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Original Article

Sex Differentiation from Fingerprint Ridge Density

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Abstract

Background

Determination of sex is an important parameter other than age, race and stature during forensic identification and crime scene investigation. Females tend to have finer and denser ridges on their fingertips than males. Present study aims at differentiating gender from fingerprint ridge density.

Material and Methods

This is a cross sectional study conducted from March 2022 to March 2023 in Nobel Medical College Teaching Hospital, Nepal. Seven hundred fingerprints samples (350 males and 350 females), from 70 Nepalese medical students were collected and analyzed for gender differences. Comparative analysis was done using Student's t-test ($p<0.05$). Likelihood ratio and posterior probability using Baye's theorem were calculated to interpret the possibility of gender differentiation from various fingerprint ridge densities.

Results

Students t-test revealed significant difference ($p < 0.001$) between the fingerprint ridge density of male and female ($t= -16.733$). The results showed ridge density $\leq$14/25mm^{2}and $\geq$15/25mm^{2}are "more likely than not" from males and females respectively. Posterior probability using Baye's theorem further revealed ridge density $\leq$13/25mm^2(C/C^1=5.75,P=0.86) and $\geq$16/25mm^2 (C^1/C=4.29, P^1=0.84) have higher probability of originating from males and females respectively. No any male and female had ridge density >16/25mm^{2}and <13/25mm^{2}respectively.

Conclusion

The study reveals statistically significantly greater fingerprint ridge densities in female than in male Nepalese medical students.

Keywords: *Autopsy, Fingerprints, Gender*

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Introduction

Fingerprints are the pattern of epidermal ridges found over the fingertips of humans. These friction ridges correspond with the dermal rete ridges and help human for easy grasp of objects. The elevated portions of them produce various patterns that can be arranged in loop, whorl, arch and even combined. The pattern remains unchanged throughout life and doesn't match even with the monozygotic twins [1].

The process of comparing a suspected and a known fingerprint during identification process is referred as Dactyloscopy. This helps by determining, during crime investigation and various civil matters, whether two prints are from same source [2]. Personal identification based on fingerprint has become an established norm in forensic investigations. It has an utmost relevance in decomposed, fragmented body parts and in crime scenes [3].

Sex determination is one of the important primary characters of identification besides race, age and stature. Apart from the fact that finger ridge pattern are highly individualistic there also occurs sexual dimorphism in the same. Females tend to have fine epidermal ridges in contrast to males. Acree was the first to reveal statistically significantly higher ridge density in female fingertips through his study [4]. Negligible studies in this context are done in Nepal. Hence this study focuses on gender differentiation from fingerprint ridge density amongst medical students in Nepal [5].

Materials and Methods

A descriptive cross sectional study was done in Forensic Medicine Department, Nobel Medical College Teaching Hospital; Biratnagar, Nepal from March 2022 to March 2023. Ethical approval for the same was obtained from Institutional Review Committee of NMCTH (IRC-NMCTH 802/2023). The sample size was calculated using, $n=z^2p\ (1-p)/e^2$. Where, z=2.05 (96% confidence limit), p=0.5(50% population proportion) and e=0.04 (4% allowable margin of error).The estimated minimum sample size was 657 but 700 cases (350 male fingerprints and 350 female fingerprints) were included after obtaining consent for the same. Nepalese medical students without history of burn, eczema, leprosy, acute injuries and scars over their fingertips were considered. The participants were asked to wash their hand with soap and water and dry it completely with clean towel. Plain impressions of all ten fingertips were produced on A4 size paper using a stamp pad as suggested by Cumins and Midlo [6]. A transparent sheet with a square (5mm X 5mm) drawn over it was then placed over each finger impression and the number of ridges were counted on radial and ulnar areas in diagonal direction, with the help of a magnifying lens, as shown in Fig 1. The average number of ridges on both the areas was considered as ridge density of that particular finger which was taken as a unit of study. This was according to the method given by Acree MA. These data were recorded in standard proforma and entered and analyzed using SPSS software. Comparative analysis was done using Student's t-test where 'p' value < 0.05 was considered significant. Likelihood ratio and posterior probability using Baye's theorem was calculated to find out the favored odds regarding the strength of possibility of fingerprint ridge density originating from either gender.

Figure 1: Radial and Ulnar areas for counting number of ridges

Results

The study consisted of 700 fingerprint samples, 350 from males and 350 from females, from participants aged between 18 to 30 years. Frequency distribution of the ridge density between males and females is depicted in Figure 2. The mean density of the fingerprint ridges were 13.82 and 15.36 for male and female respectively. Significant difference between the ridge densities ($p<0.001$) was observed between the genders by Students t-test (t= -16.733). Descriptive statistics and result of t-test for the ridge density is shown in Table 1.

Probability densities for both genders at various ridge counts (C and C^1) and their likelihood ratios (C/C^1 and C^1/C) were calculated. It was seen that ridge density $\leq$14/25mm^2(C/C^1=1.76, P=0.66) and $\geq$15/25mm^2 (C^1/C=1.56, P^1=0.62) are"more likely than not" from males and females respectively. Posterior probability using Baye's theorem was further calculated which revealed that ridge density $\leq$13/25mm^2 (C/C^1=5.75,P=0.86) and $\geq$16/25mm^2 (C^1/C=4.29, P^1=0.84) have higher probability of originating from males and females respectively. No any male had ridge density

>16/25mm^2 and no any female had ridge density <13/25mm^2. Calculations for all ridge densities are shown in Table 2.

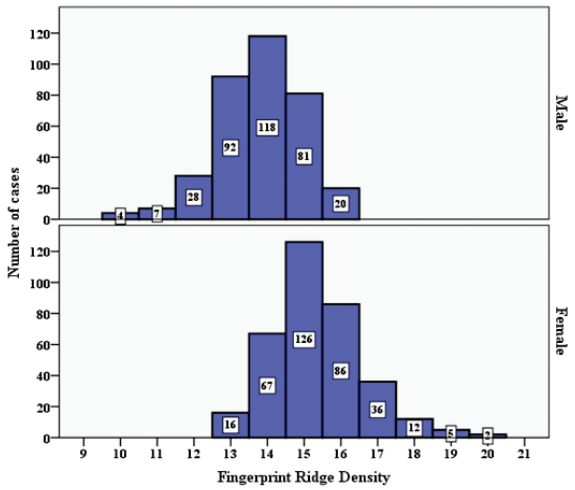

Figure 2: Frequency distribution of fingerprint ridge density in males and females

Table 1: Descriptive statistics of fingerprint ridge density in both genders

Statistics	Male	Female
Number	350	350
Mean	13.82	15.36
Std. Error of Mean	0.063	0.067
Std. Deviation	1.173	1.260
Median	14	15
Minimum	10	13
Maximum	16	20

t-test (-16.733) P < 0.001

Table 2: Probability density and likelihood ratio from observed ridge counts

Fingerprint Ridge Density / 25mm^2	Probability Density		Likelihood ratio		Flavored odds	
	Males (C)	Females (C^1)	(C/C^1)	(C^1/C)	Male (P)	Female (p^1)
10	0.0114	-	-	-	0.995	0.005
11	0.02	-	-	-	0.985	0.015
12	0.08	-	-	-	0.95	0.05
13	0.2629	0.0457	5.75	0.17	0.86	0.14
14	0.3371	0.1914	1.76	0.57	0.66	0.34
15	0.2314	0.36	0.64	1.56	0.38	0.62
16	0.0572	0.2457	0.23	4.29	0.16	0.84
17	-	0.1029	-	-	0.06	0.94
18	-	0.0343	-	-	0.02	0.98
19	-	0.0143	-	-	0.006	0.994
20	-	0.0057			0.002	0.998

Discussion

Practitioners of forensic medicine are often confronted with decomposed and fragmented body remains that may arrive from a scene of mass disaster, scene of crime or a fatal aircraft and vehicular accidents. Personal identification in such scenarios is one of the prime concerns to the stake holders. Determination of sex together with age, race and stature of such samples is the usual path followed for narrowing the identification process. Sex determination is done by rectifying various primary and secondary sexual characters wherever possible. Grossly fragmented and decomposed bodies demand somatometric and anthropometric examinations, which incorporate measuring various bones and body parts to deduct gender. Many studies in this context have been done previously that have tried various bones and body parts for similar purpose [7, 8, 9].

Recent studies have suggested potential use of fingerprint ridge density in gender determination. The first study in this field with promising result was conducted by Acree MA in 1999, where significant gender difference in fingerprint ridge density was demonstrated. It was seen that fingerprint ridge density ≤11/25mm^2 is likely from male and ≥12/25mm^2 is likely from female. This was true for both African American and Caucasian population [4]. Finer and more crowded ridges in females are ascribed to the presence of more X chromosomes in females in contrast to Y chromosome leading to more widely placed epidermal ridges over the fingertips of males. Increased body surface area in males may also be partly responsible for widely placed coarse fingerprint ridges. This further confirms the fact that fingerprint ridge density can be a good sexual trait which is genetically determined [10, 11].

Present study revealed that fingerprint ridge density ≤13/25mm^{2}is probably of male and ≥16/25mm^2 of female origins for Nepalese adults. This was in accordance to the other studies done in Indian population where almost all showed that female having denser fingerprint ridge density than male. However the method of taking fingerprint and area of ridge count differed considerably. Nithin MD et al (2011) used rolled prints of all ten fingers and took mean value as final ridge density as a study unit, in South Indian population. They considered upper radial portion of the print, single area of 25mm^2, for counting [12]. Similarly Krishnan K et al (2013) considered three areas in the fingerprint; namely ulnar, radial and basal, for counting the ridges in adult North Indian population. They found out ridge density significantly higher in radial and ulnar than that of the basal area. It was also seen that ridge density varies among different fingers of same person

and among different areas of same finger as well. This was one of the reasons behind considering each fingerprint as a separate sample in present study [13]. Rodomero EG et al (2013) performed similar study on 393 adult Argentinian population residing at various altitudes where is showed much higher values. The mean ridge density for Ramal region of Argentina was 17/25mm^2 and 19/25mm^{2}over radial areas of male and female respectively. The study showed variation in ridge density among people residing at various altitudes. It also revealed difference in ridge density between Argentinian and Spanish samples [14]. Sharma S et al (2021) did a systematic review of the studies done on sexual dimorphism from fingerprint ridge densities in various populations after 1999. After analyzing various studies they concluded that fingerprint ridge densities are an accurate sexually dimorphic trait but they vary considerably among populations. It was further recommended that population specific study can be of good value in practical forensic scenario [15]. Hence present study is an attempt for the same, incorporating Nepalese medical students, who represent adult Nepalese population.

Conclusion

The present research shows that there is statistically significant difference between fingerprint ridge densities of male and female Nepalese students.The ridge density is higher in females compared to males.

Recommendation

This can be considered as an important parameter for gender differentiation during postmortem examinations of mutilated body parts and decomposed bodies. It will also prove equally helpful in investigating suspicious fingerprints retrieved from crime scenes. Further study in this subject on Nepalese population with larger sample size involving other areas of the finger is suggested.

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Conflict of interest: None

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