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Research Article

Sex Determination from Fingertip Features among South Indian Population

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ABSTRACT

The project was on determining the sex of South Indian population which includes 5 southern states of India from the unique and reliable evidence of fingerprint. The parameters like ridge density and ridge count were selected to do the observatory study on 100 males and 100 females. The conventional ink impression method was improvised and substituted with digital image capturing of fingerprints. The sensitivity and specificity of the method was determined for checking the reliability of the method.

Keywords: Sex determination; Digital imaging; Ridge count; Ridge density

INTRODUCTION

Person identification has always been an important aspect in every phase of investigation. The stature, sex, age and race are the basic features that we look for. Fingerprints were always a reliable source for individual identification. It is unique, universal, non-replicable form of evidence which differ from person to person and even within finger to finger of the same person. The study of fingerprints for personal identification is called Dactyloscopy or Dactylography, in which the impressions from the fingerprint ridges are taken for the purpose of identification of the individual [1]. The fingerprints are non-destructive and easily classifiable evidences that are easily accessible and suitable form of method for individualization. Hence, it is a permanent reliable method for individualization. It helps you to narrow down your suspects, identify unknown corpses, to identify mentally retarded, missing persons and will provide further investigation leads. The influence of genes on fingerprint formation as well as its hereditability is still in dispute. According to the studies, they are regulated by a single major gene. Some suggests that its development can be even driven by the environmental factors in the intra-embryonic development stage [2]. Only severe mutilation or skin disease can change the fingerprints. Ridges are independent of age and they increase in size within the finger according to the finger breadth and surface [3]. Mainly the parameters like ridge count, ridge density, ridge thickness to valley thickness ratio were studied in order to find the ethnicity as well as sexual differences within the prints. Males had higher probability of having low ridge density and thus broader ridges mainly, among African, American and Caucasian population [4]. The study by Krishnan et al. showed similar trend among North Indian population. The applications of sex determination from fingerprints can extend to identification of the individual among a mass disaster where the body parts get mixed up, identification of the person from the decomposed body, identification of a missing person along with other evidences like dental records, anthropometry, DNA, blood type etc [5]. Hence the aim of this study is to study the general trend of ridge densities among both the sexes among South Indian population and to determine whether ridge count or ridge density is a better parameter for sex determination.

MATERIALS AND METHODS

Two hundred healthy individuals (100 males and 100 females) were selected for the study, mainly within the age group of 18-65 years. The age group was considered so that the ridges have completely developed. Generally, the subjects were the South Indian students of Manipal Academy of Higher Education, Manipal, and Karnataka. The study was conducted with the approval of the Ethics Committee, KMC, Manipal. The subjects with any skin disease or permanent scar or injury on fingerprints were excluded. And the informed consent was taken from the subjects and asked to wash their hands and dry them properly. The fingertip images of each subject were captured using a Panasonic DMC-FH2 digital camera of 14 megapixels, 28-112 mm focal length, made in Japan. A code number was given from the thumb of the right hand till little finger of left-hand R1–

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L5. Images were, later transferred to the computer and zoomed up 65% using Adobe Photoshop, 2015 version.

Rather than the conventional method of calculating the ridge count by counting the lines intersecting through the imaginary line considered from core to delta of a fingerprint, the following procedure was followed for each fingerprint. A longitudinal line was considered along with the fingerprint through the core point. The innermost point of the pattern area is considered as the core of the pattern. Further, a perpendicular line of interest was considered which represent the fingerbreadth, which also passed through the core point. 10% from both the sides of the line of interest was not considered as counting the lines in these areas were difficult. Finally, a square was drawn on the outer radial part of the fingerprint with its side length equal to the remaining half of the line of interest [6]. The method proposed by Acree [7] was followed which included counting of the ridge count diagonally from corner of the square to other corner. And the square area was calculated by multiplying its side length by itself. Then ridge density was calculated by dividing this ridge count by its square area. The mean value for each hand as well as for each individual was calculated. The value differences among both the sexes were analyzed statistically through SPSS software for Windows Version 23.0.

To describe about the data, descriptive statistics mean & standard deviation were used. To find the significant difference between the bivariate samples in Independent groups, the unpaired sample t- test was used. The Receiver Operator Characteristic (ROC) curve analysis was used to find the Sensitivity, Specificity with cut off for the gender identification. In both the above statistical tools, the probability value .05 is considered as significant level.

RESULTS

The mean of total ridge density among both the sexes were compared. Also the parameters like the mean of ridge density of left hand as well as right hand of both the sexes were compared. The three values were found highly significant with a p-value of 0.001 (Figure 1 and Table 1).

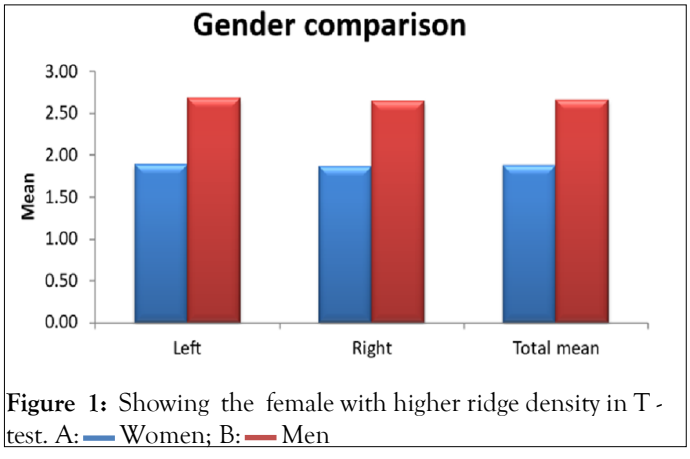

Figure 1: Showing the female with higher ridge density in T - test. A: Women; B: Men

Details	Total mean of equal variances not assumed	Left values of equal variances not assumed	Right values of equal variances not assumed
Levene's test for equality of variances			
F	5.926	5.476	0.02
Significance	0.016	6.381	0.012
t-test for equality of means			
t	-3.378	-3.333	-3.294
df	189.574	189.136	189
p-value	0.001	0.001	0.001
Mean difference	-0.7872	-0.7918	-0.78452
Standard error difference	0.23305	0.23759	0.23819
Interval of the difference 95% confidence			
Lower	-1.24687	-1.2605	-1.25438
Upper	-0.32744	-0.32315	-0.31467

Table 1: Showing the significance of total mean, left hand and right hand values of males and females.

The t-test was performed for the left hand values of male and female with total samples of 100 individuals (50 male and 50 female). The total mean as well as the left hand values seemed to be significant with a p-value of 0.029 and 0.043 respectively. The same method of t-test was followed for the values of right hand of both male and female. The total mean as well as the right hand values were found significant with p-values of 0.013 and 0.023 respectively (Figures 2 and 3).

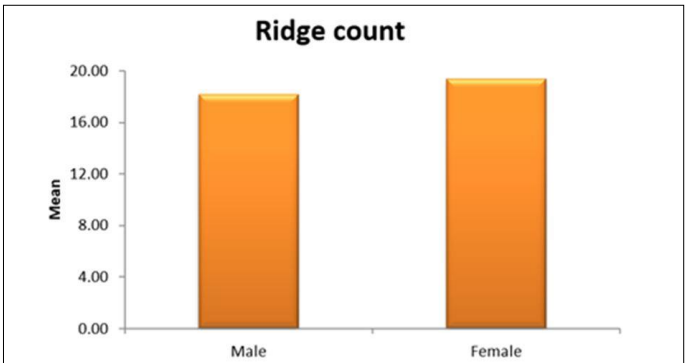

Figure 2: Showing females with higher ridge density than males.

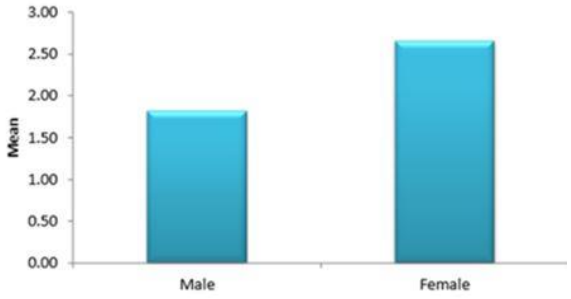

Figure 3: Showing females with higher ridge count than males.

Within the ROC curve, all the values including the total mean, left hand and right hand values have covered an area which is nearly equal that is 0.701, 0.684 and 0.690 respectively. All these values seemed to be highly significant with p-values of 0.001 (Figure 4).

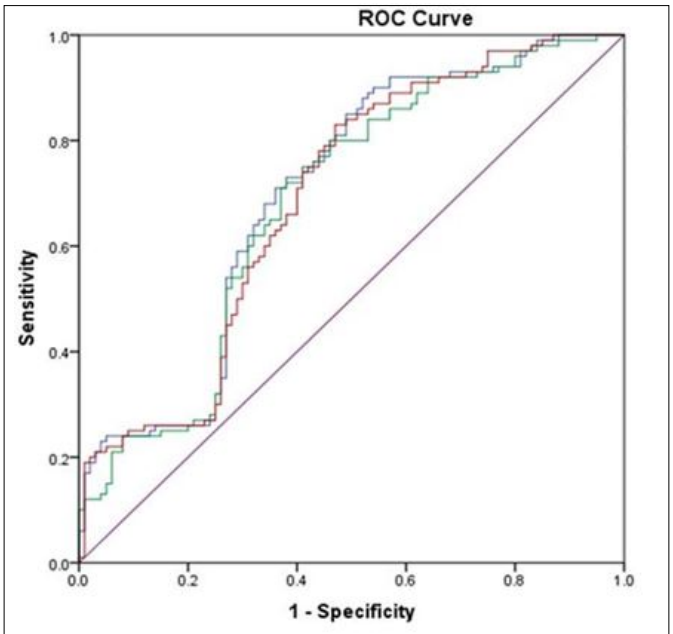

Figure 4: Showing the ROC curve for the total mean, left ha-nd and right hand ridge densities of male and female. A: Reference line; B: Total mean; C: Left; D: Right

With the ROC curve, the cutoff values were determined. For the total mean values, cutoff value was determined to be 1.5, which implied the values above or equal to 1.5 is more probable to be of a female while the values of total mean below the cutoff value tend to be of a male. The sensitivity and specificity of the total mean was obtained to be 66. The ROC curve determines the cut off values for left hand values and right hand values separately. The left hand values were calculated to get a cut off value of 1.606. The values above or equal to 1.606 were tending to be more of a female while the values below 1.606 tend to be of a male. The sensitivity and specificity of the values were obtained to be 65. Similarly the ROC curve determined the cutoff value as 1.486 above or equal to be more probable to be a female while the values below tend to be of male. The sensitivity and specificity of the values aggregated to 63.

Hence females tend to have higher ridge density than males when compared with total mean of ridge density, ridge density within left hand as well as ridge density of right hand.

DISCUSSION

The pattern as well as the parameters like ridge count, ridge density which was included in this study, showed significant changes with both the genders as well as for different regions. This study was focused on ridge count and ridge density variables among South Indian population. The conventional method of collecting fingerprint samples by Ink impression method was replaced by advanced digital images. As this method was followed by Wang [8], showed more resistant to environmental changes and skin defects. The outer radial area around the pattern was selected for calculating ridge count and ridge density as it showed a regular flow of pattern type and was less affected by the curved part of fingerprints. The ridge count was calculated by considering a longitudinal axis bisecting a line of interest through the central core region. A square was considered with the side equal to half of the length of the line of interest. This ensured the study of variation of ridge count with the finger breadth. The analyzed results found significant changes within total mean of ridge density among both the sexes as well as the ridge density values of left hands of both the sexes and ridge density values of right hands of both the sexes were compared and found significant. The ridge count and ridge density among both the sexes showed significance. The results showed higher ridge density within females than males which was seen in Chinese, Malaysian, Egyptian etc. populations. And the ridge count and ridge density showed significant sexual dimorphism. These were contrast results when compared to the works of Wang et al. [8] where males showed higher ridge density than females. These can be included as topological differences.

The higher ridge density among females was explained by Acree [7] as the females tend to have smaller finger breadth. Further the ridges were arranged within smaller surface area when compared to males. Hence they tend to show higher ridge density than males. The ridges of females were finer while males had coarser ridges. Another factor which affected the ridge count and ridge density was the distance between the ridges. According to the study reported by Moore [9], the males tend to have larger distance between the ridges than females which explained the lower ridge density among males. Further analyzing the pattern distribution among different fingers, double loops were more often seen on thumb which was calculated to be 51.7% and 75% among females and males respectively. Little finger of females showed low number of arch patterns while little and ring finger of males showed no or least number of arch patterns. Other combinations like central pocket loops and accidentals were very rare in occurrence and more often seen on the middle finger of both the sexes.

In Figures 2 and 3 shows that the significant difference among male and female with respect to the parameters like ridge count and ridge density respectively. Hence it is evident that the difference exhibited in the ridge density between male and females were larger than the difference within their ridge count.

The ridge density was a better and significant parameter for sex determination than ridge count.

Certain correlations and trends were spotted while analyzing the samples. The hand which had double loop on any of the finger had more probability of exhibiting both the patterns like loops and whorls on other fingers. The explanation which can be given for this is double loops are the combination of both loops and whorls. Further the trend of repetition was more often spotted for thumb finger. It was observed that, if thumb of a hand exhibited a pattern like arch or double loop, the thumb of other hand also seemed to exhibit the same pattern. This trend was observed among both the sexes. Further studies need to be conducted on pattern distribution among fingers. Again the same distribution can be varied according to different populations.

CONCLUSION

The ROC curve covered an area approximately equal to 0.7 which is above 0.5 and proven to be useful. The study also showed slight variations from the range of ridge densities and fingerprint pattern distribution of other topographies like North Indian population, Chinese, Malaysian etc. Hence the possibility of exploiting these parameters like ridge count, ridge density as well as the distribution of fingerprint patterns can be further studied in depth to estimate the regional differences occurring among various Populations.

Hence this study helps us to point out the sex of the individual from the ridge density and ridge count among South Indian Population.

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