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# Sibling and non-sibling fingerprints comparison of Pakhtun population of Swat district, KP, Pakistan

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## Abstract

**Background:** Fingerprint and other ridges are considered to be the best forensic science tool for identification of humans, alive or dead, and even for decomposed bodies. These fingerprint ridges exhibit various static features throughout life which reflect the person biology. This branch gained immense importance since the past few decades in congenital abnormality. This study was to carry out fingerprints analysis of sibling and non-sibling for differentiation and gender identification.

**Methods:** A total of 80 pairs of fingerprints (1600 prints) were collected from persons aged 15 to 30 years using rolling method. Out of which 20 pairs were brother-brother, 20 were sister-sister, 20 were brother-sister and 20 Pairs were random. Each fingerprint was analyzed for the gender identification on the basis of minutiae, ridge density and types. All the fingerprints were analysed using ACE-V method. After comparison SPSS software was used for further analysis.

**Results:** Our result showed that the types of fingerprints identified was whorl (50%) followed by loop (45.25%), arch (4.5%) and 0.25% of the accidental type. The dominant type was whorl while accidental was the least common type of fingerprints. Statistical analysis showed that between the groups, brother-brother and sister-sister was significant while rest of the groups was not significant. Moreover, greater ridge density was observed in female as compared to male.

**Conclusion:** It is concluded that the sibling fingerprints had greater similarity as compared to non-sibling, however both male and female fingerprints were significantly different in term of ridges density. This study may be useful in crime scene investigation.

## Introduction

The science of fingerprints and other related ridges of skin is known as dermatoglyphics. These ridges are most prominent which can be used for the gender identification of a person [1-4] Thus, we can infer from these studies that peculiarity of ridges density is a good feature for gender identification. During 12th to 19th weeks of gestational period, the primary dermal ridges configuration of fingerprints are formed which become fixed and permanent [5,6]. The ridge patterns of fingerprint are reflective of a person's biology because these patterns exhibit different number of unique properties. Statistically, these features of fingerprint vary between ethnic group, genders and age categories which can be used for sex determination [7,8].

The identity of unknown perpetrator on a crime scene can be predicted by the clues to age and gender. The conventional method used for classification of gender have some limitation in term of crime scene investigation because these mostly depend on the bone and teeth availability and other physical feature which allows for age and gender estimation. Fingerprints has a unique nature which persist throughout life without change. It has been used as a biometric for age and gender identification while played important role in the identification of suspect in crime scene [9]. In 2010, Canadian Police reported the crime statistics which showed that crime rate was high in youth, reaching the peak at 18 years of age. The same data showed that crime rate decreased with increase in age [10]. The crime rate at 18-44 year of age was higher while it decreased after 44 years according to the 'crime in India statistics-2010' [11].

Different methods are used by previous studies for identification. Among these methods, fingerprint has proved to be feasible and infallible and superior to the conventional methods [12]. In both criminal and civil cases identification, fingerprint have been use as a biometric sign more than 100 years due to their unique features [8]. Furthermore, the chance of identical fingerprints between two persons is one in sixty-four thousand million population. Identical twins have the same DNA, but their fingerprint is different as any other unrelated person. Therefore, no fingerprint are found to be identical between two individuals [13]. Several studies found weakness in accurately classifying gender [14], while some others have proposed a new method is proposed by comparing different classification rates [15-17].

Gender identification of sibling and non-siblings can be done through fingerprints because of their unique characteristics. Several studies have been performed in the context of gender identification. They encountered males' fingerprints with low density of epidermal ridges than females in different populations [3,4,8,17]. In the current research project, a similar practice has been made to compare fingerprints of siblings and non-siblings sample population to find similarity index and the gender identification. As for the record, no such study has been published over the comparison of similarity index and ridge density among different groups of siblings and non-sibling. The aim of our study was to find out the similarities and differences between siblings and non-siblings' fingerprints on the basis of minutiae.

## Methods

### Study area

This study was conducted in District Swat of Khyber Pakhtunkhwa (KP), Pakistan. The district is inhabited mostly by Yousafzai tribe while different smaller tribe are also present. Majority of the people speak Pashto language, but various other languages are also spoken by a small number of the local populace.

### Sample collection

After taking approval from the Institutional Ethical Committee, the samples were collected anonymously. Before taking fingerprints samples, inform consents were obtained from each individual or their guardian. A total of 80 pairs of fingerprints (1600 prints) samples were collected in which 60 pairs were siblings (sister-sister = 20 pairs, brother-brother = 20 pairs, brother-sister = 20 pairs) and 20 pairs were non-siblings with the age range of 15-30 years. Individuals below 15 or above 30 years of age were excluded. Individuals with finger injuries, severe deformity such as congenital and polydactyl were also excluded from the study.

### Procedure and Identification of Fingerprints

An informative file of white paper was made which contain blocks for fingerprints of both hands and age. Each participant hands were ensured to be clean prior to taking fingerprints. The volunteer was then guided according to the procedure to keep their arms on the table or other comforts to avoid rolling of the finger. The fingerprints of both hands were taken by touching the bulb of finger on the paid and insured that the ink spread in the same proportion of the bulb. In case of blurring, fingerprint was retaken from the same participant and then the participant was asked to clean their hand with wipes or tissue. ACE-V method were used for comparison of fingerprint [18]. Different types of fingerprints including Composite, Loops Arches and Whorls were first identified and then the points and ridges of fingerprint were compared on the 8, 12 and 16 points after zooming 4X. After zooming fingerprints

ridge density, matching and mismatching point were obtained. All the data were analyzed using IBM SPSS Statistics v 21 (IBM Inc. USA) by applying comparison mean and descriptive statistics.

## Results

A total of 1600 fingerprint were observed in the present study in which 20 pairs were collected from brother-brother, 20 from sister-sister, 20 from brother-sister and 20 pairs from random male and female. Out of 1600 fingerprint, some fingerprints were distorted during samples and are not used in comparison and the remaining 60 pairs in which 15 pairs were sister-sister, 15 were brother-brother, 15 were brother-sister and 15 pairs of random male and female were analyzed. In order to observe the ridges of fingerprint, each were scanned and then zoomed at 2.5x and some were 4x. The fingerprints were compared on 8, 12 and 16 points of identification. The process was done manually in laboratory using ACE-V method instead of software or any database. Figure 1 represents different types of fingerprints identified in the present study population. All the fingers of four groups were analysed for comparison of matching and mismatching. For instance, figure 4 shows both left and right thumb and figure 5 showing left and right index fingerprints comparison of brother-brother, sister-sister, brother-sister and random. The rest of fingerprints of these groups were analysed on the same method.

| Finger | Differences | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Right thumb | Between Groups<br>Within Groups | .266<br>1.872 | 3<br>56 | .089<br>.033 | 2.658 | .057 |
| Left thumb | Between Groups<br>Within Groups | .119<br>1.480 | 3<br>56 | .040<br>.026 | 1.506 | .223 |
| Right index | Between Groups<br>Within Groups | 0.228<br>1.100 | 3<br>56 | 0.70<br>.206 | 3.868 | .014 |
| Left index | Between Groups<br>Within Groups | .142<br>1.189 | 3<br>56 | .047<br>.021 | 2.235 | .094 |
| Right middle | Between Groups<br>Within Groups | .018<br>2.276 | 3<br>56 | .006<br>.041 | .151 | .929 |
| Left middle | Between Groups<br>Within Groups | .037<br>1.051 | 3<br>56 | .012<br>.019 | .666 | .576 |
| Right ring | Between Groups<br>Within Groups | .094<br>1.107 | 3<br>56 | .031<br>.020 | 1.577 | .205 |
| Left ring | Between Groups<br>Within Groups | .052<br>1.045 | 3<br>56 | .017<br>0.19 | .931 | .432 |
| Right little | Between Groups<br>Within Groups | .052<br>1.061 | 3<br>56 | .017<br>.019 | .924 | .435 |
| Left little | Between Groups<br>Within Groups | .022<br>.849 | 3<br>56 | .007<br>.015 | .474 | .702 |

**Table 1:** Fingerprint comparison of left and right hand between group and with group

Table 1 shows significant differences of the ten fingers between groups and within groups. The right index is significant with p- value .014 and the rest of fingers were non-significant in which the right thumb with p- value .057, left thumb with p- value.223, left index with p- value .094, right middle with p- value .929, left middle with p- value .576, right ring with p- value .205, left ring with p- value .432, right little with p- value .435 and left little with p- value.702. Our result showed that the dominant types of fingerprints identified was whorl (50%) followed by loop 45.25%), arch (4.5%) and 0.25% of the accidental type as shown in the figure 3. The result also showed that the fingerprints of sibling and random are quite different in term of right index. Among the fingerprints of four groups, the right index of brother-brother and sister-sister showed statistical difference. Both left- and right-hand fingers were compared on 8, 12 and 16 points.


**Figure 1:** Different types of fingerprint (A) Whorl, (B) Composite whorl, (C) Right loop, (D) Left loop and (E) Arch

In 8-point comparison, 4 points were match and 4 were mismatched. With the 12 points comparison of the same fingers, 5 points were match and 7 points were mismatched and finally with 16 points comparison 7 points were matched and 9 points were mismatched as shown in the figure 2. Both matching and mismatching percentage with 8 points were 50%, while the percentage of matching and mismatching with 12 points were 41.6% and 58.3%. The matching percentage of fingerprint with 16 points were 43.75% and mismatching were 56.25% as shown in the figure 2.

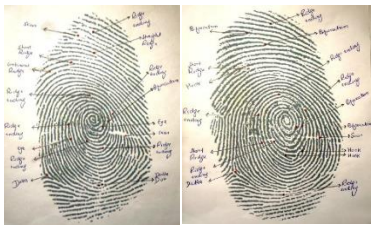

**Figure 2:** Comparison of fingerprint based on 8, 12 and 16 points.

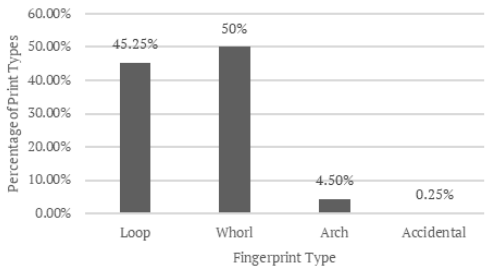


**Figure 3:** Percentage of overall fingerprint types.

| Multiple Comparisons | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dependent Variable fingerprint | (I) groups | (J) groups | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| | | | | | | Lower Bound | Upper Bound |
| Tukey HSD | brother-brother | sister-sister | .14200 | .05117 | .037 | .0065 | .2775 |
| | | brother-sister | .03380 | .05117 | .911 | -.1017 | .1693 |
| | | Random | .13333 | .05117 | .055 | -.0022 | -.0022 |
| | sister-sister | brother-brother | -.14200* | .05117 | .037 | -.2775 | -.0065 |
| | | brother-sister | -.10820 | .05117 | .161 | -.2437 | .0273 |
| | | Random | -.00867 | .05117 | .998 | -.1442 | .1268 |

**Table 2:** Multiple comparison analysis of study population.

| Fingerprint | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Right thumb | 60 | .2603 | .19036 | .02458 | .2112 | .3095 |
| Left thumb | 60 | .2002 | .16466 | .02126 | .1576 | .2427 |
| Right index | 60 | .1874 | .15002 | .01937 | .1486 | .2261 |
| Left index | 60 | .1902 | .15025 | .01940 | .1514 | .2290 |
| Right middle | 60 | .2165 | .19718 | .02546 | .1656 | .2674 |
| Left middle | 60 | 0.1827 | 0.13581 | 0.01573 | 0.1476 | 0.2177 |
| Right ring | 60 | 0.2022 | 0.2022 | 0.01842 | 0.1653 | 0.239 |
| Left ring | 60 | 0.1605 | 0.1639 | 0.01761 | 0.1253 | 0.1957 |
| Right little | 60 | 0.1358 | 0.13738 | 0.01774 | 0.1003 | 0.1713 |
| Left little | 60 | 0.1275 | 0.12144 | 0.01568 | 0.0961 | 0.1589 |

Table 3 provide descriptive statistics including the mean, standard deviation and confidence interval for dependent variable (fingerprints) for each separate group. The right thumb with mean value .2603, Std. D .19036 and CI .2112/.3095, left thumb with mean value .2002, Std. D .16466 and CI .1576/.2427, right index with mean value .1874, Std. D .15002 and CI .1486/.2261, left index with mean value .1902, Std. D .15025 and CI .1514/.2290, right middle with mean value .2165, Std. D .19718 and CI .1656/.2674, left middle with mean value 0.1827 , Std. D 0.13581 and CI 0.1476/0.2177, right ring with mean value 0.2022 , Std. D 0.2022 and CI0.1653/0.239, left ring with mean value 0.1605, Std. D 0.1639 and CI0.1253/0.1957, right little with mean value 0.1358, Std. D0 .13738 and CI0.1003/0.1713, left little with mean value 0.1275, Std. D 0.12144 and CI 0.0961/0.1589.

**Table 3:** Descriptive analysis of four groups fingerprints.

| Left hand Finger | t-Value | df | P-value | Mean Difference | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Left thumb (female) | 25.867 | 42 | .000 | 16.30233 | 13.5510 | 15.8443 |
| Left thumb (male) | 25.440 | 42 | .000 | 13.41860 | 12.3541 | 14.4831 |
| Left index (female) | 24.887 | 42 | .000 | 13.46512 | 12.3732 | 14.5570 |
| Left index (male) | 26.410 | 42 | .000 | 12.18605 | 11.2549 | 13.1172 |
| Left middle (female) | 27.969 | 42 | .000 | 13.72093 | 12.7309 | 14.7110 |
| Left middle (male) | 26.036 | 42 | .000 | 12.25581 | 11.3058 | 13.2058 |
| Left ring (female) | 27.402 | 42 | .000 | 12.27907 | 11.3747 | 13.1834 |
| Left ring (male) | 21.757 | 42 | .000 | 12.44186 | 11.2878 | 13.5959 |
| Left little (female) | 26.203 | 42 | .000 | 16.30233 | 15.0468 | 17.5579 |
| Left little (male) | 22.382 | 42 | .000 | 11.04651 | 10.0505 | 12.0425 |

Table 4 provides statistical value of ridges density between left hand fingers of both male and female of four groups. All the left-hand fingers of both male and female were significant with P-value .0000. The table also provide t-value, mean difference and CI. Left thumb of male with t-value 25.867, CI 13.5510/ 15.8443 and MD 13.41860 and female left thumb with t-value 25.440, CI 12.3541/14.4831 and MD 16.30233, male left index(t-value 26.410, CI 11.2549/13.1172) and MD 12.18605, female left index (t-value 24.887, CI 12.3732/14.5570) and MD 13.46512, male left middle (t-value 26.036, CI 11.3058/13.2058 and MD 12.25581, female left middle (t-value 27.969, CI 12.7309/14.7110 and MD 13.72093, male left ring (t-value 27.402, CI 11.3747/13.1834 and MD 12.44186, female left ring (t-value 21.757, CI 11.2878/13.5959 and MD 12.27907, male left little (t-value 22.382, CI 10.0505/12.0425 and MD 11.04651, female left little (t-value 26.203, CI 15.0468/17.5579 and MD 16.30233.

**Table 4:** Ridges comparison of both male and female left hand.

| Right hand finger | t-Value | df | P-value | Mean Difference | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Right thumb (female) | 38.856 | 42 | .000 | 17.25581 | 16.3596 | 18.1520 |
| Right thumb (male) | 37.946 | 42 | .000 | 15.69767 | 14.8628 | 16.5325 |
| Right index (female) | 33.830 | 42 | .000 | 13.86047 | 13.0336 | 14.6873 |
| Right index (male) | 32.905 | 42 | .000 | 12.39535 | 11.6351 | 13.1556 |
| Right middle (female) | 25.687 | 42 | .000 | 14.09302 | 12.9858 | 15.2002 |
| Right middle (male) | 29.681 | 42 | .000 | 12.32558 | 11.4875 | 13.1636 |
| Right ring (female) | 25.687 | 42 | .000 | 14.09302 | 12.9858 | 15.2002 |
| Right ring (male) | 25.204 | 42 | .000 | 12.53488 | 11.5312 | 13.5385 |
| Right little (female) | 25.631 | 42 | .000 | 13.04651 | 12.0193 | 14.0737 |
| Right little (male) | 33.475 | 42 | .000 | 12.02326 | 11.2984 | 12.7481 |

Table 5 provides statistical value of ridges density between right hand fingers of both male and female. All the right-hand fingers of both male and female were significant with P-value .0000. Table also provide t-value, mean difference and CI. Right thumb of male with t-value 38.856, CI 16.3596/18.1520 and MD 15.69767, female right thumb with t-value 37.946, CI14.8628/16.5325 and MD 17.25581, male right index t-value 33.830, CI 13.0336/14.6873 and MD 12.39535, female right index t-value 32.905, CI 11.6351/13.1556 and MD 13.86047, male right middle t-value 25.687, CI 12.9858/15.2002 and MD 12.32558, female right middle t-value 29.681, CI 11.4875/13.1636 and MD 14.09302, male right ring (t-value 25.687, CI 12.9858/15.2002 and MD 12.53488, female right ring t-value 25.204, CI 11.5312/13.5385 and MD 14.09302, male right little t-value 25.631, CI 12.0193/14.0737 and MD 12.02326, female right little t-value 33.475, CI 11.2984/12.7481 and MD 13.04651.

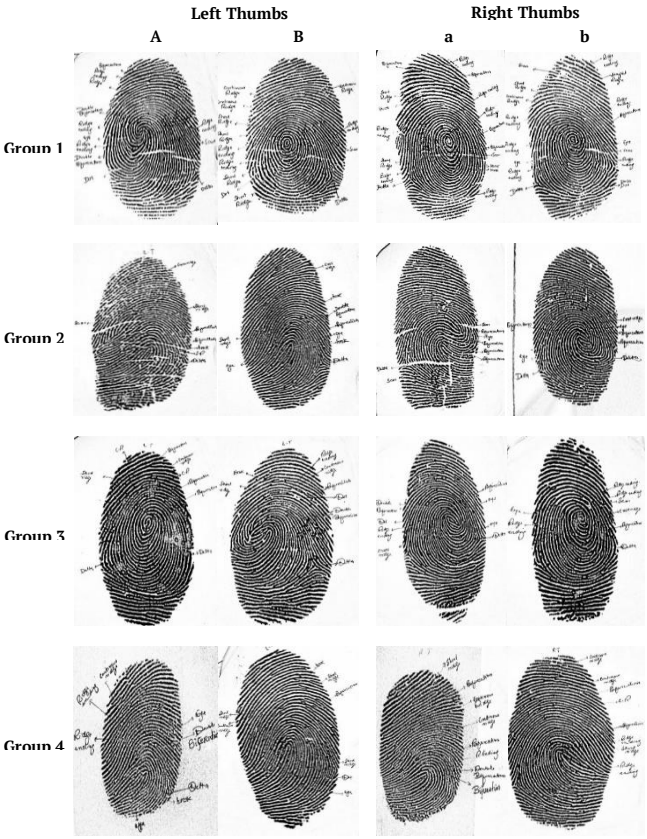


**Figure 4:** Left and Right thumbs comparison of the four groups; (1) brother-brother, (2) sister-sister, (3) brother-sister, and (4) non-siblings. Whereas 'A' and 'B' represent left thumbs while small 'a' and 'b' represent right thumbs of two individuals from the groups.

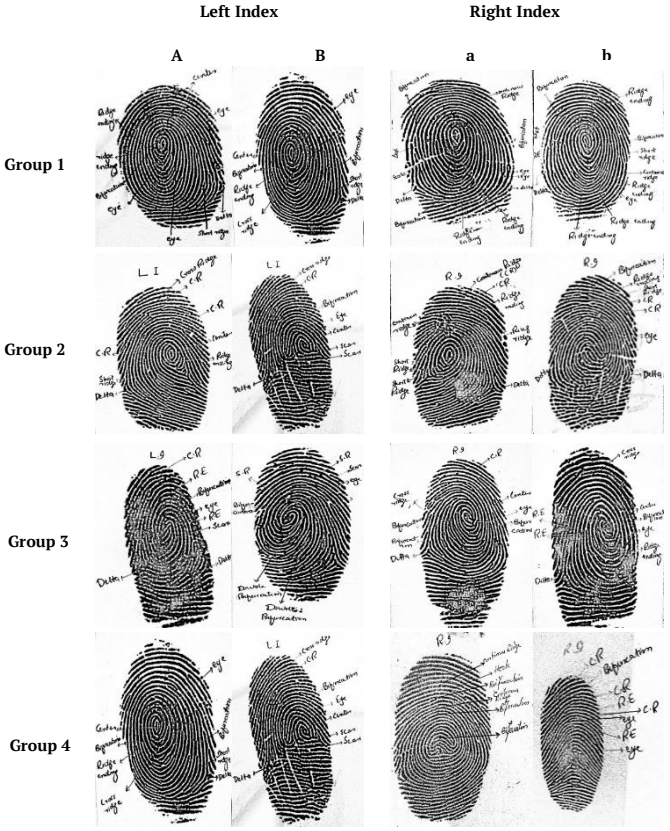


**Figure 5:** Left and Right index comparison of the four groups; (1) brother-brother, (2) sister-sister, (3) brother-sister, and (4) non-siblings. Whereas 'A' and 'B' represent left thumbs while small 'a' and 'b' represent right index of two individuals from the groups.

## Discussion

The study of skin ridges organization of human palm and sole ridges examination is known as Dactylography or dermatoglyphics. The ridges formation starts at the 13$^{th}$ week of development. They start to move back on the thenar and hypothenar area of the hand, tips of digits and in the other similar area of the foot and finally complete at the 19$^{th}$ week of development. These ridges showing variable features from site to site which do not occur in other people or on the different digits of the same person, even in identical twins. Ridges points are undeviating, while these characteristics vary in each individual which are very beneficent in biological studies. In the present study we investigated the sibling and non-sibling fingerprints and we found that the sibling and non-sibling can be recognize and discriminated on the basis of their fingerprints. Overall, four types of fingerprints including loop, whorl, arch and accidental were found in which 50% were whorl, 45.24 % were loop, 4.50% were arch and 0.25% were accidental types. The results showed that the whorl types fingerprint is dominant in all followed by loop, arch and accidental types. The results also showed that whorl types are more common in both sibling and non-sibling fingerprints. The statistical analysis of fingerprint showed that there was no statistically significant difference between the all fingers of four groups except right index which have significant differences with p-value .014. The two groups of both brother-brother and sister-sister with P-value .037, sister-sister and brother-brother with P-value .037 were significant while the rest of the groups were statistically non-significant. The results also showed that the fingerprint of sibling is a little more similar as compared to non-sibling.

Our finding is in agreement with previous studies in term of whorl type [19] and in term of arch type [20] of fingerprints. This study was in disagreement with other studies in the type of fingerprints [19-22]. Our study support the results in term of whorl type dominancy in Mundas tribal [19]. This studies also support the finding of in term of arch types fingerprint distribution which is the least types in monozygotic and dizygotic twins in the same population [20]. However, the finding of the

present study was in disagreement with the studies of earlier studies. The first study on indigenous black Zimbabweans in which the ulnar loop were found the most common type in most sexes, followed by whorl type in male and arch in female [22]. One more study conducted study on 360 unrelated Adi karnataka population of Mysore city of Karnataka State, found the most common types of fingerprint was loop with a frequency of 57.11% followed by whorls (27.89%) and arches (15.00%) [21]. Another study conducted by [19] on the Mundas and Lodhas tribals in West Bengal and found that the loop type was common in Lodhas while Mundas tribal have most commonly whorl and loop types fingerprint [19]. Another study reported in the same population on monozygotic and dizygotic twins that showed that the dominant types of fingerprints was loop followed by whorl and arch [20]. Our study supports this in term of arch type distribution of fingerprint in four different groups of Pakhtun population.

The ridge pattern, volar pad formation are similar in sibling due to genetic especially in monozygotic twins [23]. Non-sibling did not share any genetic information, whereas sibling share 50% information [24,25]. Due to these genetic reasons, the present research revealed that sibling fingerprints inherited from parent to offspring with greater similarity than non-sibling. One more study reported that fingerprints have strong relation with blood group of human [26]. However, for the blood type, individual actually inherit two alleles or two gene from parents [27]. Thus, genetically the fingerprints indirectly inherit from parent to offspring.

In the present study the mean difference in the ridge density of both male and female fingerprint were observed. In female right thumb mean ridge density was (17.25581), left thumb (16.30233), right index (13.86047), left index (13.46512), right middle (14.09302), left middle (13.72093), right ring (14.09302), left ring(12.27907), right little (13.04651) and left little (16.30233) and male right thumb (15.69767), left thumb (13.41860), right index (12.39535), left index (12.18605), right middle (12.18605), left middle (12.25581), right ring (12.53488), left ring (12.44186), right little (12.02326) and left little (11.04651). It is concluded from the above observation that female ridges density is more than male and female have thin ridges as compared to ridge density of male in all four groups. By applying the t-test, in both male and female which shows that the ridges density of both male and female fingerprint have significant difference with p- value (.000). The ridge density may vary among male and female fingerprints reported by previous studies. Among them, the one study reported by [28] in which palm dermatoglyphics of 809 individuals of both male and female in Sardinian population. They found that ridges density in male is greater than female [28]. One more study reported by [8] and he suggested 13 ridge is more common in male and 14 ridges in female fingers [8]. Another study conducted in Chinese population by [4] and suggested more than 13 ridges is of female origin and 12 ridges in male, which shows that significant differences is present in which the female ridges density is greater than male [4]. The ridges density of 13 in female and 11 or less in Malaysian population were common reported by [4]. The ridges density greater than 17/25 mm2 in female and less than 16 in female in Spanish Caucasian were reported by [3]. The findings of the present study support the earlier studies of Federal Bureau of Investigation in 1998. They found that ridges density of both male and female in Caucasian American and African American are significantly different. The finding of ridges density in both sibling and non-sibling is greater in female than the male of sibling and non-sibling.

It may be concluded that enormous information is available regarding the fingerprint ridges distribution, pattern, minutiae and density. The most common type of fingerprint among four groups was whorl followed by loop. Arch and accidental were the least observed type of fingerprint. This study also showed that the fingerprints of four groups have no statistical difference except right index showing statistical differences. This study demonstrates that between groups, brother-brother and sister-sister are significantly different while the rest of the groups have no statistical differences. Moreover, this study also showed that the fingerprints of sibling is more similar as compared to non-siblings, however both male and female fingerprints were significantly different in terms of ridge density. Consequently, this study may help crime scene investigation.

## Competing interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

## Authors' Contribution

Subhanuddin and Noor Ullah Khan collected the samples and performed the experimental work. Aftab Ahmad and Murad Ali Rahat analyzed the data. Naseer Ullah, Fazal Akbar, Muzafar Shah and Akhtar Rasool helped in writing the manuscript and reviewing of the data. Muhammad Israr was PI of the study.

## References

1. Acree MAJFsi. Is there a gender difference in fingerprint ridge density? Forensic Science International, (1999); 102(1): 35-44.
2. Ceyhan EB, Sağiroğlu Ş. Gender inference within Turkish population by using only fingerprint feature vectors; 2014. IEEE. pp. 146-150.

3. Gutiérrez-Redomero E, Alonso C, Romero E, Galera VJFSI. Variability of fingerprint ridge density in a sample of Spanish Caucasians and its application to sex determination. Forensic science international, (2008); 180(1): 17-22.
4. Nayak VC, Rastogi P, Kanchan T, Yoganarasimha K, Kumar GP, et al. Sex differences from fingerprint ridge density in Chinese and Malaysian population. Forensic Science International, (2010); 197(1-3): 67-69.
5. Mulvihill JJ, Smith DWJTJop. The genesis of dermatoglyphics. The Journal of Pediatrics, (1969); 75(4): 579-589.
6. Babler WJBdoas. Embryologic development of epidermal ridges and their configurations. Birth defects original article series, (1991); 27(2): 95-112.
7. Badawi AM, Mahfouz M, Tadross R, Jantz RJI. Fingerprint-Based Gender Classification. (2006); 6(8): l.
8. Sudesh Gungadin MJIJoMU. Sex determination from fingerprint ridge density. Internet Journal of Medical Update, (2007); 2(2): 1-4.
9. Maltoni D, Maio D, Jain A (2003) S. Prabhakar,"4.3: Minutiae-based Methods'(extract) from Handbook of Fingerprint Recognition". Springer, New York.
10. Dauvergne M, Turner JJJCCfJS. Police-reported crime statistics in Canada, 2009. (2010); 30(2): 1D.
11. India PSJMOHA, Government Of India, New Delhi. National Crime Records Bureau. (2011).
12. JJUSFBoI H. The science of fingerprints: Classification and uses. (2006).
13. Nithin M, Balaraj B, Manjunatha B, Mestri SCJJoF, Medicine L. Study of fingerprint classification and their gender distribution among South Indian population. Journal of Forensic and Legal Medicine, (2009); 16(8): 460-463.
14. Sumathi G, Jeyasekaran G, Shakila RJ, Sivaraman B, Arunkumar G, et al. Molecular identification of grouper species using PCR-RFLP technique. Food Control, (2015); 51300-306.
15. Rajesh DG, Punithavalli M. Wavelets and Gaussian mixture model approach for gender classification using fingerprints; 2014. IEEE. pp. 522-525.
16. Tom RJ, Arulkumaran T, Scholar MJIJoET, Technology. Fingerprint based gender classification using 2D discrete wavelet transforms and principal component analysis. International Journal of Engineering Trends and Technology, (2013); 4(2): 199-203.
17. Wadhwa R, Kaur M, Singh KJIJoE. Age and Gender Determination from Finger Prints using RVA and dct coefficients. IOSR Journal of Engineering, (2013); 3(8): 2250-3021.
18. Ashbaugh DR. Quantitative-qualitative friction ridge analysis: an introduction to basic and advanced ridgeology. 1999; CRC press.
19. Purkait RJJ. Fingerprint Classification: A comparative study among Mundas and Lodhas. Medico-legal Update, (2003); 14(1): 31-32.
20. Rahat MA, Khan AS, Bibi R, Haris M, Akbar F, et al. Monozygotic and Dizygotic Twins Differences in Fingerprint Patterns of Swat District. Advancements in Life Sciences, (2020); 7(4): 232-236.
21. Gangadhar M, Rajasekhara Reddy KJMiI. Finger dermatoglyphics of Adikarnatakas: a scheduled caste population of Mysore City, Karnataka. Man in India, (2003); 83(1-2): 183-193.
22. Igbigbi PS, Msamati BCJMSM. Palmar and digital dermatoglyphics of indigenous black Zimbabweans. Medical science monitor, (2002); 8(11): CR757-CR761.
23. Li S, Jain A (2009) Encyclopedia of biometrics. 2009. Springer Verlag.
24. Brock J-AK, Allen VM, Kieser K, Langlois SJJoO, Canada G. Family history screening: use of the three generation pedigree in clinical practice. Journal of obstetrics and gynaecology Canada, (2010); 32(7): 663-672.
25. Harden KP, Hill JE, Turkheimer E, Emery REJBg. Gene-environment correlation and interaction in peer effects on adolescent alcohol and tobacco use. Behavior genetics, (2008); 38(4): 339-347.
26. Rastogi P, Pillai KRJJoIAoFM. A study of fingerprints in relation to gender and blood group. Indian Journal of Forensic and Community Medicine, (2010); 32(1): 11-14.
27. DJA C. Facts. ABO blood and human origins. (2008); 37(2): 10.
28. Floris GJAjopa. Sex and side differences and correlations between quantitative palmar characteristics in a sample Sardinian population. American journal of physical anthropology, (1975); 42(2): 277-280.