J.A., Rivaldería, N., Alonso-Rodríguez, C. and Gutiérrez-Redomero, E.2018. Impact of aging on fingerprint ridge density: anthropometry and forensic implications in sex inference. Science & justice, 58(5): 323-334.
- Shrestha, I. and Malla, B.K.2019. Study of fingerprint patterns in population of a community. Journal of the Nepal Medical Association, 57(219): 293-296.
- Shrestha, R., Hirachan, N., Koju, S., Shrestha, N. and Lamichhane, A. 2019. Association of fingerprints with the ABO blood grouping among students in Gandaki Medical College. Journal of Gandaki Medical College-Nepal, 12(2): 63-66.
- Singh, D.V., Kumar, D.K., Singh, D.K. and Pal, D.G. 2024. Dactylography-clinical profiling of medical students. International Journal of Life Sciences Biotechnology Pharma Research, 13(6): 157-162.
- Sreekumar, B., Kumar, P.S. and Fernandes, A.V.2023. Across sectional study of fingerprint patterns and ridge densities in relation to sex. Journal of Indian Academy of Forensic Medicine, 45(4): 339-344.
- Taduran, R.J.O., Tadeo, A.K.V., Escalona, N.A.C. and Townsend, G.C. 2016. Sex determination from fingerprint ridge density and white line counts in Filipinos. Homo, 67(2): 163-171.
- Ujaddughe, M.O., Abue, A.D., Izunya, M.A., Ezeuko, V.C., Eze, I.G. and Baxter-Grillo, D. 2015. Assessment of dermatoglyphic patterns and sex distribution in Esan ethnic group of Edo state, Nigeria. International Journal of Basic, Applied and Innovative Research, 4(1): 9-14.
- Vankara, A.P., Bollu, M. and Perli, M., D.2021. Relationship of primary fingerprint patterns with blood groups and gender: a dermatoglyphic study. International Journal of Medical Research & Health Sciences, 10(3): 31-39.
- Varma, R.K., Anand, B.V. and Suresh, A.V. 2023. A study on relationship between the sex and patterns of fingerprints and distribution of patterns of fingerprints among gitam medical students. International Journal of Academic Medicine and Pharmacy, 5(4):1514-1517.
- Wijerathne, B.T., Rathnayake, G.K., Adikari, S.C., Amarasinghe, S., Abhayarathna, P.L. and Jayasena, A.S. 2013. Sexual dimorphism in digital dermatoglyphic traits among Sinhalese people in Sri Lanka. Journal of Physiological Anthropology, 32: 1-9.
- Yaacob, R., Hadi, H., Ibrahim, H., Zakaria, Y. and Nik Hassan, N.F. 2022. Evaluating the potential application of palmprint creases density for sex determination: an exploratory study. Egyptian Journal of Forensic Sciences, 12(1): 26.
- Zeeshan, R.M., Ahmad, R., Junaid, M., Ahmad, A., Rasheed, A. and Zafar, M. 2024. Dermatoglyphics and their association with gender and blood group in medical students at Islam Medical and Dental College: dermatoglyphics association with gender and blood group in medical students. Pakistan Journal of Health Sciences, 5(12):93-97.