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Original Communication

Sex differences from fingerprint ridge density in the Indian population

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ABSTRACT

Determination of individuality is one of the prime concerns in forensic investigation. The study of fingerprints is widely used in providing a clue regarding identity. The present study was undertaken to study the sex differences in fingerprint ridge density in the Indian population. The study done on 100 males and 100 females revealed that significant sex differences occur in the fingerprint ridge density. The present study shows a statistically significant difference in fingerprint ridge densities of male and female fingerprints in people of Indian origin. A mean fingerprint ridge density of 12 ridges/25 mm^2 or less is found to be more likely to be of males and a mean ridge count of more the 12 ridges/25 mm^2 is more likely to be of female origin.

1. Introduction

Determination of individuality is one of the prime issues in forensic practice. Among the number of parameters available for establishing the identity of an individual, fingerprints are extensively used in providing a clue regarding identity.[1–7] No two fingers are found to have identical prints, and it is an overwhelming mathematical probability that no two ever will be found to match.[8] The ridge patterns are formed in the human fetus before birth and remain the same throughout a person's life and even after death until they are lost through decomposition. Moreover, fingerprints are made up of a number of easily recognizable features that permit them to be classified and filed for later reference. Thus it is possible to identify not only criminals but also victims of amnesia and unidentified corpses when records of prints are available.

The ever increasing pattern of crime has made fingerprinting an indispensable tool in the hands of investigating officers. If the sex of the individual is established with certainty, the burden of the investigating officer would be reduced by half. In this context, sex based differences in fingerprint patterns and the density of the finger ridges becomes relevant. Jantz found sex and race differences in finger ridge count correlations.[9] Moore[10] mentions that females have finer epidermal ridge detail than males and Okajima[11] found fork index to be higher in female fingerprints when compared to males. In the present study an attempt has been made to identify the sex of the person in the Indian population using fingerprint ridge density.

2. Material and methods

Hundred male and 100 female healthy Indian subjects aged between 18 and 25 years were chosen randomly. All the subjects were students studying in various educational institutions in Manipal, India. The purpose of the study was explained to the participants and their informed verbal consent was taken. The subjects were asked to wash their hands clean. A clean plain glass plate of 15 × 15 cm size was smeared with printers black ink with the help

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Fig. 1. 25 mm^2 area used for counting fingerprint ridge density.

Table 1
Descriptive statistics: fingerprint ridge density in males and females.

Sex	Number of ridges/25 mm^2				
	Min	Max	Mean	SD	SE
Male (n = 100)	9.6	12.5	11.049	1.111	0.11
Female (n = 100)	12.0	15.9	14.198	0.634	0.02

SD – standard deviation, SE – standard error.

Table 2
Frequency distribution of mean fingerprint ridge densities.

Mean ridge density[a]	Females	Males
9–10	00	16
10–11	00	64
11–12	02	18
12–13	07	02
13–14	66	00
>14	25	00
Total	100	100

[a] Average number of ridges/25 mm^2 per sample.

of a roller. The subjects were asked to apply their finger bulbs on the smeared plate and then transfer them onto the paper. Regular pressure was applied and all 10 plain finger prints were obtained.

The upper portion of the radial border of the prints was chosen as the area for analysis because all finger print pattern types show a similar ridge flow in this region. This method serves to isolate ridges within a well defined area, facilitating the process of ridge counting. A 5 × 5 mm square was drawn on a transparent film and placed on the fingerprint samples in the chosen area (Fig. 1). The epidermal ridges from one corner of the square to the diagonally opposite corner were counted. Dots were not counted. Forks were counted as two ridges excluding the handle and a lake was counted as two ridges. This value represented the number of ridges in 25 mm square area and reflected the ridge density value.

The ridge density value was obtained for all 10 fingers and the mean was calculated. This mean represented a single data point for that particular individual. Specific comparison of means was made and calculations were performed using SPSS, version 10.1, statistical analysis program (SPSS, Inc., Chicago, IL). Posterior probability inferences of sex based on ridge density values were made by calculating the likelihood ratio (LR) (Eq. (1)) based on the Baye's theorem. The favoured odds were also computed.

$$^{*}\mathrm{LR} = \frac{\text{Probability of a given fingerprint originating from a male contributor(C)}}{\text{Probability of a given fingerprint originating from a female contributor}(\mathrm{C}^1)} \quad (1)$$

3. Results and discussion

Descriptive statistics of fingerprint ridge densities for male and female subjects are shown in Table 1. Ridge density ranged from 12 to 15.9 ridges/25 mm^2 for females with a mean of 14.198 ridges/25 mm^2 (SE = 0.02), and from 9.6 to 12.5 ridges/25 mm^2 for males with a mean of 11.049 ridges/25 mm^2 (SE = 0.11). Females were found to have significantly higher ridge density than males ($p < 0.001$). Ridge thickness and furrows are the two important factors which determine the density of ridges. Researchers worked on ridge thickness in fingerprints and showed that males have coarser finger ridges than females which suggests that males will have fewer ridges in a given area than females and thus, lesser ridge density.[12,13] Findings of our study are in accordance with the findings of Mark Acree[14] who reported higher ridge densities in females as compared to males, with a mean of 13.32 ridges/25mm^2 and 11.14 ridges/25 mm^2 in Caucasian females and males respectively, and 12.61 ridges/25 mm^2 and 10.90 ridges/25 mm^2 in Afro-American females and males respectively. It is observed that the difference between the means of Indian females and males is 3.149 ridges/25 mm^2. The frequency distribution of mean ridge densities is shown in Table 2. It is observed that 64% of the males have a mean ridge density of 11 and 66% of the females have a mean ridge density of 14. It is observed that none of the males have a mean ridge density of more than 13 and there are no females who have a mean ridge density below 12. Twenty nine subjects (20 males and 7 females) were in the overlapping zone.

Probability densities derived from the frequency distribution were used to calculate the likelihood ratio and posterior probabilities of sex designation for given ridge count for subjects using Baye's theorem (Table 3). A fingerprint possessing 12 ridges/25 mm^2 has large probability of being from males ($p = 0.9$). A fingerprint possessing 13 ridges/25 mm^2 has a higher probability of being from females ($p = 0.77$). There is a high probability ($p = 0.99$) of a fingerprint of $\geqslant$14 ridges/25 mm^2 of being from a female origin. The probability of fingerprint of $\leqslant$11 ridges/25 mm^2 of being from a male origin is very large ($p = 0.99$). Odds ratio was calculated for subjects. It is observed that a fingerprint ridge count of 12/25 mm^2 or less is more likely of male origin and a fingerprint ridge count of more than 12/25 mm^2 is more likely of female

Table 3
Probability densities and likelihood ratios derived from observed fingerprint ridge count of Indian subjects.

Ridge count[a]	Probability density				Favoured odds
	Males (C)	Females (C^1)	C/C^1	C^1/C	Male Female
9–10	0.16	0.001	160	0.006	0.99 > 0.01
>10–11	0.64	0.001	640	0.001	0.99 > 0.01
>11–12	0.18	0.02	9	0.11	0.90 > 0.1
>12–13	0.02	0.07	0.28	3.5	0.23 < 0.77
>13–14	0.001	0.66	0.001	660	0.01 < 0.99
>14	0.001	0.25	0.004	250	0.01 < 0.99

[a] Average number of ridges/25 mm^2 per sample.

origin. Our study supports Moore's study[15] that reported a higher value of mean ridge to ridge distance in males and lesser value in females, thus a higher ridge density in females when compared to males. Our results are similar to the findings of Mark Acree[14] who found fingerprint ridge count of 11 ridges or less/25 mm^2 to be more likely of male origin and fingerprint ridge count of 12 ridges or more/25 mm^2 to be more likely of female origin. However, the demarking value for males and females was higher in our study thus suggesting that racial differences do occur in fingerprint ridge density.

4. Conclusions

The present study shows a statistically significant difference in fingerprint ridge densities of male and female fingerprints in people of Indian origin. It shows that a mean fingerprint ridge density of 12 ridges/25 mm^2 or less is more likely to be of males. Likewise a mean ridge count of more than 12 ridges/25 mm^2 is more likely to be of female origin. Thus the study confirms that females have greater ridge density, hence finer ridge details, than men.

The degree of ridge densities can be used as a presumptive indicator of sex of an unknown print left at a crime scene. However, this study has a serious limitation that all ten fingerprints are required for the determination of the sex. There is further scope to standardize this result. Additional studies on individual fingers in different population groups are proposed. The result of this study is significant and can prove to be an important tool for the forensic experts and law enforcement authorities.

Conflict of Interest

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Ethical approval

None decleared.

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