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Original Research Article

Fingerprint Pattern Distribution In A Cohort of Southeastern Haryana

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Fingerprint pattern, Dermatoglyphic Indices, Pattern Intensity Index, Dankmeijer's Index, Furuhata's Index.

Abstract

Introduction: Fingerprint is the most common method of personal identification in forensic anthropology. Distribution of fingerprint is the most common method of personal identification. Variation in distribution of fingerprint pattern across the India is observed. **Material & Methods:** This study was conducted on 650 individuals comprising of 37.23% females and 62.77% males. **Results & Disscussion:** Fingerprint pattern in all the participants were in the order of Loop > Whorl >Composite > Arch. In male loops were higher than female (56.35% vs 53.88%), while whorl (32.45% vs 33.51%), composite (6.42% vs 6.86%) and arch (4.78% vs 5.76%) were more in female. Dermatoglyphic indices; Pattern Intensity Index (PII), Dankmeijer's Index (DI) and Furuhata's Index (FI) of the present population was 12.11, 15.93 and 59.89, respectively. Applying the Mann Whitney U test to the obtained results, gender differences were found to be statistically insignificant ($p > 0.05$). Comparison of available data was done with other studies and dendrogram. using Ward Linkage method has been drawn based on indices to know the degree of affinity with different population across India. **Conclusion:** The study population in present cohort showed closed ethnic affinity with the population from the central India and UP.

1. Introduction

Fingerprints are the commonest methods used for personal identification in forensic anthropology.[1] The ridges and the valleys on the skin of the human fingertip form distinctive patterns called dermatoglyphics. The term dermatoglyphic (derma – skin, glyphic – carve) was first coined by Cummins and Midlo.[2]

These patterns are developed entirely in utero and are permanent throughout their lifetime. Injuries like cuts, burns and, bruises can temporarily damage the quality of fingerprints but when fully healed, patterns are restored. Prints of these patterns are called fingerprints and the study of these prints in identification is called dactylography.[3] For the purpose of matching the fingerprints, analysis and subsequent comparison of various features of the fingerprint pattern is needed.

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The analysis of fingerprint includes noting of characteristics pattern of ridges and minutiae points which are unique to each pattern.[4] It has been noted that there is normal variation in these traits representing hereditary differences between members of separate populations and within the same population. Hence dermatoglyphics traits are most useful in studying population dynamics.[5]

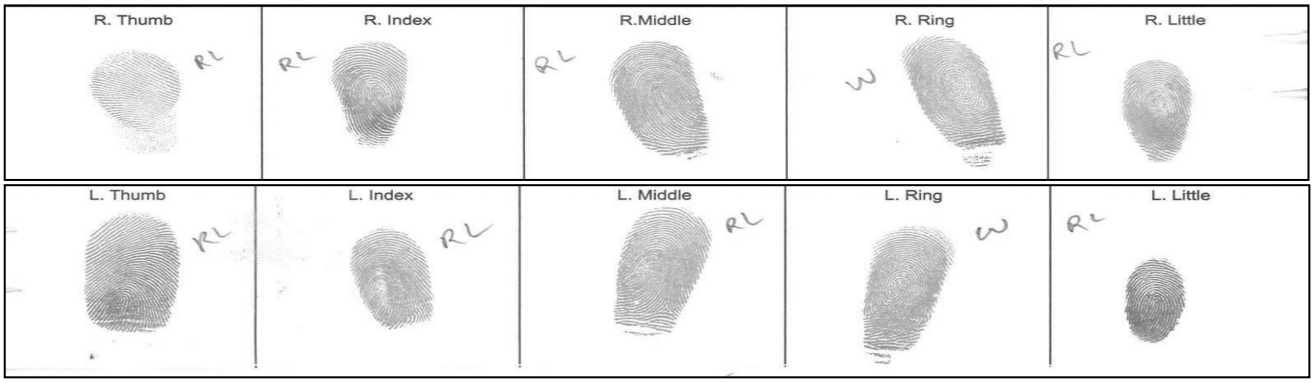
The present study was aimed to estimate the detailed frequency distribution of various fingerprint patterns in the present geographical locations, to establish the most and least predominant patterns, to find out the existence of any statistically significant gender differences, and to compare the results with the population of neighboring states.

2. Material & methods:

After the clearance from Institutional Ethical Committee, a cross-sectional study was conducted between November 2014 and November 2016. The study enlisted the participation of 650 people, with 242 (37.23%) females and 408 (62.77 %) males, with ages ranging from 18 to 66, with a mean of 24.83 years. The participants were chosen through a simple random sampling technique. All subjects were informed about the purpose and nature of the study. Only healthy individuals who have given written consent, were included in the study. Individuals with visible signs of any disease, deformities, injury to the palmer surface of the hand were excluded from the study.

Before taking prints, the subjects were instructed to wash, air-dry their hands. A self-inked pad (Kores India) was placed on a wooden table. The unglazed white bond paper was applied firmly over a wooden pad. The bond paper was divided into two (right and left), and each further into five columns marked as a thumb, index, middle, ring, and little. The subjects were asked to relax their arms and palmer aspects of the distal phalanges of the right hand were inked on the ink pad starting from the little finger.[6]

Fig. 1: Photograph showing the fingerprint impression.



To get a full print of the ridged region of the distal phalanges, the fingers were rolled from side to side. Any external pressure was avoided during the process to ensure that no smudging of the prints occurs. The same procedure was done for recording the fingerprint of the left hand. Thus, fingerprints of both hands were obtained and recorded (**Fig.1**).

Data analysis: The fingerprint obtained on the impression sheet were categorized according to Henery's classification[7] into various groups and subgroups. The observations were recorded on an excel spreadsheet. All types of whorls (concentric, single spiral, double spiral, accidental etc.) were grouped under the category of whorls. The loops were categorized into the ulnar loop and radial loop based on the opening of the loop. The arch was subdivided into plain and tented. All the composite whorls like central pocket loops, lateral pocket loops, and twin loops are grouped under the broad category of 'composite'. A quantitative assessment of the fingerprint pattern of the study population in each sex was done using the following calculations-

- **Pattern Intensity Index** (P.I.I)[8] = (2 x % whorl +1 x % loop) ÷10
- **Dankmeijer's Index** (D.I.)[9] = [(% arches x100)] ÷ % whorl).
- **Furuhata's Index** (F.I.)[10] = [(% whorl x 100)] ÷% loop.

All the observations of the present study were entered in Microsoft Excel 365 (Redmond, Washington USA). After completion, all the data was transferred into SPSS version 23.0 (IBM SPSS; Chicago, IL, USA) and further descriptive statistical analyses were carried out with the same. Applying the Shapiro-Wilk test using a histogram showed the absence of normality of distribution of fingerprint

pattern among the participants. Therefore, the Mann-Whitney U test was used to compare the distribution between male and female participants. The null hypothesis postulated that the distribution of fingerprint patterns is the same in both sexes. Value of $p \leq 0.05$ was decided to reject the null hypothesis. Biological relationships based on the P.I.I., D.I., and F.I. of dermatoglyphic patterns were established using the dendrogram analysis based on ward linkage cluster analysis with other populations of India.

3. Observations and results:

A total of 6500 fingerprints were studied in a total of 650 volunteers (408 males and 242 females) and their patterns were identified. The age of the volunteers was between 17 years to 65 years with a mean age of 24.87 years. Fingerprint patterns in all the participants were in the order of Loop > Whorl >Composite > Arch. The detailed frequencies are shown in **figure 2.** Detailed frequency distribution of major fingerprint patterns in each digit of both hands among both the sex is presented in **table no. 1 and 2.** Ulnar loop pattern was predominant in both males and females and the highest frequency was observed in the middle finger of both the sex. The frequency of tented arch was lowest in both the sex and particularly were absent in left the ring finger in the case of male and in the ring and little finger of both the hands in the case of female. The gender wise distribution of various major fingerprints is presented **in figure 3.**

Figure 2: Pie chart showing digital pattern distribution in all the participants.

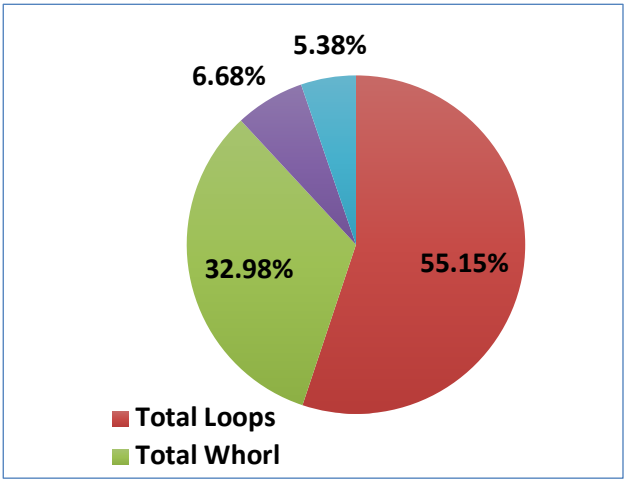


Figure 3: Graph showing different percentages of digital patterns in each sex.

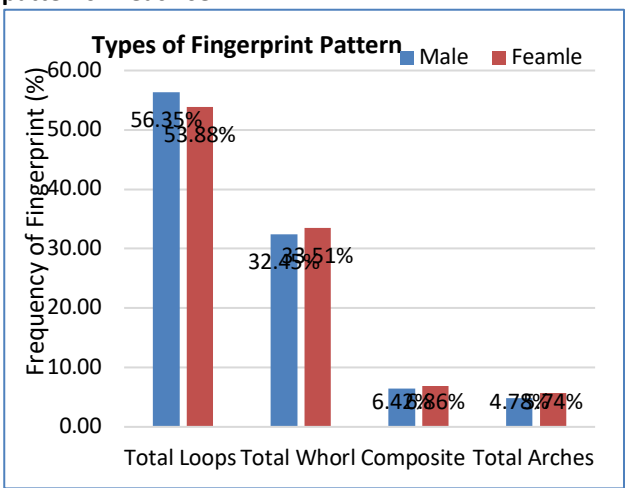


Table 1: Frequency distribution of fingerprints in the males in %

	Fingerprint Pattern						
	Finger	Loops %		Whorl %	Composite %	Arch %	
		Ulnar	Radial			Plain	Tented
Left Hand	Little	11.86	0.69	5.54	1.52	0.34	0.05
	Ring	10.98	1.67	6.18	0.98	0.2	0
	Middle	10.78	0.74	5.78	1.22	1.08	0.39
	Index	9.46	0.74	7.94	1.03	0.34	0.49
	Thumb	7.94	2.84	4.31	2.3	1.42	1.18
Sub Total		51.03	6.67	29.75	7.06	3.38	2.11
Right Hand	Thumb	8.48	2.75	6.47	1.52	0.44	0.34
	Index	7.6	0.29	9.75	0.78	0.98	0.59
	Middle	12.06	0.29	6.86	0.3	0.39	0.1
	Ring	9.9	1.03	6.32	1.61	1.08	0.05
	Little	11.7	0.88	5.74	1.57	0.05	0.05
Sub Total		49.75	5.25	35.15	5.79	2.94	1.13
Combined		50.4	5.96	32.5	6.43	3.16	1.62
		56.36		**32.45**	**6.43**	**4.78**	

Male (N= 408) has a larger mean rank Female (N= 242) in all the digits of both hands and thus tends to take larger values. The distribution of fingerprint patterns compared in both hands and with each sex on the Mann-Whitney U test. The results showed that fingerprint pattern distribution was different in both males and females in all the fingers except in the left thumb, where the difference was insignificant ($p < 0.001$) (**Table 3**). The P.I.I., D.I., and F.I. were calculated from finger pattern types. The overall mean values of P.I.I, D.I., and F.I. were observed to be 12.11, 15.93, and 59.89 respectively. Males exhibited a higher mean P.I.I, while the mean values of D.I. and F.I. were less compared to females. The frequency of fingerprint patterns and indices were compared with previous studies. (**Table 4 & 5**). A dendrogram using the Ward Linkage method has been drawn based on the frequency distributions of P.I.I., D.I. and F.I. reported for various studied populations of India to know the degree of affinity. (**Fig.4**).

Figure 4: Dendrogram of cluster analysis by Wald's Linkage method based on pattern intensity index (P.I.I.), Dankmeijer's index (D.I.), and Furuhata's index (F.I.) showing population affinity of the present study.

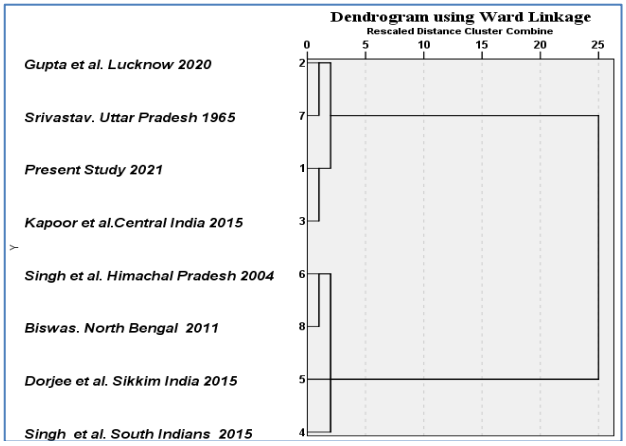


Table 2: Frequency distribution of fingerprints in female in (%)

	Fingerprint Pattern						
	Finger	Loops %		Whorl %	Composite %	Arch %	
		Ulnar	Radial			Plain	Tented
Left Hand	Little	8.6	1.4	8.43	1.16	0.41	0
	Ring	9.59	1.9	5.79	2.15	0.58	0
	Middle	9.67	0.99	6.86	0.41	1.82	0.25
	Index	9.92	1.82	5.7	1.16	0.99	0.41
	Thumb	9.75	0	5.37	2.23	0.99	1.65
Sub Total		47.52	6.12	32.15	7.11	4.79	2.31
Right Hand	Thumb	8.84	0.33	6.78	1.32	1.9	0.83
	Index	9.42	0.74	7.85	1.32	0.33	0.33
	Middle	11.16	0.5	7.11	0.58	0.58	0.08
	Ring	10.41	0.91	5.87	2.48	0.33	0
	Little	10.17	1.65	7.27	0.91	0	0
Sub Total		50	4.13	34.88	6.61	3.14	1.24
Combined		48.76	5.12	33.51	6.86	3.97	1.78
		53.88		**33.52**	**6.86**	**5.74**	

Table 3: Non-parametric test result of frequency of pattern of fingerprints in each digit compared with both sex.

		Left Thumb	Left Index	Left Middle	Left Ring	Left Little	Right Thumb	Right Index	Right Middle	Right Ring	Right Little
Mean Rank	Male	341.16	305.79	330.28	322.22	337.73	329.64	319.08	326.40	324.33	330.67
	Female	299.10	358.73	317.44	331.02	304.89	318.51	336.32	323.98	327.47	316.78
Mann-Whitney U test		42978	41327	47418	48031	44380	47677	46751	49000	48892	47258
Z test		-2.902	-3.784	-.925	-.635	-2.391	-.777	-1.237	-.183	-.224	-1.022
Asymp. Sig. (2-tailed)		.004	.000	.355	.526	.017	.437	.216	.855	.823	.307

Group Variable = Sex

Table 4: Comparison of frequency of fingerprint pattern of the present study with other studies.

Study Population	Sex	N	Loop %	Whorl %	Arch %	Composite %
Present Study 2021	M	408	56.35	32.45	4.78	6.42
	F	242	53.88	33.51	5.74	6.86
Gupta P et al 2020	M	28	55.66	40.28	3.22	
	F	28	56.76	38.57	5.00	
Joshi K 2018	M	100	55	32.5	5.3	7.2
	F	100	58	30	6.2	5.3
Kapoor et al 2015	M	240	52.33	28.17	3.5	16
	F	240	48.17	27.83	5.33	18.67
Singh et al 2015	M	48	42.2	41.08	3.74	-
	F	57	48.2	35.36	6.3	-
Dorjee et al 2015	M	150	64.33	31	4.67	
	F	150	75	21.33	3.66	
Singh et al 2004	M	50	49	49	2	
	F	50	53.33	46.86	1.81	
Srivastav 1965	M	90	54	41.55	4.44	
	F	91	56.15	40.21	3.62	
Banik et al 2009	M	104	47.7	52.19	0.11	
	F	103	42.81	55.69	1.5	
Biswas 2011	M	101	42.16	55.1	2.75	
	F	101	48.24	50.2	1.57	

Table 5: Comparison of fingerprint indices of the present study with other studies.

Study Population		Pattern Intensity Index	Dankmeijer's Index	Furuhata's Index
Present Study 2021	**M**	12.13	14.73	57.59
	F	12.09	17.13	62.19
	M+F	12.11	15.93	59.89
Gupta P et al 2020	**M**	14.16	7.38	73.28
	F	14.32	13.02	68.10
	M+F	14.24	10.20	70.69
Baryah et al 2019	**M**	13.88	12.49	152.7
	F	13.61	12.4	129
	M+F	13.75	12.45	140.85
Kapoor et al 2015	**M**	10.87	12.42	53.83
	F	10.38	19.15	57.77
	M+F	10.63	15.79	55.8
Singh et al 2015	**M**	33.6	6.79	137.4
	F	32.8	13.9	94.4
	M+F	33.2	10.35	115.9
Dorjee et al 2015	**M**	14.17	12.93	104.51
	F	13.92	12.24	89.57
	M+F	10.05	12.59	97.04
Singh et al 2004	**M**	14.7	4.08	100
	F	15	3.41	118
	M+F	14.85	3.75	109
Srivastav 1965	**M**	13.7	10.69	76.95
	F	13.65	9	71.62
	M+F	13.68	9.85	74.29
Biswas 2011	**M**	15.24	4.98	130.7
	F	14.86	3.13	104.07
	M+F	15.05	4.05	117.39

4. Discussion:

Dermatoglyphics have been used to examine the origin and structure of human populations.[11] Its utilization has become increasingly common as the perception grows that they may offer new insights regarding ancient affinities among the native population and variabilities in a multi-ethnic society. This assumption was reinforced by previous accounts that dermatoglyphics portrayed expected ethno historical and geographical patterns convincingly.[12] Comprehensive work done by Bhasin[13] on dermatoglyphics of Indian population supported cast, socioeconomic status, language found that the order of prevalence of whorl, loop, and arch within the overall Indian population was loop>whorl>arch. The same distribution of fingerprint patterns was noted in the present study. Analysis of quantitative characters of fingerprints of the Yadav by Gupta et al[14] in 2020 showed a frequency of loop pattern as the highest followed by whorl and arches.

In 2018, Sahoo[15] has conducted fingerprint analysis of 200 individuals from Punjab, Tamil Nadu, West Bengal, and Rajasthan and found the frequencies of various fingerprint patterns as follows: UL (58%) >W (32%)>RL (5%)>PA (3%)>TA (2%). The results are in consonance with the current study where distribution of fingerprint pattern follows the identical order as UL (49.58%) >W (32.98%)>RL (5.54%)>PA (3.57%)>TA (1.7%) (**fig.4**). General distribution of fingerprint within the present study as shown in **table 4**, agree with the study done by Joshi [16], who studied two hundred individuals from Delhi comprising of an equal number of male and female and found a loop (56.5%) as the most common pattern followed by whorl (31.25%), composite (6.25%) and arch (6%). The geographical proximity of the above population with the present study population might be the explanation for the congruent observation.

On observation of **table no. 5**, the frequency of loop pattern outnumbered the whorl except the study done by Banik et al [17] and Biswas [18]. Both the authors combined the composite pattern of fingerprints like twin loops, lateral pocket loops, central pocket loops, and accidentals in the whorl category leading to an increase of frequency of whorl. The frequency distribution of fingerprint pattern regarding sex showed the high rates of loops in males (56.35% vs. 53.88%) while other patterns (Whorl: 32.45% vs. 33.51%, Arch: 4.78% vs. 5.74%, and Composite: 6.42% vs. 6.86%) were found more in females. This is in contrast with most of the other studies. The reason for this variation could be ethnic diversity.

Cummins and Midlo [2] envisaged the effect of genetic and environmental factors on phenotypic variation of dermatoglyphics. On reviewing the literature myriad studies were conducted in the past to identify the dermatoglyphic traits of the Indian population based on geographical location and according race. On comparison of results of the present study showed the close affinity with the study done by Kapoor et al [19]on the Muslim population of Central India, the Rajput population of Himachal Pradesh done by Singh et al [20], and the work done by Shrivastav et al [21] on the population of Uttar Pradesh. Cluster analysis of the results of previous studies was done, based on PII, DI, and FI, and a dendrogram was obtained. From the dendrogram analysis based on finger pattern indices, it has been observed that the present study population is closely related to populations from Central India and Utter Pradesh. However, the present population is separated from others such as North Bengal [18], South Indians [22], and Sikkim [23].

The present study provides insight into the frequency distribution of various fingerprint patterns in males and females. The importance of the P.I.I. lies in its recognition as a valuable ethnic determinant.[24] Although the study population was not classified in any race in the present study, but the results of cluster analysis showed a racial affinity with the population of the neighboring state.

5. Conclusion:

The present study demonstrated the distribution of the fingerprint pattern was of the order that loops were the most common pattern (55.12%), followed by whorls (32.98%), composite (6.64%), and arches (5.26%) respectively. There was no statistically significant difference in fingerprint pattern found between males and females and among both hands ($p>0.05$). Results of this study were compared with the various population from India and differences were noted. Various indices were computed and compared with other studies. The study population in the present cohort showed a closed ethnic affinity with the population from central India and UP.

Ethical Clearance: IEC approval is taken from the Institutional Ethical committee.

Contributor ship of Author: All authors equally contributed.

Conflict of interest: None to declare.

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