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ORIGINAL ARTICLE

Sex differences in the thumbprint ridge density in a central Indian population

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KEYWORDS

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Abstract *Background:* Identification of sex plays a vital role in forensic and medico legal investigations. Fingerprints are considered to be the most precise and reliable indicators for personal and gender identification.
Objectives: The objective of this study was to determine any significant difference in the thumbprint ridge density of males and females in a central Indian (Marathi) population to enable the determination of gender.
Methods and materials: The study was conducted on 200 subjects (100 males and 100 females) in the age group of 18–30 years. Ridge densities on the right- and left-hand thumbprints were determined using a newly designed layout and analysed statistically.
Results: The results showed that females tend to have a higher thumbprint ridge density in both the areas examined, individually and combined. Applying the *t*-test, the differences in the ridge densities of males and females at LoC (Left of Centre), RoC (Right of Centre) and Combined (LoC + RoC) were found to be statistically significant at $p < 0.01$ levels, proving the association between gender and fingerprint ridge density. Probability densities for men and women derived from the frequency distribution (at LoC, RoC and Combined) were used to calculate the likelihood ratio and posterior probabilities of gender designation for the given ridge count for subjects using Baye's theorem.
Conclusion: It was concluded that differences in the thumb ridge density can be used as an important tool for the determination of gender in cases where partial thumbprints are encountered as evidence either at the crime scene or on any document(s) of forensic significance.

1. Introduction

Identification of sex plays a vital role in forensic and medico legal investigations. Identification means determination of the individuality of a person. It may be complete (absolute) or incomplete (partial). Complete identification means the absolute fixation of the identity of a person. Partial identification implies ascertainment of only some facts about the identity (like

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sex, age, stature, etc.) while others still remain unknown. The most successful approach for individualization utilises a combination of more than one method.[1] Amongst the number of parameters available for establishing the identity of an individual, fingerprints are considered to be the most precise and reliable indicators of personal and gender identification.[2–8] No two fingers are found to have identical prints, and it is an overwhelming mathematical probability that no two will ever be found to match.[9] It has been estimated that chances of two persons having identical finger impressions are about one in sixty-four thousand million of the world population.[10] Identical twins, originating from one fertilised egg, are arguably the most alike of any beings on earth. They share the same DNA profile because they began their existence as one entity, yet their fingerprints are as distinctive as any unrelated persons.[11]

While comparing the fingerprints of the suspects with the latent fingerprints found at the crime scene, the fingerprint examiners usually study the ridge counts and ridge characteristics. Consequently, these two characteristics of the fingerprints have been widely studied by the researchers and analysts.[2–6,12–18] The ever increasing frequency of crime has made fingerprinting an indispensable tool in the hands of investigating officers. If the sex of the individual could be established with certainty, the burden of the investigating officer would be reduced by half.[14,15]

Thumb impressions are of distinct importance. They are even used in lieu of signature in India in many important documents including (but not limited to) wills, sale deed, notarized documents, bank cheques, bank documents, property documents, competitive examinations, attendance forms, etc. Thumb impressions are often considered in civil and criminal cases as prominent evidence. Whenever a person touches, holds, and/or lifts any object such as a pen, paper, glass, firearm, a knife, a currency note, etc. there is a more than certain chance that the thumbprint would get transferred onto the object(s). To the best of our knowledge the use of thumbprint ridge density for sex determination amongst Indians has not been achieved till now, hence this study.

Fingerprint ridge density is defined as the fingerprint ridge count corresponding to a defined fingerprint area. Fingerprint ridge density has been shown to be sexually dimorphic in Spanish Caucasians,[2] Spanish populations[3–5] the Sardinian population,[6] Egyptian,[16] Chinese, Malaysian[15] and some Indian populations[14] including the south Indian population,[17] Indo-Mauritian population,[18] etc. Other fingertip features;[16] palm print ridge density[19] and footprint ridge density[20] were also studied in the past for sex differences. In the present study an attempt has been made to identify the sex of a person in a Central Indian (Marathi) population using thumbprint ridge density.

2. Materials and methods

2.1. Collection of samples

In this study, 200 Marathi subjects (100 males and 100 females) were chosen randomly from the Central Indian (Marathi) population, aged between 18 and 30 years, residing in Nagpur city, India. The purpose of the study was explained and verbal informed consent was taken from all the subjects' individually.[14] Subjects with any evidence of disease and injury of the fingertips that was likely to alter the fingerprint pattern (leprosy, scars of the fingertips, lacerations) were excluded.[17]

Table 1 Sex wise distribution.

Sex	Male	Female
Prints	100 * 2	100 * 2
Total number	200	200

The selected subjects were asked to wash and dry their hands. A clean fingerprint plate was smeared with Kores® thumb impression ink (black), with the help of a roller.[14] The subjects were then asked to ink their right and left thumbs, rolling nail to nail [17] on the inked surface, and imprint them on the finger-print slip in the designated area. Hence a total of 400 prints were analysed in the current study (Table 1). The prints were taken in triplicate to avoid any confusion at any later stage.

2.2. Analysis

A new and improvised method for thumbprint ridge density calculation was devised. On a transparency sheet a format was drawn as shown in Fig. 1. Two straight lines bisecting each other were drawn. This bisecting point was placed at the core or centre of the print. 5 mm above this, another transverse line was drawn. Two squares of 25 mm^2 each were drawn on both sides (left and right). These were our chosen areas for analysis. Ridge counting was performed in these designated areas and the values were tabulated. At the time of counting the number of ridges, this transparency was superimposed on the print (Fig. 2), so that the lower intersection lies on the core/centre of the print, in cases of Whorls and Loops. In Arches the intersection was kept on the lowest ridge which flows continuously from one side to the other side of the print. 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.[14] The tabulated values for both sides represented the ridge density in a 25-mm^2 area.

Various statistical calculations were performed on the obtained data. 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 calculated as:

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

3. Results and discussion

Descriptive statistics of ridge densities in males and females is shown in Table 2. In males, the ridge density ranged from 9 to 15 ridges per 25 mm^2 at both the Left of Centre (LoC) and the Right of Centre (RoC) with the mean ridge density of 11.58 and 11.82, respectively. In females, the ridge density ranged from 12 to 19 ridges per 25 mm^2 at the LoC with the mean ridge density of 14.6 and 12–18 ridges per 25 mm^2 at the RoC with the mean ridge density of 14.56. The range of LoC and RoC combined is observed to be 19–27 ridges with 23.40 as the mean and 24–36 ridges with the mean value of