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Sex differences from fingerprint ridge density in Chinese and Malaysian population

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ABSTRACT

The fingerprints are very typical for a human being. The present study was undertaken to study the gender differences in fingerprint ridge density in Chinese and Malaysian population. The study done on 200 subjects (100 males and 100 females) of Chinese origin and 100 subjects (50 males and 50 females) of Malaysian origin revealed that significant gender differences occur in the finger ridge density. Fingerprint mean 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 13 ridges/25 mm^2 is more likely of female origin in Chinese subjects. Fingerprint mean ridge density of 11 ridges/25 mm^2 or less is found to be more likely to be of males and a mean ridge count of more the 13 ridges/25 mm^2 is more likely of female origin in Malaysian subjects.
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1. Introduction

Fingerprints are very typical for a human being. Although, considered as an infallible method of identification [1] it has severe limitation for forensic individualization [2]. The ridge patterns of fingerprints develop in the intrauterine life and remain the same until death before being altered by decomposition [1]. Moreover, fingerprints are made up of a number of easily recognizable features that permit them to be classified and filed for later reference. It is now an established fact that these patterns are unique and specific to a particular individual. Thus it is possible, to identify not only criminals but also victims of amnesia and unidentified corpses using this technique.

The ever increasing and changing pattern of crime has made fingerprinting an indispensable tool in the hands of investigating officers. With the inference of the sex of the suspect from the prints available at the crime scene, the burden of the investigating officer is reduced. Previous researchers have explored the possibility of gender differentiation using fingerprints [3–6]. Acree reported higher fingerprint ridge densities in females among Caucasian and African American population [7]. Gungadin reported similar observations in Indian population [8]. In a more recent research similar observations are reported in Spanish Caucasians [9]. The present research is an attempt to study the sex differences using fingerprint ridge density in Chinese and Malaysian population.

2. Materials and methods

200 Chinese (100 males and 100 females) and 100 Malaysian (50 males and 50 females) subjects aged between 18 and 25 years were chosen randomly. All the subjects were students studying in various institutions affiliated to Manipal University, India. Purpose of the study was explained and verbal informed consent was taken from all the subjects individually. The subjects were asked to wash their hands clean. A clean plain glass plate of 15 cm × 15 cm was smeared with printers black ink with the help of a roller. The subjects were asked to apply their finger bulbs on the smeared plate and then transfer them on to the paper. Regular pressure was applied and all 10 plain finger prints were obtained.

The upper portion of the radial side of the central core region of the prints was chosen as the area for analysis as described by Acree [7] 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 mm^2 × 5 mm^2 was drawn on a transparent film and placed on the finger print 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^2 area and reflected the ridge density value.

Value was obtained for all 10 fingers and the mean was calculated. This mean represented a single data point for that particular individual. The data are assumed to be normally distributed. Specific comparison of means was made and

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Fig. 1. A fingerprint showing the area (25 mm^2) used for counting fingerprint ridge density.

calculations were performed using SPSS, version 11.0, statistical analyses programme (SPSS Inc., Chicago, IL, USA). Posterior probability inferences of gender, based on ridge density values were made by calculating the likelihood ratio (LR) based on the Baye's theorem. The favoured odds were also computed.

$$LR = \frac{\text{Probability of a given finger print originating from a male contributor(C)}}{\text{Probability of a given finger print originating from a female contributor}(C^1)}$$

3. Results and discussion

Descriptive statistics of dermal ridge densities for male and female subjects of Chinese and Malaysian origin is shown in Tables 1 and 2, respectively. In Chinese subjects, the ridge density ranged from 9.3 to 14.9 ridges/25 mm^2 for males with a mean of 11.73 ridges/25 mm^2 (S.E. = 0.11), and from 11.1 to 16.4 ridges/25 mm^2 for females with a mean of 14.15 ridges/25 mm^2 (S.E. = 0.10). In Malaysians, ridge density ranged from 9.4 to 14.4 ridges/25 mm^2 for males with a mean of 11.44 ridges/25 mm^2 (S.E. = 0.14), and from 11.4 to 15.3 ridges/25 mm^2 for females with a mean of 13.63 ridges/25 mm^2 (S.E. = 0.13). 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. Cummins and Ohler worked on ridge thickness in fingerprints and showed that males have coarser finger ridges than females which suggest that males will have less ridges in a given area than females and thus less ridge density [10,11]. Findings of our study are in accordance with earlier studies that report higher ridge densities in females as compared to males in different ethnic groups [7–9]. It is observed that the difference between the mean ridge density among females and males is 2.42 ridges/25 mm^2 in Chinese and 2.19 ridges/25 mm^2 in Malaysian subjects.

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

Gender	Ridge density/25 mm^2				
	Min	Max	Mean	S.D.	S.E.
Male (n = 100)	9.3	14.9	11.73	1.066	0.11
Female (n = 100)	11.1	16.4	14.15	1.038	0.10

S.D. – standard deviation, S.E. – standard error.

Table 2
Descriptive statistics: ridge density in males and females in Malaysian population.

Gender	Ridge density/25 mm^2				
	Min	Max	Mean	S.D.	S.E.
Male (n = 50)	9.4	14.4	11.44	0.988	0.14
Female (n = 50)	11.4	15.3	13.63	0.906	0.13

S.D. – standard deviation, S.E. – standard error.

Table 3
Frequency distribution of mean ridge densities in Chinese and Malaysian population.

Mean ridge density	Chinese		Malaysian	
	Males	Females	Males	Females
9–10	12	0	5	0
10–11	37	0	31	0
11–12	35	9	8	4
12–13	12	7	6	12
13–14	04	50	0	26
14	0	34	0	8
Total (n)	100	100	50	50

The frequency distribution of mean ridge densities is shown in Table 3. It is observed that among Chinese 84% of the males have a mean ridge density of less than 12 and 84% of the females have a mean ridge density of more than 13. It is observed that none of the males have mean ridge density of more than 14 and there are no females who have mean ridge densities below 11. Among Malaysians, 72% of the males have a mean ridge density of less than 11 and 92% of the females have a mean ridge density of more than 12. It is observed that none of the males have mean ridge density of more than 13 and there are no females who have mean ridge densities below 11.

Probability densities derived from the frequency distribution were used to calculate the likelihood ratio and posterior probabilities of gender designation for given ridge count for subjects using Baye's theorem (Tables 4 and 5). In Chinese, a fingerprint possessing <12 ridges/25 mm^2 has large probability of being from males (p = 0.8). A finger print possessing >13 ridges/25 mm^2 has a higher probability of being from females (p = 0.92). There is a high probability (p = 0.99) of a finger print of ≥14 ridges/25 mm^2 of being from a female origin. The probability of fingerprint of ≤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 dermal ridge count of 12/25 mm^2 or less is more likely of male origin and a dermal ridge count of more than 13/25 mm^2 is more likely of female origin. In Malaysians, a fingerprint

Table 4
Posterior probabilities and likelihood ratios derived from observed ridge count of Chinese subjects.

Ridge count[a]	Probability density				Favoured odds Male Female
	p(RC/C)	p(RC/C′)	p(RC/C)/ p(RC/C′)	p(RC/C′)/ p(RC/C)/	
9–10	0.12	0.001	120	0.008	0.99 > 0.01
10–11	0.37	0.001	370	0.002	0.99 > 0.01
11–12	0.35	0.09	3.8	0.25	0.80 > 0.2
12–13	0.12	0.07	1.7	0.58	0.64 > 0.36
13–14	0.04	0.5	0.08	12.5	0.08 < 0.92
14	0.001	0.34	0.002	340	0.01 < 0.99

RC – ridge count.
[a] Average number of ridges/25 mm^2 per sample.

Table 5
Posterior probabilities and likelihood ratios derived from observed ridge count of Malaysian subjects.

Ridge count[a]	Probability density				Favoured odds Male Female
	p(RC/C)	p(RC/C′)	p(RC/C)/ p(RC/C′)	p(RC/C′)/ p(RC/C)/	
9–10	0.1	0.001	100	0.01	0.99 > 0.01
10–11	0.62	0.001	620	0.001	0.99 > 0.01
11–12	0.16	0.08	2.0	0.5	0.66 > 0.66
12–13	0.12	0.24	0.5	2.0	0.33 < 0.66
13–14	0.001	0.52	0.001	520	0.01 < 0.99
14	0.001	0.16	0.006	160	0.01 < 0.99

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

possessing <11 ridges/25 mm^2 has large probability of being from males ($p = 0.99$). A finger print possessing >13 ridges/25 mm^2 has a higher probability of being from females ($p = 0.66$). Odds ratio was calculated for subjects. It is observed that a dermal ridge count of 11/25 mm^2 or less is more likely of male origin and a dermal ridge count of more than 13/25 mm^2 is more likely of female origin. Our study supports Moore's study, that reports 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 [12]. Our results are similar to the findings of earlier studies in different populations [7,8]. Differences in demarking value for fingerprint ridge density among males and females of Chinese and Malaysian origin as well as the earlier studies however suggests that racial differences do occur in finger print ridge density.

4. Conclusion

The present research confirms that females have greater ridge density hence, finer ridge details than men in Chinese and Malaysian population. The mean ridge densities thus, can be used as a presumptive indicator of gender of an unknown print left at a crime scene. Our research observes that fingerprint mean ridge density of 12 ridges/25 mm^2 or less is more likely to be of male origin and a mean ridge density of more the 13 ridges/25 mm^2 is more likely of female origin in Chinese population. Likewise fingerprint mean ridge density of 11 ridges/25 mm^2 or less is more likely to be of male origin and a mean ridge density of more the 12 ridges/25 mm^2 is more likely of female origin in Malaysian population. The study confirms the observations of earlier researchers and shows that racial differences exist in fingerprint ridge densities. Further studies on fingerprint ridge density in individual fingers and 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.

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