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Analysis and Detection of Thumbprint Creases within 3 Generations of a Family in the Population of Himachal Pradesh

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Abstract

Fingerprints are the unique features that provide individuality. As one of the biometric traits, fingerprints are the most reliable and accurate method. They are considered one of the most significant types of evidence in court of law. Since ridges and valleys form fingerprint pattern, sometimes secondary creases or white lines break the pattern which are adjacent to epidermal ridges. Creases appear as straight, curved and jagged white lines which also act as a parameter for fingerprint identification purpose. However, the identification of these fingerprint impressions can be altered by various factors such as dryness, injuries, deformities, dirt etc., by which the results may be altered or the significant rate of identification would decrease. In order to improve the performance of detection, this study is aimed to detect creases in thumbprints and to determine any genetic inheritance among three generations within the family. The study is done by taking samples from 15 families of Himachal Pradesh geographical region, which include grandfather, grandmother, father, mother and their child or children. It has been examined that there might be a link between the genetic inheritance of fingerprint creases within three generations of a family as 53.3% families showed inheritance from 1st to 3rd generation. And secondly, the average crease count in females have higher on left thumb (1.86) and males on right thumb (2) within the geographical region of Himachal Pradesh. It has been observed that the right thumb creases are slightly higher as compared to left in the population of Himachal Pradesh.

Keywords: Thumbprint; creases; identification; generation; inheritance; population; variation.

1. Introduction

Fingerprints are a unique pattern made from epidermal ridges and valleys containing small minutiae on the finger skin that are used to identify the individual. Ridges are the raised lines that run on the epidermal layer parallelly, which helps in gripping and holding various objects. Whereas, the space in between the epidermal ridges is called a valley or furrow. Uniqueness and permanence are the properties that make the fingerprint useful for identification and verification of an individual. The identification of a person involves 3 levels. Level 1 includes details like fingerprint patterns, e.g., arch, loop, whorl and composite pattern. Level 2 consists of features such as minutiae (Galton characteristics), e.g., dot, bifurcation, spur, crossover, ridge ending, etc. Level 3 contains features of ridges, i.e., ridge density, white lines or creases, pores and any kind of permanent scar {1}. The identification and detection of fingerprints is generally done by means of analyzing the features, like minutiae. But sometimes the development of fingerprints gets rugged and lacking clarity, it leads to poor detection. Then creases can also be considered as a parameter to improve the performance of detection. Creases can be defined as the stripes or lines crosses the epidermal ridges and break the pattern. They can be temporary or

permanent. It appears white because that area does not come into contact with the substrate (inkpad) and is therefore not developed. Sometimes, it appears due to aging, manual labor, and self-infliction to fool the biometric system [2].

In the past, limited studies have been conducted on fingerprint white lines or creases and the genetic inheritance of fingerprint creases. A study concluded that the white line count is a useful method for sex determination and shows that females tend to have a high white line count as compared to males, who have no or fewer white lines [3]. Whereas a similar study was conducted on the Hausa population concluded that the mean FWLC (fingerprint white line count) was higher in females in all ten digits of the hand [4]. And who also concluded that the number of white lines present on the left digit was greater than that of the right digit [4]. In another study conducted on adult Nigerians, concluded that white lines are a potential method for sex determination among adult Nigerians of Hausa ethnic origin. Females had a significantly higher mean FWLC value (2.24 ± 2.03) than males (0.85 ± 1.29), or the absence of white lines is of male origin [5]. Meanwhile study conducted on fingerprint white line counts in the population of the Philippines. Similar results were found in previous studies, showed males were more likely to have a 0 white line count as compared to females having 2 or more. The results also support the determination of sex interference in Filipinos on the basis of fingerprint white line counts [6]. Whereas a recent study was done in order to establish the significant difference between fingerprint white lines among the Yogyakarta population. Similar results were found, with females having a greater white line count than males. And fingerprint white line count acts as a tool for gender interference among the population of Yogyakarta [7]. Females have higher metabolic age, visceral fat, and body fat and are observed to have a higher FWLC than males; the FWLC of the left thumb correlates with visceral fat [8]. The fact that parents contribute half of their DNA to their offspring or their genetic blueprint. It determines various characteristics of an individual, like skin color, height, etc. Studies showed that more than one gene may be involved in the dermatoglyphics, but the results are not simple; there are variations in the formation of the fingerprints [9]. Patterns of the fingerprint can be inheritable, but minute characteristics can't, which makes the fingerprints unique to each individual. In the case of the genetic inheritance of fingerprint characteristics, few studies have been done. A study concluded that the inheritance of particular genes involved in the dermatoglyphics said to be transmitted by carriers to their offspring among Habbanite and other populations may lack certain genes or other factors involved in the fingerprint characteristics. He hypothesized that fingerprints have an inheritable quality [10]. Meanwhile a study examined the link between the fingerprints and genetics and showed that fingerprint patterns were very similar within the family, with only small variations in the fingerprint characteristics, which makes them unique. He also concluded that the arch and loop would be the dominant patterns, and analyses showed that there is a small difference between the fingerprints of siblings [11]. Another study which was done on monozygotic and dizygotic twins confirmed that the ridge count is predominantly genetically influenced. And results stated that the left-hand fingers have a negatively heritability index that corelates with higher arc pattern frequency, while the right-hand fingers are positively associated with loop pattern and negatively associated with whorl pattern [12]. Meanwhile similar kind of study has been done on identical twins in order of analysis of fingerprints and palmprints. And results illustrated that there is variation observed in ridge count, ATD angle and pattern type in identical twins [13]. The present study was set to achieve the following objectives: (i) sex determination from thumb creases (ii) genetic inheritance of creases within three generations of a family, among population of Himachal Pradesh.

2. Methodology

In the present study, random sampling of 15 families with 3 generations including grandparents, parents and child or children was done. The study took place in the geographical region of Himachal Pradesh. A total of 82 individuals were randomly chosen for the study (out of which 39 were males and 43 were females). The study involved the collection of biodata of individual including age, sex and generation of family. Informed consent had been obtained from the individuals. Individuals without any physical deformities or injuries on the thumbs of both hands were included in the sampling. A pre-designed form consisting of data including names, age, generation and columns for left- and right-hand thumb impression was made. For the impression, black ink was smeared on thumb and impressed on white paper sheet. Plain and rolled thumbprints of both the hands had been taken for analysis. The data so collected was then analyzed with magnifying lens. The white line creases were marked and noted. The number, length and direction of creases were examined and analyzed. Genetic inheritance was observed within three generation of a family by analyzing the presence of creases. The above-mentioned observations were noted carefully.

3. Results and discussion

The main aim of the study of fingerprint creases among three generations of families is to examine the relationship between the fingerprint creases and inheritance patterns and also to find out the link between the fingerprint creases in determination of the sex of individual.

In this study, samples of 15 families were collected with 82 participants and the collected data was formulated and analyzed. The results are formulated in Tables 1-3.

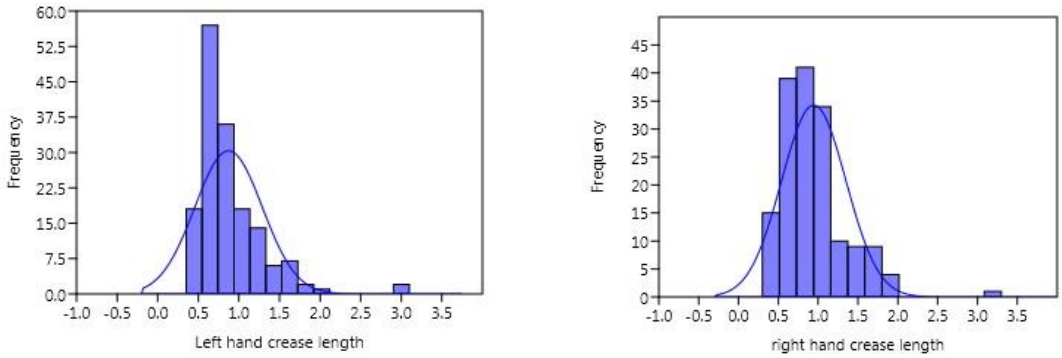
Sex	Participants	No. of Creases		Average Creases	
		Left	Right	Left	Right
Male	39	61	78	1.56	2
Female	43	80	81	1.86	1.88

Table 1: Results of the average no. of creases in both thumbs in males and females

Table 1 shows the average number of creases across the left hand and right thumb for the interference of sex among population of Himachal Pradesh. And it was observed that the average number of creases on left thumb in males (1.56) and females (1.86) and on right thumb in males (2) and females (1.88). Considerably, females tend to have more average number of creases on left thumb and males on right thumb supporting the study done on Hausa population [3].

	Left Hand	Right Hand
Mean	0.8723602	0.9443827
Variance	0.1727469	0.1633664
Kurtosis	9.140547	6.327889
Skewness	2.347641	1.720927
Coeff. Var	47.64411	42.7989

Table 2: Result of variation in left and right thumb creases



Graph 1 and 2 showing the average creases length in both thumbs

Table 2 shows the variation in thumbprint creases of both hands among the population of Himachal Pradesh. By analyzing the following dataset, it was observed that on average (mean), right thumb creases (0.944) are slightly higher as compared to left thumb creases (0.872). While in case of variance, both thumb creases indicating the similar variability. Both datasets show positive kurtosis, with left thumb creases having a higher kurtosis (heavier tails) than right thumb creases. Left thumb creases exhibit a skewness of 2.40, indicating a right-skewed distribution, whereas right thumb creases also show skewness, but to lesser extent (1.72). The coefficient of variation for left thumb creases is 47.67%, and for right thumb creases, it is 42.80%. This indicates the relative variability in comparison to the mean, i.e., for left thumb (0.872) and for right thumb (0.944), with higher values suggesting higher relative variability.

No. of families showing inheritance	Families	Average
Within 3 generations	3	0.2
From 1st to 2nd generation	1	0.066
From 2nd to 3rd generation	0	0
From 1st to 3rd generation	8	0.5
No inheritance within 3 generations	3	0.2
total	15	

Table 3: family inheritance pattern across generations

There's no certain evidence related to zigzag genetic inheritance that has been seen within 3 generations of a family. But based on the presence of creases, Table 3 shows the observed results. 20% of the total, i.e., 3 families, show inheritance within three generations. It indicated that there is a pattern of inheritance that persists through three generations. While 1 family (6.6%) exhibits inheritance from 1st to 2nd generation. And in case of 2nd to 3rd generation, there is no family showing apparent continuation of inheritance pattern. While 8 families (53.3%) demonstrate inheritance from 1st to 3rd generation. And there were 3 families (20%) which do not show any inheritance within three generations. This suggested the variability in inheritance patterns among the observed families even that there is variation in the number, length and inheritance of fingerprint creases in both thumbs of individual among three generation of family.

Research conducted by Sir Taura et al., 2019 concluded that number of fingerprint white lines are significantly different on comparison of both the hands in males and females [4]. Sir Algani et al., 2022 studied that females have higher fingerprint white line count as compared to males [7]. But the result shows that the females have higher average crease count on left thumb while males on right thumb.

Research done on inheritance of patterns by Sir Stalis et al., 1976 assumed that basic fingerprint pattern is ulnar loop and different genes are involved in deviations of fingerprint. He concluded that the transmission of genes affecting the fingerprint characteristics to offspring is done by particular carriers [10]. Sir Brien et. al., 2020 illustrated in their study that a common pattern was passed down to offspring and can make a link where fingerprints between the siblings shows similarities and supports inheritance of fingerprint characteristics [11]. And the present study results show that within three generations, 3 families in total were showing inheritance patterns while 3 were not. And 8 families were showing transmission from 1st to 3rd generation.

4. Conclusion

The present study shows that there may be relationship between crisscross inheritance (transmission of genes from mother to son and from father to daughter and transmission to 2nd generation, i.e., to a grandson or granddaughter through the carrier of the 1st generation) and fingerprint characteristics, which have been observed within 3 generations of families in the Himachal Pradesh region. Whereas in the case of sex interference, females have been observed to have a higher average number of creases in the left thumb as compared to males, who have a higher number in the right thumb in the population of the Himachal Pradesh geographical region. These findings support the previous studies done on the inheritance of fingerprint characteristics through visible and latent fingerprints [14,15] and the possibility of having link between them can be there. If there is any link between them, it can provide valuable information about a person's family relationship. This information may be valuable in missing person cases, paternity testing, and other scenarios where family connections are relevant.

The observation for comparison between the creases of both thumbs and the right thumb has been observed with a higher mean or average and with higher variations as compared to the left hand among the population of Himachal Pradesh. The average crease count is higher in the right hand as compared to left hand. The main takeaway from our study is that, based on this research work, it can be concluded as fingerprint creases can be used for interference with sex.

Novelty: The result from our study concluded that thumbprint creases might be useful in sex interference, as females tend to show a higher average number of creases on the left thumb and males on the right. And if we'll talk about inheritance

patterns between generations of families, then there can be a possibility of association between them, as 53% of families in total show inheritance patterns from the 1st to the 3rd generation, and 20% are those that do not show any such inheritance patterns.

A vast study with a strong and large database and modern tools and techniques can be carried out in order to find out these certain factors or to establish any link between inheritance and fingerprint creases.

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Conflict of Interest

The authors declare that no conflict of interest.

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