A Forensic Study on Fingerprint Comparison Between Lucknow and Raebareli Population in India

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Abstract:

Background: Dactylography, also known as dactyloscopy, refers to the scientific investigation of fingerprints with the primary objective of identification. The field of study is continuously advancing, with novel techniques being documented and refined. The capacity of the examination to ascertain the gender and identification of an individual has been extensively documented and documented. The identification of individuals through the analysis of fingerprints is considered to be a highly reliable and accurate method within the medical and academic communities. Limited research has been undertaken and published pertaining to the utilisation of fingerprint patterns in discerning the distribution of said patterns among individuals of the male and female genders. The primary aim of this research endeavour was to ascertain the prevailing fingerprint patterns among individuals of both genders within the Lucknow and Raebareli populations. Additionally, the study sought to conduct a comparative analysis of the fingerprint patterns observed between these distinct populations.

Methods: The research sample comprised of 200 participants, comprising of 100 individuals from the Lucknow population and 100 individuals from the Raebareli population, within the age range of 18-21 years. Each participant was instructed to apply pressure to their fingertip on the ink pad and subsequently onto the unmarked chart paper in order to transfer the impression of their fingerprint. The fingerprints of all the individuals were successfully identified and categorized into distinct patterns, namely loops, whorls, and arches. The data were subjected to statistical analysis using the Z-test.

Results: The study subjects exhibited a predominance of loops as the prevailing fingerprint pattern. The population of Raebareli exhibited a significantly higher prevalence of loops and arches, while the population of Lucknow demonstrated a greater occurrence of whorls. In our comprehensive investigation, a comparative analysis of fingerprint patterns among the populations of Lucknow and Raebareli regions unveiled a notable disparity in the occurrence of whorls and arches.

Conclusion: A discernible disparity in the dermatoglyphic patterns pertaining to whorls and arches has been observed between the populations of Lucknow and Raebareli. The observed divergence in fingerprint patterns among two distinct populations indicates the need for additional research to explore the correlation between individuals and their respective groups across a wider range of populations.

Keywords: Dactyloscopy, Ulnar loops, Sex Identification, fingerprint, fingerprint patterns.

Introduction

The determination of individuality or identification is a fundamental concern within the field of forensic practise. Several significant parameters commonly observed for the purpose of identification include race, gender, age, skin texture and features, speech and voice characteristics, footprints, deformities, hair characteristics, tattoo marks, scars, occupational marks, handwriting, garments and personal articles, gait pattern, and DNA profile [1-10]. This may result in either circumstantial identification or definitive identification. However, among all these parameters, one that is particularly notable and widely utilised is "Dermatoglyphics." Fingerprints

frequently serve as the stimuli that ultimately contribute to the positive identification of individuals involved in a criminal investigation, including suspects, victims, perpetrators, or deceased individuals.

Dermatoglyphics refers to the scholarly investigation of friction ridges and their patterns formed on the palmar and plantar surfaces. Alternatively, the examination of fingerprints conducted for identification purposes is known as Dactylography. The dermatoglyphics patterns, which are the configurations of dermal ridges that form the human fingerprint, are generated during the

early stages of intrauterine development, specifically between the 7th and 21st week of gestation. These patterns reach their complete formation at approximately 7 months of foetal development. According to the literature, it has been documented that the formation of ridges is influenced by the presence of blood vessel-nerve pairs located at the interface between the dermis and epidermis during the prenatal developmental stage [2].

The capacity of fingerprints to ascertain gender and individual identification has been extensively demonstrated and documented in medical and academic literature. Nevertheless, a limited number of investigations have been undertaken utilizing fingerprints for population identification. The analysis of fingerprint characteristics serves as a valuable tool in the identification and differentiation of individuals and populations. An individual can be characterized in an approximate manner through the analysis of fingerprint patterns, while their unique identification can be achieved by examining the minutiae present in their fingerprints. Fingerprint pattern frequencies play a significant role in characterizing a particular group or population. Several scientific studies have demonstrated that the dermatoglyphic patterns exhibited by fingerprints exhibit a prevalence within specific populations, indicating a higher occurrence of certain fingerprint types within particular populations [2, 4].

Therefore, the primary objective of this study was to ascertain and establish the prevailing dermatoglyphics pattern among diverse individuals in two distinct populations of India, namely Lucknow and Raebareli.

Methods

Sample population

The overall study population comprised of 200 participants who were enrolled as students at two tertiary care hospital. This group was further divided into two subgroups: 100 individuals (50 males and 50 females) belonged to the age group of 18-21 years. The study excluded participants who presented with permanent dermal lesions on their digits, specifically the fingers or thumbs, as well as individuals exhibiting any manual anatomical abnormalities resulting from trauma or pathological conditions.

Fingerprints recording and examination

The utilised materials consisted of an ink pad, white chart paper, and a magnifying lens. Each participant was instructed to perform hand hygiene by thoroughly washing their hands. Subsequently, they were directed to gently press their fingertip onto the inked stamp pad and then onto the blank chart paper in order to transfer the unique fingerprint impression. The identical procedure was replicated for all the digits of both upper extremities. In this manner, the dermatoglyphic patterns of all ten digits were individually captured on the corresponding blocks of the identical sheet of paper.

The fingerprint patterns were examined utilizing a magnifying lens and were classified according to the visual characteristics of ridge lines.

In order to classify the fingerprints in this study, the classification scheme proposed by Galton was used depending upon their primary pattern:

1. Loops 2. Whorls and 3. Arches

Statistical Analysis

The data were analyzed for percentage proportions and compared. Statistical analysis was performed using Z-test and $P < 0.05$ was considered to be statistically significant.

Results

Overall, no 2 or more individuals had a similar type of fingerprint patterns in all the fingers of both hands.

When the analysis of sexual dimorphism was conducted on the aggregated populations, it was observed that males and females exhibited a predominance of loop patterns (52% and 54%, respectively) and whorl patterns (40% and 40%, respectively). Females exhibit a greater prevalence of loops (54%) and whorls (40%), while males demonstrate a higher prevalence of arches (8%). A comparative analysis of fingerprint patterns between males and females was conducted using the Z-test. The results revealed a statistically significant difference (P = 0.002) solely in relation to arches, as indicated in Table 1. This suggests that the distribution of loops and whorls in males and females was relatively similar.

Table 1: Comparison of fingerprint patterns between sexes across both populations

Patterns	Males	Females	Total	Z score	P value
Whorls	**385**	**417**	**802**	−0.143	0.889
Loops	**501**	**564**	**1065**	-1.106	0.267
Arches	**78**	**55**	**133**	2.496	0.002

In the population of Lucknow, it was observed that loops were the most prevalent pattern type, accounting for 51% of the sample. Whorls were the second most common pattern type, comprising 44% of the sample, while arches were the least common, representing only 5% of the sample. In the male

population of Lucknow, the prevalence of whorls was found to be 44%, while arches accounted for 7%. In contrast, among the female population of Kerala, whorls

were less prevalent. Instead, loops were found to be the predominant pattern, accounting for 55% of the

cases. A comprehensive statistical analysis was conducted to compare the various fingerprint patterns observed in the male and female populations of Lucknow. The results revealed significant disparities ($P < 0.001$) solely in the case of arch patterns, as depicted in Table 2.

Table 2: Fingerprint patterns between sexes across Lucknow populations

Patterns	Males	Females	Total	Z score	P value
Whorls	163	203	366	−0.610	0.542
Loops	255	294	549	0.454	0.653
Arches	40	45	85	0.244	0.810

In the Raebareli population, the prevalence of loops was found to be predominant at 55%, followed by whorls at 37%, and arches at 8%. Females in the Raebareli region exhibited a greater prevalence of loops (54%), whorls (37%), and arches (9%) compared to their male counterparts in Raebareli. A comprehensive statistical analysis was conducted to compare the various fingerprint patterns observed in the male and female populations of Raebareli. The results, as presented in Table 3, indicate that there is no statistically significant difference between these patterns.

Table 3. Fingerprint patterns between sexes across Raebareli populations

Patterns	Males	Females	Total	Z score	P value
Whorls	436	366	802	3.194	0.001 (S)
Loops	516	549	1065	−1.479	0.139
Arches	48	48	133	−3.321	0.001 (S)

Upon evaluating the overall patterns exhibited by the study subjects encompassing both Lucknow and Raebareli, it was observed that loops constituted the predominant fingerprint pattern, accounting for 53% of the total patterns identified, surpassing other types of fingerprint patterns. The population of Raebareli exhibited a significantly higher prevalence of loops (55%) and arches (8%) compared to the population of Lucknow. However, the population of Lucknow exhibited a higher prevalence of whorls (44%) compared to the population of Raebareli. The z-test analysis conducted to compare the fingerprint patterns between the populations of Lucknow and Raebareli regions yielded statistically significant differences for whorls (p = 0.001) and arches (p = 0.001).

Discussion

Cummins et al. conducted a study that revealed the influence of both genetic factors and environmental stimuli on the development of ridge patterns. Specifically, they observed that the configurations of these patterns are partially determined by hereditary factors, while also being influenced by accidental or environmental factors that induce stress and tension during foetal development. Finger ridge patterns exhibit a high degree of heritability, possess remarkable durability, and remain unaffected by the ageing process, making them prominent human characteristics. Dermatoglyphic traits are hereditary characteristics that are unique to each individual. They are expected to fulfil a significant role in human biological research. These characteristics are highly advantageous in studies pertaining to population identification [5].

When a cohort consists of individuals who share genetic relationships, the underlying genetic mechanisms governing the formation of fingerprints result in shared qualitative and quantitative characteristics, thereby generating a collective fingerprint uniqueness within the cohort. These prevalent attributes facilitate the distinction among endogamous populations. Forensic anthropology is replete with illustrative instances elucidating the dermatoglyphic disparities among endogamous cohorts predicated on racial, religious, geographical, or caste affiliations [4].

Over the course of the previous century, it has become evident that heterogeneous populations exhibit significant disparities in the prevalence of dermatoglyphic patterns. These transcripts are commonly utilised for the examination of ethnic diversity, genetic factors, and human biology [4]. Therefore, the current study aims to assess the prevailing fingerprint patterns within the population of Lucknow and Raebareli.

In the examination of fingerprint patterns within the male and female cohorts of the entire study population, it was observed that loops exhibited the highest prevalence, followed by whorls and arches. Our findings were consistent with the studies conducted by Rastogi and Pillai [3], Mehta and Mehta [6], and Nithin et al. [insert appropriate citation format]. [7] Females exhibit a greater prevalence of loops and whorls, whereas males demonstrate a higher prevalence of arches. This finding is consistent with the research conducted by Ekerette et al., which demonstrated that females in

the Akwa Ibom state of Nigeria exhibit higher levels of loops compared to males [8].

The present study conducted a comprehensive analysis of fingerprint patterns in both male and female individuals, revealing a noteworthy disparity solely in the case of arch patterns. Likewise, Sangam et al. (2011) conducted a study that unveiled noteworthy sexual disparities in the distribution of fingerprint patterns within the Andhra Pradesh region [9]. The aetiology behind the sexual dimorphism observed in dermatoglyphics patterns can be substantiated by

the notion that variations in heritability and developmental variability between genders may contribute to the manifestation of these patterns [10].

In the Kerala population, the prevalence of loops was observed to be higher compared to whorls and arches. In the population of males in Kerala, there was a higher prevalence of whorls and arches compared to females in Kerala. Conversely, loops were found to be more prevalent among females in Kerala. Additional statistical analysis was conducted to compare the various fingerprint patterns observed between males and females within the Kerala population. The results revealed that there were statistically significant differences observed solely in the case of arch patterns.

In the population of Raebareli, dermatoglyphic patterns were observed, with loops being identified as the most prevalent, followed by whorls and arches. The female population in Raebareli exhibited a greater prevalence of loops, whorls, and arches in comparison to their male counterparts in the same region. Nevertheless, the statistical analysis conducted on the entire fingerprint patterns of both male and female individuals within the Raebareli population revealed no substantial disparity. The findings of this study exhibited a resemblance to the research conducted by Qayyum et al. in Rawalpindi [11].

Upon evaluating the overall patterns exhibited by the entire cohort of study participants, encompassing subjects from both Lucknow and Raebareli, it was observed that loops emerged as the prevailing fingerprint pattern. The population of Raebareli exhibited a significantly higher prevalence of loops and arches compared to the population of Kerala. However, the population of Kerala exhibited a higher prevalence of whorls compared to the population of Raebareli. In continuation of our research, a comprehensive analysis was conducted to compare the fingerprint patterns observed within the populations of Lucknow and Raebareli. The findings of this investigation unveiled a noteworthy dissimilarity in the occurrence of whorls and arches between the two populations. The observed disparity in the frequencies of

dermatoglyphic patterns between two populations can be attributed to the hereditary nature of these traits, which exhibit gradual changes within a given population. However, due to genetic admixture, the resulting variability may be prominently pronounced. The observation that this characteristic is purportedly influenced by multiple genes suggests that the impact of genetic admixture may augment the prevalence of gene heterozygosity [12].

A comprehensive review of the existing literature has yielded no singular study conducted in India that specifically focuses on the comparative analysis of fingerprints within the populations of Lucknow and Raebareli. Hence, our research study stands as the pioneering investigation assessing the prevailing fingerprint pattern within two distinct populations in India. Nevertheless, a number of investigations have been conducted in various nations, including the study by Namouchi in the Tunisian population and the research by Sabir et al. in North African populations, which propose the utilisation of fingerprints for population identification [2].

Conclusion

Dermatoglyphics has been extensively documented as a scientifically rigorous and invaluable methodology for conducting medico-legal, anthropological, and genetic investigations. Given that the heritability of dermatoglyphic patterns is polygenic in nature, it is important to note that the frequencies of arches, loops, and whorls may exhibit variations across different populations. Hence, within the scope of our research, a discernible disparity in the dermatoglyphic patterns between the populations of Lucknow and Raebareli is evident specifically in the categories of whorls and arches. The observed divergence in fingerprint patterns among two distinct populations indicates the need for additional research to explore the correlation between individuals and their respective groups across a broader range of populations.

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