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FINGERPRINT PATTERN ASSOCIATIONS WITH BLOOD GROUPS AND GENDER: FORENSIC AND ANTHROPOLOGICAL INSIGHTS FROM RAYALASEEMA REGION, SOUTHERN INDIA

Zoology

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ABSTRACT

Dermatoglyphics, the study of fingerprint ridge patterns, is a reliable tool for personal identification with applications in forensic science, hereditary screening and medico-legal investigations. This study aimed to examine the association between fingerprint patterns, ABO and Rh blood groups, and gender among university students, and to evaluate their potential forensic relevance. A total of 302 students (aged 18–25 years) from Yogi Vemana University, Andhra Pradesh, India, were included. Fingerprints of all ten digits were recorded using standard ink methods and classified as loops, whorls, or arches. ABO and Rh blood groups were determined by agglutination method. Associations between fingerprint patterns, blood groups, and gender were analyzed using chi-square tests. The sample comprised 71.5% females (male-to-female ratio 1:2.5). Blood group O was most prevalent (38.1%), followed by B (34.2%), A (18.2%), and AB (9.6%). Rh positivity was observed in 97.7% of participants. Loops were the most common fingerprint pattern (54.4%), followed by whorls (34.8%) and arches (10.8%). No significant association was found between blood types A and O, but a statistically significant association was observed between fingerprint patterns and blood types B and AB ($p < 0.05$). Gender differences in pattern distribution were also significant. This first dermatoglyphic study from the Rayalaseema region identifies novel associations between fingerprint patterns, blood groups, and gender, with potential implications for forensic identification. Larger, multi-population studies are recommended to validate these findings.

KEYWORDS

Dermatoglyphics, ABO blood group, gender, fingerprints, Rayalaseema, forensic anthropology

1. INTRODUCTION

The identification of individuals is fundamental to numerous personal, social, and judicial processes. Various techniques, including sex determination, blood grouping, dermatoglyphics, DNA fingerprinting, anthropometry, iris recognition, lip prints, and postmortem examinations, have been developed to meet this need. Among these, dermatoglyphics has proven to be one of the most reliable biometric tools, widely utilized for over 150 years[1,2]. Beyond its applications in medicine, genetics, and anthropology, dermatoglyphics plays a pivotal role in forensic science and forensic anthropology, particularly in disaster victim identification (DVI)[3,4]. In forensic contexts, dermatoglyphics remains indispensable for criminal investigations and victim identification, owing to the uniqueness and permanence of fingerprint patterns[5-7]. Its accuracy underpins the criminal justice systems of many countries worldwide. In medicine, fingerprint analysis is used to detect genetic disorders and chromosomal abnormalities, including Down syndrome and Turner syndrome, offering a non-invasive alternative to traditional sampling methods in diagnostics[1,8,9]. Dermatoglyphics is also a crucial component of anthropometric and population studies[10]. By examining fingerprint patterns, researchers gain insights into genetic diversity, population structure, and evolutionary history[11]. Population-specific traits revealed through such studies can shed light on human migration, genetic drift, and adaptation[12,13]. Recent investigations have also explored associations between fingerprint patterns and personal or health-related characteristics, suggesting correlations with cognitive abilities, intellectual capacity, and predisposition to conditions such as diabetes and hypertension[14-16]. These findings indicate that dermatoglyphics may help predict both disease risk and certain behavioural tendencies[17]. The present study examines the association between fingerprint patterns, gender, and blood groups (ABO and Rh) among postgraduate students of Yogi Vemana University, YSR Kadapa, Andhra Pradesh[18-20]. Few studies have documented dermatoglyphic characteristics in populations from the Rayalaseema region, despite its unique genetic and demographic features[21]. By addressing this gap, the current work aims to contribute to the understanding of regional fingerprint patterns, with potential applications in forensic science, medical diagnostics, and the development of population-specific biometric databases[3,21-23].

2. MATERIAL AND METHODS

Study Design and Setting

This cross-sectional survey was conducted from March 1 to May 30, 2021 at Yogi Vemana University, YSR Kadapa, Andhra Pradesh, India.

Study Participants and Sample Size

The study targeted students aged 18–25 years, using a universal sampling approach to examine the association between fingerprint patterns, ABO and Rh blood groups, and gender. A total of 302 postgraduate students participated.

Inclusion criteria: All eligible students without conditions affecting fingerprint patterns.

Exclusion criteria: Individuals with hand or finger abnormalities, missing digits, permanent scars on fingertips, or webbed fingers were excluded.

Study Tool and Data Collection

A structured survey sheet was used to record participant's demographic details and biometric data. Each participant provided written informed consent. The survey sheet included:

- Name, age, gender, educational qualification
- Blood group (ABO and Rh factor)
- Height, weight, and other genetic traits
- Fingerprint impressions from all ten fingers

Fingerprint Collection and Analysis

Fingerprint impressions were taken from all ten fingers on standardized A4 sheets using stamp pad ink. Participants were instructed to wash and dry their hands before pressing each fingertip on the ink pad and then onto the sheet.

Analysis was performed using a magnifying lens, following Galton's classification (1892)[24]:

- Loops (radial and ulnar): curved ridges returning on themselves; one triradius.
- Arches (plain and tented): ridges crossing from one side to the other; no triradius
- Triradii (ridge intersection points) were recorded for each pattern (Fig.1-3).

Blood Group Determination

Participants' ABO and Rh blood groups were documented. For those

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unaware of their blood group, slide agglutination testing was conducted using antisera A, B, and D.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics for Windows, Version 24.0 (IBM Corporation). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequency and percentages. The Chi-square test was applied to assess the association between fingerprint patterns, blood groups, and gender, with a significance level set at $p < 0.05$. Graphs were generated using Matplotlib (version 3.7.1) in Python.

Ethical Considerations

The study protocol was approved by the Institutional Ethical Committee (IEC), Yogi Vemana University (Proposal No. 03/IEC/VAP/YVU/ZOO/2021-22) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

3. RESULTS

3.1 *Blood Group Distribution*

Among the 302 participants, females comprised 71.5% of the sample, giving a male-to-female ratio of approximately 1:2.5. The most prevalent blood group was O (38.1%), followed by B (34.2%), A (18.2%) and AB (9.6%). Chi-square analysis indicated no statistically significant difference in blood group distribution between males and females ($\chi^2 = 12.34$, $p = 0.006248$). Females showed a higher prevalence of blood group O, whereas blood group B was most common among males (Table 1, Fig. 4).

3.2 *Rh Factor Distribution*

Overall, 97.7% of participants were Rh-positive (Rh), while 2.31% were Rh-negative (Rh). Among Rh individuals, O (37.7%) was the most common type, followed by B (33.1%). The least common were A and O , each accounting for 0.33% of the population. The chi-square test showed no significant association between Rh factor and ABO blood group ($\chi^2 = 3.9721$, $p = 0.264488$) (Table 2, Fig. 5).

3.3 *Fingerprint Pattern Distribution by Gender*

Across all participants, loops were the most common fingerprint pattern (54.4%), followed by whorls (34.8%) and arches (10.8%). Loops occurred more frequently among males (41.04%), whereas whorls were more common among females (57.12%). Arches were slightly more frequent in males (11.4%). A significant association was found between fingerprint pattern distribution and gender ($\chi^2 = 24.34$, $p < 0.00001$) (Table 3, Fig. 6).

3.4 *Fingerprint Patterns and ABO Blood Groups*

Loops were predominant in female AB individuals (66.2%) and male O individuals (52.3%). Whorls were most common among female A individuals (37.8%) and male B individuals (46%). Chi-square analysis revealed significant associations between fingerprint patterns and blood group B ($\chi^2 = 33.82$, $p < 0.00001$) and blood group AB ($\chi^2 = 7.196$, $p = 0.02737$), but no association with blood groups A and O (Table 4, Fig. 7).

3.5 *Fingerprint Patterns and Rh Factor*

Loops were more frequent among Rh individuals (55.1%) than Rh individuals (48.6%). Whorls were also more common in Rh (34.4%) compared to Rh (25.7%), whereas arches were notably higher in Rh (25.7%) than Rh (10.5%). A statistically significant association was found between fingerprint patterns and Rh factor ($\chi^2 = 16.72$, $p = 0.000235$) (Table 5, Fig. 8).

3.6 *Fingerprint Patterns across ABO and Rh Blood Groups*

Loops were the most frequent pattern among Rh individuals across all blood groups. Among Rh individuals, blood group B showed a higher frequency of whorls (66.7%), while blood group O exhibited more arches (70%). Chi-square analysis demonstrated a significant association between fingerprint patterns and Rh status within blood group B ($\chi^2 = 25.94$, $p < 0.00001$) (Table 6, Fig. 9).

3.7 *Fingerprint Patterns across Individual Digits*

Loops were most commonly found in the middle and little fingers across all blood groups. Whorls were predominantly observed in ring fingers, while arches were most frequent in thumbs. Significant associations between fingerprint patterns and individual digits were observed for blood groups A ($\chi^2 = 68.98$, $p < 0.00001$), B ($\chi^2 = 21.5854$, $p = 0.005745$), AB ($\chi^2 = 27.70$, $p = 0.000534$), and O ($\chi^2 = 62.9349$, $p < 0.00001$) (Table 7).

4. DISCUSSION

4.1 *Comparison of the Distribution of Primary Fingerprint Patterns* **(Table 8)**

The current study found loops to be the most common primary fingerprint pattern (54.4%), followed by whorls (34.8%) and arches (10.8%). This sequence aligns with many previous studies, although differences in exact frequencies are apparent. The loop frequency observed here closely matches that of Sahito et al[25] (54.45%) and Vinay and Gowri[26] (54.5%). Slightly higher loop frequencies were reported by Bhavana et al[27] (58.9%), Kumar et al[28] (69.14%) and Vankara et al[21] (72.3%). Notably, Saini and Chaudhary[29] (69.1%) and Patil et al[30] (62.35%) recorded even greater loop prevalence, suggesting that population-specific genetic or environmental factors may underlie these variations. The whorl frequency in our study (34.8%) aligns with Rastogi et al[2] (34.9%) and Narayana et al[31] (33.7%), but is higher than those reported by Sahito et al[25] (28.85%) and Vinay and Gowri[26] (28.8%). This supports the idea that whorl prevalence may be more sensitive to genetic diversity across populations. The arch frequency (10.8%) exceeds that reported by Rastogi et al[2] (6%) and Narayana et al[31] (9.7%), but matches Singh et al[32] and is lower than the 16.7% reported by Sahito et al[25]. Higher arch frequencies in certain populations may reflect regional genetic influences or sampling differences. Overall, while loop dominance is a consistent finding across studies, the proportion of whorls and arches appears to vary considerably, reinforcing the importance of population-specific dermatoglyphic research.

4.2 *Comparison of Blood Group Distribution with Previous Studies*

The ABO blood group distribution observed here - O > B > A > AB- is in agreement with studies by Bharadwaja et al, Fayrouz et al, Chaudhary et al, Kc et al, Manikandan et al, Garg et al, Nanda kumar et al and Najan et al[33-40]. Like earlier reports, our study found blood group O more common among females and blood group B more common among males. Conversely, other works- such as Khalid and Qureshi[41], Ghasemi et al[42], Mehta and Mehta[43] and Shrestha et al[44] documented a predominance of group B, while Jaff and O'Brien[45] reported A and O as most frequent. The Rh factor distribution (97.7% Rh^+, 2.31% Rh^-) matches the findings of Bharadwaja[33], Adeyemo et al[46], Khalid and Qureshi[41], Ghasemi et al[42], Mehta and Mehta[43], Fayrouz et al[34], Verma et al[47], Narayana et al[31], and Sudhikshya et al[48], confirming the high prevalence of Rh^+, particularly O^+ and B^+, across multiple populations.

4.3 *Association between Fingerprint Patterns, Gender, and Blood Groups*

The predominance of loops in this study (54.4%) reflects established dermatoglyphic trends [33,49,50.43,47,31,48,37,,38,21,2]. Loops and arches were more common among males (41.0% and 11.4%, respectively), whereas females displayed more whorls, a pattern comparable to findings by Bharadwaja et al[33], Rastogi and Pillai[50] and Sudhikshya et al [48], but differing from Mehdipour and Farhaud[51], who reported near-equal gender distribution. Within ABO groups, loops were most frequent in females with blood group AB (66.2%) and males with group O (52.3%), echoing observations by Shashikala and Aswini[52] and Deopa et al[53]. Whorls predominated in females with group A (37.8%) and males with group B (46%), while arches occurred most in females with group B (13.0%) and males with group AB (13.0%), again aligning with Deopa et al[53].

4.4 *Association with Rh Factor*

Loops were more prevalent among Rh^+ individuals (55.1%) compared to Rh^- (48.6%), consistent with Bharadwaja et al[33], Mehta and Mehta[43], Fayrouz et al[34], Saini and Chaudhary[29], Mahato et al[54] and Rastogi et al[2]. Arches were more common in Rh^-, while whorls were higher in Rh^+. The significant association between Rh factor and fingerprint patterns was particularly strong in blood group B ($\chi^2 = 25.94$, $p < 0.00001$).

4.5 *Digit-wise Pattern Distribution*

Loops were most frequent in the middle and little fingers across all groups, whorls dominated the ring fingers, and arches occurred most in thumbs. This agrees with Smail et al[55] but contrasts with Sudhikshya et al[48] and Vankara et al[21]. Significant associations between individual digit patterns and both ABO and Rh groups further support the genetic influence on dermatoglyphic traits.

5. CONCLUSIONS

This study explored the relationship between fingerprint patterns, ABO blood groups, and Rh blood types among postgraduate students

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at Yogi Vemana University, Andhra Pradesh. The observed association between fingerprint patterns, blood groups, and gender in the present study has broader implications beyond descriptive anthropometry. Both dermatoglyphic traits and ABO blood group antigens originate from the ectoderm during early embryogenesis, suggesting a possible shared genetic and developmental pathway. This raises the prospect that certain genetic loci may simultaneously influence ridge pattern formation and hematological characteristics. Given that fingerprints are unique to each individual and remain unchanged throughout life, they offer a reliable tool for personal and forensic identification. From a regional perspective, the present work contributes rare population-specific dermatoglyphic data from the Rayalaseema region of Andhra Pradesh. The unique demographic and genetic profile of this population may differ from other Indian cohorts previously studied, supporting the development of localized biometric and forensic reference databases. Furthermore, the integration of dermatoglyphic parameters with modern biometric recognition systems, particularly in resource-limited settings, could provide a low-cost, non-invasive tool for preliminary identification when conventional DNA analysis is unavailable. These insights underscore the potential of combining classical anthropometric markers with emerging digital technologies for enhanced personal identification and epidemiological profiling.

ABBREVIATIONS

ABO: Blood Grouping System
Rh: Rhesus factor
χ^2: Chi-Square (statistical test symbol)
p: Probability Value (statistical significance indicator)
SPSS: Statistical Package for the Social Sciences
DNA: Deoxyribonucleic Acid
AB: Blood Group AB

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AUTHORS' CONTRIBUTIONS

Anu prasanna Vankara: framed the concept and methodology. Mariyadasu Perli and Manaswitha Bollu: collection of data through a survey. Anu prasanna Vankara and Ravi Teja Shegu Venkata: compilation of data and statistical analysis. All authors contribute to writing, reviewing, and final editing. All authors read and approved the final manuscript.

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Availability of Data and Materials

The data supporting the findings of this study are available with the first author in the Department of Zoology, Yogi Vemana University.

Declarations

Ethics Approval and Consent to Participate

The Institutional ethical committee (IEC, YVU) clearance was obtained for the study with Proposal No. 03/IEC/VAP/YVU/ZOO./ 2021-22 dated 21.02.2022. Written informed consent was obtained from all participants after explaining the study objectives. The study protocol was in accordance to the Declaration of Helsinki.

Consent for Publication

All authors have approved the manuscript for submission and publication.

Competing Interests

The authors declare that there are no competing interests.

Table-1: Distribution of blood groups based on gender (n= 302)

Blood group	Male (n= 86)	Female (n= 216)	Total (n= 302)
A	14	41	55
B	30	73	103
AB	16	13	29
O	26	89	115
Total	**86**	**216**	**302**
Statistics	**χ^2 = 12.34 ; p= 0.006248 ; p<0.05; N.S**		

N.S. = Not significant

Table-2: Distribution based on Rh factor of blood groups

Blood group	Rh+ve (n= 295)	Rh-ve (n= 07)	Total (n= 302)
A	54	01	55
B	100	03	103
AB	27	02	29
O	114	01	115
Total	**295**	**07**	**302**
Statistics	**χ^2 = 3.9721; p= 0.264488; p<0.05; N.S**		

N.S. = Not significant

Table-3: Assortment of primary patterns of fingerprints based on gender (n= 302)

Types of fingerprint pattern	Males (n= 86)	Females (n= 216)	Total (%) (n= 302)
Loops (% within sex)	409 (47.55 %)	1234 (57.12 %)	1643 (54.4 %)
Whorls (% within sex)	353 (41.04 %)	697 (32.26 %)	1050 (34.8 %)
Arches (% within sex)	98 (11.4 %)	229 (10.6 %)	327 (10.8 %)
Total	860 (100 %)	2160 (100 %)	3020 (100%)
Statistics	**χ^2 = 24.34*; p= <0.00001; p<0.05; Significant**		

Table-5: Display of primary fingerprints patterns in all digits of both hands among Rh+ve and Rh-ve Individuals (n= 302 x 10)

Types of Fingerprint patterns	Rh+ve (n= 295)	Rh-ve (n= 7)
Loops (% within Rh)	(1625) 55.1 %	(34) 48.6 %
Whorls (% within Rh)	(1016) 34.4 %	(18) 25.7 %
Arches (% within Rh)	(309) 10.5 %	(18) 25.7 %
Total (%)	2950 (100 %)	70 (100 %)
Statistics	**χ^2= 16.72*; p = 0.000235; Significant at p < 0.05**	

Table-4: Array of primary fingerprints patterns in all digits of both hands among males, female students of ABO blood groups (n=302 ×10=3020)

Types of Fingerprint patterns	Blood group A (n=55)		Blood group B (n=103)		Blood group AB (n=29)		Blood group O (n=115)	
	Males (14)	Females (41)	Males (30)	Females (73)	Males (16)	Females (13)	Males (26)	Females (89)
Loops (% within males and females in each blood group)	(68) 48.6 %	(222) 54.1 %	(124) 41.3 %	(432) 59.2 %	(81) 50.6 %	(86) 66.2 %	(136) 52.3 %	(494) 55.5 %
Whorls (% within males and females in each blood group)	(61) 43.6 %	(155) 37.8 %	(138) 46 %	(203) 27.8 %	(58) 36.25 %	(31) 23.8 %	(96) 36.9 %	(308) 34.6 %
Arches (% within males and females in each blood group)	(11) 7.85 %	(33) 8.05%	(38) 12.6 %	(95) 13.01%	(21) 13.1 %	(13) 10 %	(28) 10.7 %	(88) 9.8 %
Total	140 (100%)	410 (100%)	300 (100%)	730 (100%)	160 (100%)	130 (100%)	260 (100%)	890 (100%)
Statistics	χ^2 = 1.503; p= < 0.472; N.S at p<0.05		**χ^2 = 33.82*; p= <0.00001; Significant at p<0.05**		**χ^2 = 7.196*; p= 0.02737; Significant at p<0.05**		χ^2 = 0.838; p= 0.65771; N.S. at p<0.05	

N.S. = Not significant

Table-6: Array of primary fingerprints patterns in all digits of both hands among ABO blood group and Rh blood type individuals (n= 302 x 10)

Types of fingerprint patterns	Blood group A (n=55)		Blood group B (n=103)		Blood group AB (n=29)		Blood group O (n=115)	
	Rh+ve (n=54)	Rh-ve (n=01)	Rh+ve (n=100)	Rh-ve (n=03)	Rh+ve (n=27)	Rh-ve (n=02)	Rh+ve (n=114)	Rh-ve (n=01)
Loops (% within Rh of blood group)	274 (50.7 %)	9 (90%)	567 (56.7 %)	3 (10 %)	132 (48.9 %)	12 (60 %)	587 (51.5 %)	3 (30 %)
Whorls (% within Rh of blood group)	223 (41.2 %)	-	307 (30.7 %)	20 (66.7 %)	107 (39.6 %)	5 (25%)	444 (38.9 %)	-
Arches (% within Rh of blood group)	43 (7.96 %)	01 (10%)	126 (12.6 %)	07 (23.3%)	31 (11.5 %)	3 (15%)	109 (9.56 %)	7 (70 %)
Total	540 (100%)	10 (100%)	1000 (100%)	30 (100%)	270 (100%)	20 (100%)	1140 (100%)	10 (100%)
Statistics	$\chi^2 = 0$		**χ^2 = 25.94*; P= <0.00001; Significant at p<0.05**		χ^2 = 1.6915; P= 0.4292; N.S. at p<0.05		$\chi^2 = 0$	

N.S. = Not significant

Table-7: Distribution of primary fingerprints patterns in individual digits of both hands in ABO blood group individuals (n= 302 x 10) (L- loops; W- whorls; A- arches)

Types of fingerprint patterns	Blood group A (n= 55)			Blood group B (n=103)			Blood group AB (n= 29)			Blood group O (n= 115)		
	L	W	A	L	W	A	L	W	A	L	W	A
Thumb finger (% types of fingerprints within each blood group)	57 (51.8%)	31 (28.1%)	22 (20%)	108 (52.4%)	63 (30.5%)	35 (16.9%)	29 (50%)	16 (27.5%)	13 (22.4%)	114 (49.5%)	73 (31.7%)	43 (18.7%)
Index finger (% types of fingerprints within each blood group)	55 (50%)	44 (40%)	11 (10%)	111 (53.8%)	69 (33.4%)	26 (12.6%)	31 (53.4%)	18 (31.0%)	9 (15.5%)	115 (50%)	89 (38.7%)	26 (11.3%)
Middle finger (% types of fingerprints within each blood group)	72 (65.4%)	36 (32.7%)	2 (1.8%)	124 (60.1%)	55 (26.7%)	27 (13.1%)	39 (67.2%)	16 (27.5%)	3 (5.2%)	147 (63.9%)	68 (29.5%)	15 (6.5%)
Ring finger (% types of fingerprints within each blood group)	37 (33.6%)	71 (64.5%)	2 (1.8%)	94 (45.6%)	96 (46.6%)	16 (7.8%)	28 (48.2%)	27 (46.5%)	3 (5.2%)	106 (46.1%)	114 (49.5%)	10 (4.3%)
Little finger (% types of fingerprints within each blood group)	69 (62.7%)	34 (30.9%)	7 (6.4%)	119 (57.7%)	58 (28.1%)	29 (14.07%)	40 (68.9%)	12 (20.6%)	6 (10.3%)	148 (64.3%)	60 (26.1%)	22 (9.6%)
Statistics	**χ2 = 68.98, P =<0.00001; Significant at p<0.05**			**χ2 = 21.5854, P =0.005745; Significant at p<0.05**			**χ2 = 27.70, P =0.000534; Significant at p<0.05**			**χ2 = 62.9349, P =<0.00001; Significant at p<0.05**		

Table-8: Comparison of the distribution of primary fingerprint patterns

Authors and Year	Fingerprint patterns			
	Loops	Whorls	Arches	Composite
Bhavana et al, 2013 [27]	58.9%	29.6 %	11.5 %	-
Narayana et al, 2016 [31]	56.6 %	33.7 %	9.7 %	-
Sahito et al., 2022 [25]	54.45 %	28.85 %	16.7 %	-
Srestha et al., 2019 [44]	51.8 %	40.15 %	8.05 %	-
Saini and Chaudhary, 2019 [29]	69.1 %	25 %	7.35 %	0.7 %
Rastogi et al, 2023 [2]	55.9 %	34.9 %	6 %	3.1 %
Vadde et al., 2020 [55]	55.65 %	33.3 %	8.01 %	3.01 %
Vinay and Gowri, 2019 [26]	54.5 %	28.8 %	16.7 %	-
Patil et al., 2017 [30]	62.35 %	32.9 %	4.7 %	-
Devi et al., 2023 [57]	67 %	31.7 %	1.33 %	-
Najan et al., 2024 [40]	55.76 %	27.6 %	14.6 %	5.4 %
Pratinidhi et al., 2023 [58]	55.23 %	25.75 %	13.94 %	5.05 %
Nanda Kumar et al., 2023[39]	53 %	26.4 %	6.25 %	14.35 %
Kanchan et al., 2016 [59]	57.3 %	38 %	4.5 %	-
Vankara et al., 2021 [21]	72.3 %	24.9 %	2.68 %	-
Mohsin and Hasan, 2020 [60]	59.7 %	35.9 %	4.4 %	-
Singh et al., 2016 [32]	49.76 %	40.16 %	10.8 %	-
Kumar et al., 2023 [28]	69.14 %	26.06 %	4.80 %	-
Varlekar et al., 2024 [61]	53.2%	25.6%	6.3%	14%
Present Study	54.4 %	34.8 %	10.8 %	-

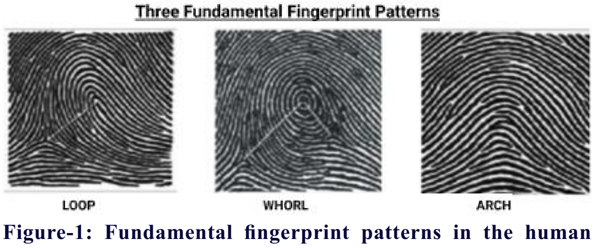

Figure-1: Fundamental fingerprint patterns in the human population

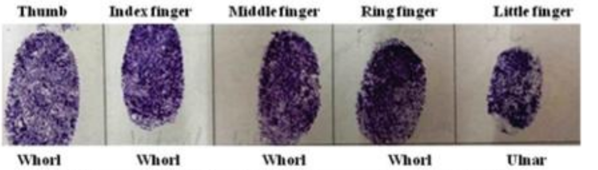

Figure 2: Right hand-rolled impressions (Original)

Figure 3: Left hand-rolled impressions (Original)

Figure - 2 and 3: Fundamental fingerprint patterns in the study population

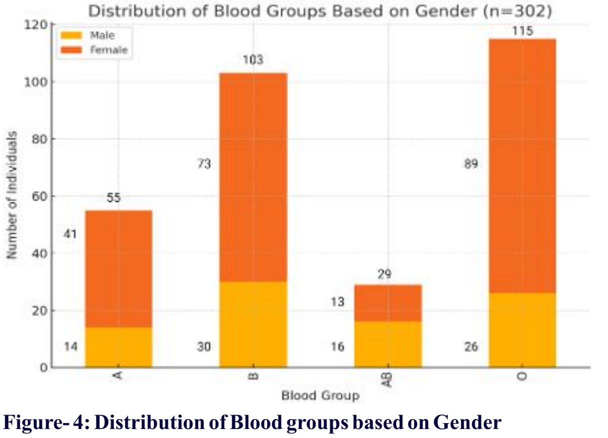

Figure- 4: Distribution of Blood groups based on Gender

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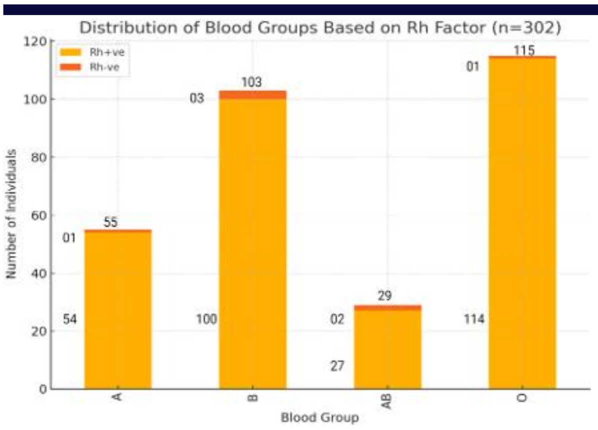

Figure- 5: Distribution of Blood groups based on Rh factor

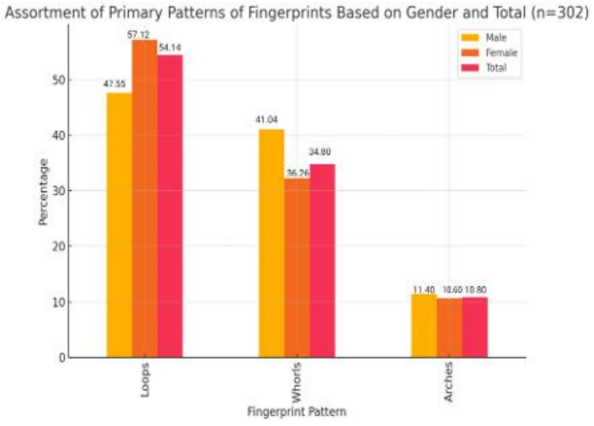

Figure- 6: Assortment of Primary patterns of fingerprints based on Gender

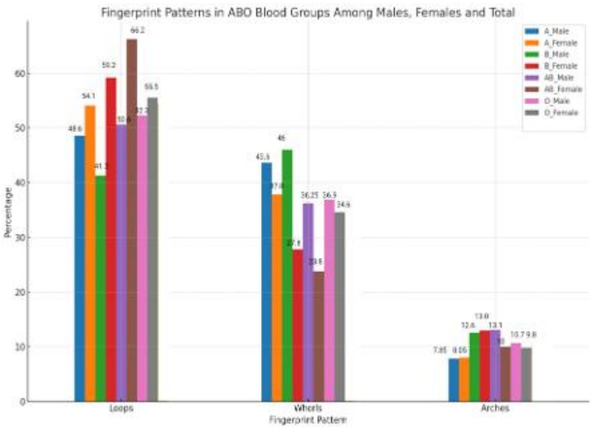

Figure- 7: Fingerprint patterns in ABO groups among males, females and total Individuals

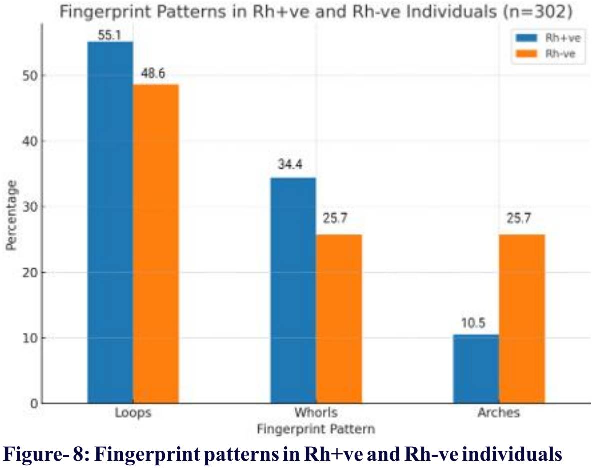

Figure- 8: Fingerprint patterns in Rh+ve and Rh-ve individuals

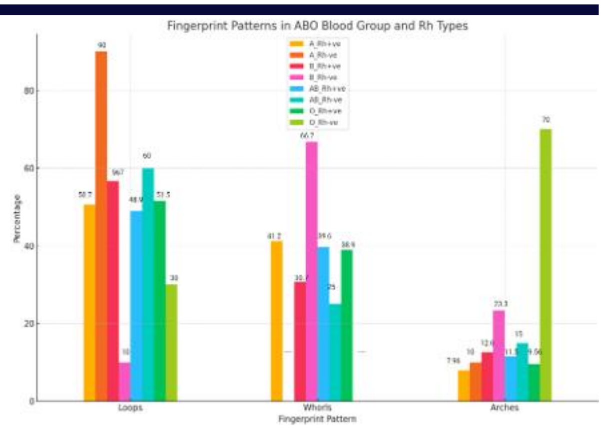

Figure- 9: Fingerprint patterns in ABO blood groups and Rh types

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