



## Original communication

## A study of sex differences in fingerprint ridge density in a North Indian young adult population

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## ABSTRACT

Fingerprints have considerable value in morphological, biological, anthropological and forensic studies. Fingerprints collected from the crime scene and from the items of evidence of crime have been successfully used to identify suspects, victims or any other person who had touched the surface in question. The thickness of epidermal ridges varies between individuals; females are supposed to have finer ridges than males and therefore a greater ridge density. The present research is an attempt to distinguish sex from fingerprint ridge density in the radial, ulnar and lower areas of a fingerprint in a North Indian population. A total of 194 individuals (97 males and 97 females) aged between 18 and 25 years were included in the study and fingerprints were collected from each finger of the participants. Thus, a total of 1940 fingerprints were obtained and epidermal ridges were counted in the radial, ulnar, and lower areas of each fingerprint. The radial and ulnar areas are the 5 mm × 5 mm areas on the radial and ulnar side of the central core respectively while the lower area is designated as 5 mm × 5 mm area adjoining the flexion crease of the terminal phalanx on a fingerprint. The fingerprint ridge density in radial, ulnar and lower areas and between sexes was compared statistically using *t*-test. The results indicate that the females tend to have a significantly higher ridge density than males in the three areas analyzed in the study. The fingerprint ridge density in the ulnar and radial areas of the fingerprints is significantly higher than the lower area. The present study suggests that the fingerprint ridge density can be a relevant and useful morphological parameter in distinguishing sex of a latent fingerprint of unknown origin from the scene of crime. The findings can also be useful in identification of mutilated remains when a dismembered hand is brought for medico-legal examination.

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## 1. Introduction

Dermatoglyphics has long been considered as an important morphological trait for studying individual variation within the domain of biological anthropology, human biology, morphology and anatomy.<sup>1–5</sup> Previous studies have shown the utility of dermatoglyphics and its possible role in the diagnosis of genetic and medical disorders.<sup>6–12</sup> Variations in fingerprint patterns among various population groups have been reported.<sup>13–15</sup> Fingerprints are permanent morphological characteristics and criminal detection

based on fingerprints is based on the principle that no two people can have identical fingerprints.<sup>16</sup> Fingerprints have been widely and universally used in forensic examinations as positive proof of identity by different law enforcing agencies for more than a century now.<sup>17</sup> 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.<sup>18–20</sup>

Fingerprint ridge density is another characteristic feature of considerable importance in fingerprints. Fingerprint ridge density is defined as the fingerprint ridge count corresponding to a defined fingerprint area. It is determined by two parameters; ridge width and distance between ridges.<sup>20</sup> A few studies have examined variability in fingerprint ridge density with respect to its application in determination of sex.<sup>20–24</sup> Applicability of fingerprint ridge density in determination of sex is based on the fact that the females

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tend to have finer ridge detail on fingers, therefore more ridges than males.

Acree<sup>21</sup> analyzed fingerprint ridge density on the radial side of fingerprints in 400 Caucasian and African American males and females aged between 18 and 67 years. The findings of the study indicated that fingerprint ridge density in females was significantly higher than males. The study further concluded that a given fingerprint possessing a ridge density of 11 ridges/25 mm<sup>2</sup> or less was most likely a male and a ridge density of 12 ridges/25 mm<sup>2</sup> or greater was most likely a female. In a similar study on 500 subjects from South India, Gungadin<sup>22</sup> concluded that a fingerprint density of 13 ridges per 25 mm<sup>2</sup> or less was most likely a male and a ridge density of 14 ridges per 25 mm<sup>2</sup> or greater was most likely a female.

Gutiérrez-Redomero et al.<sup>20</sup> conducted a study to establish a relationship between sex and fingerprint ridge density in 200 Spanish Caucasian males and females aged between 20 and 30 years. They analyzed fingerprint ridge density in a manner described by Acree<sup>21</sup> and besides radial area, the count was extended to ulnar and lower part of the fingerprint. The study concluded that females tend to have a significantly higher ridge density than males in the distal region of the fingerprint (radial and ulnar areas), but not in the proximal region (lower area). They calculated likelihood ratio to obtain probability inference of sex based in ridge density and observed that in radial area, dermal ridge count of 16 ridges/25 mm<sup>2</sup> or less was most likely to be of male origin, and a ridge count of 17 ridges/25 mm<sup>2</sup> or more was most likely to be of female origin. In ulnar area, dermal ridge count of 14 ridges/25 mm<sup>2</sup> or less was most likely to be of male origin, and that a ridge count of 17 ridges/25 mm<sup>2</sup> or more was most likely to be of female origin.

In a study on 100 males and 100 females from South India aged between 18 and 25 years, Nayak et al.<sup>23</sup> suggested that fingerprint ridge density may be a useful clue in identification of a suspect. In this study, the upper portion on the radial border of a fingerprint was analyzed according to the study conducted by Acree.<sup>21</sup> The study indicated that a mean fingerprint ridge density of 12 ridges/25 mm<sup>2</sup> or less was more likely to be of male origin and a mean ridge count of more than 12 ridges/25 mm<sup>2</sup> was more likely to be of female origin.

A recent communication,<sup>25</sup> suggests various environmental and genetic causes for sex differences in fingerprint ridge density and proposes further research on an appropriate sample in different ethnic groups to find the exact cause and kind of variability in fingerprint ridge density among males and females. The present research was planned to analyze fingerprint ridge density in a North Indian population, keeping in view the fact that population based differences exist in fingerprint ridge density and that no studies are available on the variability and sex differences in the of fingerprint ridge density in the three areas analyzed by Gutiérrez-Redomero et al.<sup>20</sup> Moreover, with regard to sex differentiation, variations in fingerprint ridge density in each finger have not been presented earlier. The present research evaluates the variability of fingerprint ridge density in the radial, ulnar and lower area of fingerprints and compares fingerprint ridge density in various fingers in individuals from North India. The present study also evaluates the differences in fingerprint ridge density between right and left hands. The research aims to find the sex differences based on fingerprint ridge density and its possible applicability in the determination of sex in forensic examinations.

## 2. Material and methods

### 2.1. Study participants

Fingerprints were collected from 194 students (97 males and 97 females) aged between 18 and 25 years from different schools and colleges of Palampur city, District Kangra in the State of Himachal

Pradesh in North India. Most of the participants belong to agricultural families with animal husbandry as a secondary occupation. Mean age ( $\pm$ S.D.) of male and female participants was 21.2 ( $\pm$ 1.9) years and 20.9 ( $\pm$ 2.1) years respectively.

### 2.2. Analysis of the fingerprints

The fingerprints were obtained from the participants by means of simple inking method as suggested by Cummins and Midlo.<sup>26</sup> A total of 1940 fingerprints were obtained from 194 males and females. Fingerprints obtained from different digits were denoted as R I, R II, R III, R IV, R V and L I, L II, L III, L IV, L V for thumb, index, middle, ring and little finger respectively on the right and left sides. The ridges on fingerprints were counted diagonally on a square measuring 5 mm  $\times$  5 mm according to the method described by Acree<sup>21</sup> and on the areas described by Gutiérrez-Redomero et al.<sup>20</sup> The radial and ulnar areas are 5 mm  $\times$  5 mm areas on the radial and ulnar side of the central core respectively while the lower area is designated as 5 mm  $\times$  5 mm area adjoining the flexion crease of the terminal phalanx in a fingerprint. For analysis of fingerprint ridge density in radial and ulnar areas a square measuring 5 mm  $\times$  5 mm was placed directly on the radial and ulnar side of the central core region respectively in such a way that the lowermost and innermost corner of the square was located on the central core of the fingerprint. For analysis of fingerprint ridge density in the lower area, a line perpendicular to the flexion crease of the terminal phalanx was drawn passing through the core and a square measuring 5 mm  $\times$  5 mm was placed diagonally on it with one corner located on the flexion crease. The radial, ulnar, and lower areas included in the study are depicted in Fig. 1. Numbers of ridges were counted diagonally on the 5 mm  $\times$  5 mm squares placed on the radial, ulnar and lower areas of the fingerprints obtained from both hands in each individual and the number of ridges per 25 mm<sup>2</sup> of the fingerprint surface was thus, obtained.

### 2.3. Statistical analysis

The variations observed in the fingerprint ridge density in all the three areas were analyzed according to typological variability, differences between right and the left hand and sexual dimorphism. The fingerprint ridge density in the radial, ulnar, and lower areas were analyzed in each finger of the participants and the mean fingerprint ridge density for each area in each finger was estimated in males and females. The differences in fingerprint ridge density between the sexes were analyzed individually for each finger in both hands and for all ten fingers together. The sample was

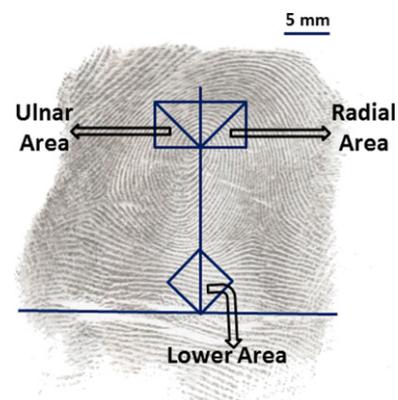


Fig. 1. Radial, ulnar and lower areas on a fingerprint where fingerprint ridge density was analyzed.

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