A Comparative Fingerprint analysis of different ethnic groups of Himachal Pradesh

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ABSTRACT:

Fingerprint is the impression left by friction ridges of the fingertips. One of the important uses for fingerprints is to help investigators link one crime scene to another involving the same person. Fingerprints are considered as crucial evidences when it comes to individual identification. The fingerprint examination involves analysis of various details such as fingerprint pattern types, ridge density and minutiae in order to identify an individual. This vast amount of time and efforts could be saved if the investigation proceeds in right direction. Preliminary results using fingerprint pattern dominance in particular ethnicity could help investigation proceed in right direction. This study was conducted over 100 individuals from different regions of Himachal Pradesh with 25 individuals from four different ethnic groups including Brahmins, Rajputs, Schedule Tribes and Schedule Caste. Rolled impressions were recorded and analyzed. Statistically significant database (at level $p<0.05$) was observed in these ethnic groups at the end of the analysis. In the end of this study, it was deduced that ethnic groups do play significant amount of role in fingerprint patterns.

Keywords: Fingerprints, fingerprint patterns, ethnic groups, chi-square test, Himachal Pradesh.

Abbreviations	Fullform
Et. al	Co-workers
&	And
Fig.	Figure
For eg.	For Example
%	Percent
Etc.	Etcetera
i.e.	That is
DNA	Deoxyribonucleic acid
ST	Schedule Tribe
SC	Schedule Cast
Chi-sq.	Chi- square
Gp	Group
ID	Identification
χ^2	Chi-Square Test Statistic
LU	Ulnar loop

LR	Radial loop
WC	Concentric whorl
WSS	Single Spiral whorl
WDS	Double spiral whorl
AP	Plain Arch
AT	Slanted arch
CPL	Central pocket loop
LPL	Lateral pocket loop
TL	Twinned loop
A	Accidentals
TFRC	Total finger ridge count
AFRC	Absolute finger ridge count

Introduction

Establishment of identity is one of the key processes in forensic sciences (Krogman & Iscan, 1986). Fingerprint is one of the most commonly used features in establishment of identity (Dalrymple et al, 2002). Fingerprint is an impression left by the friction ridges of the fingertips (Cumins & Midlo, 1943). The study of ridge pattern of fingers, sole, and palm is known as Dactyloscopy. The word Dactyloscopy origin from the ancient Greek word (daktylos mean "finger") and (skopeo means "look at"). It is the process of comparing two fingerprint impressions which are likely to have same origin or not. Fingerprint is an impression of ridge outline which appears on the anterior surface of finger of the proximal, middle and distal phalanges and same on the thumb (Singla, 2020).

Forensic significance of fingerprints includes it offers a reliable means of personal identification as no two fingerprints are identical. One of the important uses for fingerprints is to help investigators link one crime scene to another involving the same person. Due to their means of identification, fingerprints are highly important in criminal cases, including burglary, murder, or mass disaster incidents (Anon, 2022).

Ethnic diversity in Himachal Pradesh is a reflection of the regions rich historical, cultural, and social fabric, characterized by the presence of various communities, including Brahmins, Rajputs, Scheduled Tribes (ST), and Scheduled Castes (SC). Each of these groups contributes to the unique demographic mosaic of the state, with distinct cultural practices, languages, traditions, and social hierarchies. The Brahmins and Rajputs, historically associated with the priestly and warrior classes, respectively, have played significant roles in the socio-political landscape of Himachal Pradesh. Brahmins are often regarded as custodians of religious traditions, with many serving as priests, scholars, and custodians of sacred texts. Rajputs, on the other hand, have historically been landowners and warriors, with a strong presence in the feudal structures that once dominated the region. Their influence is still evident in the traditional leadership roles they occupy within rural communities (Sharma, 2004). Scheduled Tribes (ST) in Himachal Pradesh including groups such as the Gaddis, Kinnauras, and Lahaulis, inhabit some of the most remote and rugged terrains of the state, such as Kinnaur, Lahaul-Spiti, and parts of Chamba. These tribes have preserved their unique cultures, languages, and customs, often distinct from the mainstream Hindu traditions of the Brahmins and Rajputs. The Scheduled Castes (SC), which include groups like the Chamars, Balmikis, and Halis, have historically been subjected to social discrimination and economic marginalization under the traditional caste system (Singh, 2002).

Thus, the aim of this study was to compare the digital dermatoglyphic prints of ethnic populations residing in North Indian State i.e. Himachal Pradesh. It was an attempt to analyze whether digital dermatoglyphic features can be utilized for individual identification in ethnic population. This study could aid investigator to

presumptively determine the suspect's ethnicity, so that they could continue investigations in right directions while waiting for the friction ridge impression to be processed.

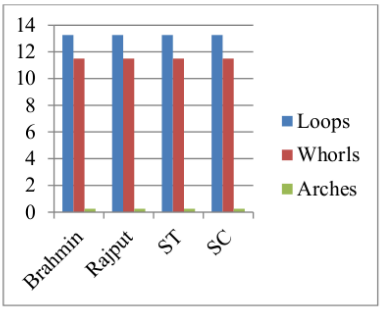
Material and Methodology

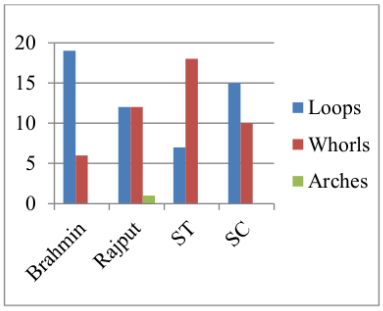
One hundred respondents provided fingerprint samples from both hands, covering every finger. 25 fingerprint samples were gathered for comparison from each of the four communities- Brahmin, Rajput, SC and ST. There were total of 1000 fingerprint samples collected. The individuals whose fingerprints were taken belonged to all age groups varying from age of 10 to 80 and were residing in various districts of the state i.e. Kangra, Chamba, Shimla, Solan, Kinnaur, Lahaul- Spiti, Una, Hamirpur, Bilaspur, Mandi.

The ink was applied evenly on the surface of the fingers after cleaning it thoroughly and then it was placed on the paper and rolled from nail edge to nail edge and little pressure was applied on the finger so that smudging of the fingerprint was avoided. Thus, the rolled finger impressions were obtained on the allotted space for that finger on the A4 sheets. Fingerprints were collected on a Performa, with each ethnic group designated by the letters A, B, C and D; persons belonging to those ethnic groups were marked A1-A2, B1-B25, C1-C25, and D1-D25; male samples were marked A/B/C/D-F1, A/B/C/D-F2,....A magnifying glass was used for the sample analysis. Using a magnifying lens, the fingerprint pattern types visible on the fingers were examined, and the type of pattern found on each finger of the individual was noted.

Results and discussion

The chi-sq. Statistical test of independence was used to validate the significant differences in the data of the ethnic groups analyzed.





a) Expected frequency of dominant fingerprint pattern in ethnic groups

b) Observed frequency of dominant fingerprint pattern in ethnic groups

For Brahmin group, the chi-sq. value was 2.494 for Loops, 2.630 for Whorls, 0.25 for Arches. For Rajput group, the chi-sq. value was 0.118 for Loops, 0.022 for Whorls, 2.250 for Arches. For ST group, the chi-square value was 2.943 for Loops, 3.674 for Whorls, 0.25 for Arches. For SC group, the chi-square value was 0.231 for Loops, 0.196 for Whorls and 0.25 for Arches.

To obtain the chi-square statistical value, chi-square value of each dominant pattern of all the ethnic groups were added to calculate sum of chi-square value. The final chi-square statistical value obtained after the sum of all chi-square values was 15.308. Once the chi-square value was obtained,

degree of freedom at 0.05 significance level was determined which came as 6. From the chi-square distribution tables, the critical value was calculated which came as approx. 12.592.

The percentage value of loops in Brahmin group was 76%, 24% for whorls and 0% for arches, in Rajput group loops were 48%, Whorls were 48% and arches were 4%, in ST group loops were 28%, whorls were 72%, arches were 0%, in SC group loops were 60%, Whorls were 40% and arches were 0%

Sr. No.	Ethnic groups	Loops	Whorls	Arches
1.	**Brahmin**	76%	24%	0%
2.	**Rajput**	48%	48%	4%
3.	**ST**	28%	72%	0%
4.	**SC**	60%	40%	0%

Percentage value of fingerprint patterns among the four ethnic groups

Chi-square statistical value (15.308) is compared with critical value (12.592). Since 15.308>12.592, the null hypothesis was rejected. This concluded that there is significant association between ethnic groups and dominant fingerprint patterns at 0.05 significance level.

Discussion

Comparative fingerprint analysis between the two ethnic groups i.e. Rajput and Brahmin was conducted among the individuals of district Solan and Shimla by Baryah and Krishnan in 2020. According to their study most commonly occurring patterns are Loops followed by whorls, composites and finally arches in both the ethnic groups.

In present study, 1000 samples from four ethnic groups of all age groups were collected and were analyzed on the basis of fingerprint pattern-types. For each finger, its fingerprint pattern was determined and then dominant fingerprint pattern of the fingers of each individual was recorded. Once all the dominant fingerprint patterns among each ethnic group were determined, the dominant fingerprint pattern variation among the sexes of each ethnic group was also determined to check whether gender plays any role in pattern dominance. Loops were found dominant whereas whorls were found less in Brahmin group, Loops and whorls were equals dominant among Rajput group, Whorls were found dominant in ST group whereas SC group has loops dominant but had significant amount of whorls in them. After the statistical analysis, it was clear that ethnicities do play significant role in fingerprint pattern distribution but gender plays no role in these variations.

The previous studies of dermatoglyphics pattern variation like Baryah and Krishnan (2020) were conducted on two ethnic groups i.e. Brahmin and Rajput only, also the age group of the individuals whose samples were taken were mostly young adults. While the present study was conducted over individuals from four ethnic groups belonging from different age groups. Statistically using Chi-sq. of independence test, the alternate hypothesis is accepting here while the null hypothesis is rejected.

This suggests that there is significant association between ethnic groups and dominant fingerprint patterns at 0.05 significant levels. This concludes that the distribution of fingerprint pattern varies across different ethnic groups. Chi-sq. of independence test is also used to check whether gender plays any role in

pattern dominance. Here, the null hypothesis is accepting whereas the alternate hypothesis is rejecting which suggests that gender does not have any role in these pattern dominances among the ethnic group.

Conclusion

Fingerprint pattern analysis plays an important role in criminal investigation. This study was focused on application of dominant fingerprint pattern analysis data from the four ethnic groups of Himachal Pradesh. The data from this study could be used as preliminary analysis for future reference purpose in order to provide direction for the investigation that the particular fingerprint pattern found might belong to a particular ethnic group.

This study investigated the distribution of dominant fingerprint patterns (loops, whorls, and arches) within and between various ethnic groups as well as between the sexes. With 25 members from each of the four ethnic groups—Brahmin, Rajput, ST, and SC—four groups were specifically examined. To ascertain whether there was a significant correlation between the distribution of fingerprint patterns and ethnic group as well if there's any role of gender in these variations, a Chi-sq. test of independence was performed. Every individual from all four ethnic groups had their fingerprint patterns recorded. As well as to investigate any correlations between dominant fingerprint patterns and gender, data on sex (male/female) were also gathered along with age and place.

After analysis, the result was deduced using chi-sq. statistical test which suggested that ethnicity play significant role in pattern distribution while gender doesn't play much role in pattern distribution among those ethnicities. The statistical test verifies these results and indicates that the observed differences in the fingerprint patterns among the four ethnic groups are statistically significant. This suggests that ethnicity might influence the distribution of the dominant fingerprint patterns. This analysis has found the evidence that different ethnic groups tend to variations in their dominant fingerprint patterns. For eg: Brahmins predominantly have loops, whereas ST group predominantly have whorls. The variation in patterns across group is unlikely to be due to random chances, indicating a potential underlying relationship between the ethnicity and fingerprint patterns.

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