FORENSIC CORRELATION OF LIP PRINT PATTERNS, FINGERPRINT TYPES, AND ABO BLOOD GROUPS AMONG EGYPTIAN AND SAUDI ADULT POPULATIONS

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ABSTRACT

Background: Forensic identification can significantly benefit from identifying the relationships between ABO blood groups, fingerprint patterns, and lip-print patterns. This study aimed to explore these associations in 200 Egyptians and 200 Saudis. **Aim of the work:** The main goal was to identify the most common ABO blood types, fingerprint patterns, and lip-print patterns in these populations. Additionally, this study sought to analyze any correlations between these biometric markers, providing valuable data for identification purposes. **Subjects and methods:** The research employed Tsuchihashi's classification for lip prints, Michael Kuchen's fingerprint classification, and the standard agglutination method for ABO blood grouping. **Results:** The study revealed that the ulnar loop was the most common fingerprint pattern across Egyptian and Saudi populations, with blood group A being the most prevalent. Type III (Intersecting grooves) and Type IV (Reticulate grooves) were the most frequent lip print patterns. Statistically significant associations were found between lip print patterns (Types III and IV) and specific fingerprint types (loops and whorls) across multiple quadrants. A notable relationship emerged between blood group O and specific lip print patterns (Types III and IV), indicating a potential correlation between blood group and lip print types. Furthermore, loops and whorls were more commonly linked to blood groups A and O in both populations. **Conclusions:** These results underscore the potential utility of combining these biometric features in forensic applications. Further research with larger samples is recommended to validate these findings and explore additional population-specific patterns.

Keywords: *Forensic Identification; Egyptians; Saudis; Lip-finger prints; ABO-Grouping.*

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INTRODUCTION

Fingerprinting and DNA tests are frequently used to identify sex and ancestry ***(Fonseca et al., 2014)***. In particular, in crime scenarios, several additional tools, such as bite marks, palatal rugae patterns, and lip prints, might be employed for human identification whenever more individualization criteria are needed ***(Srilekha et al., 2014; Best et al., 2017)***.

Dermatoglyphics is concerned with the scientific analysis of the arrangement of epidermal ridges on the volar aspect of the plantar and palmar regions ***(Kucken and Newell, 2005)***. Fingerprints are categorized into three major types: arch, loop, and whorl. Dermatoglyphics is an accepted and trustworthy approach to establishing a person's identity ***(Harsha and Jayaraj, 2015)***.

Sexual dimorphism plays a critical role in forensic identification, aiding in narrowing down missing and suspect person lists. Traditionally, various skeletal features, such as the pelvis, have been analyzed to determine sexual dimorphism, yielding varying levels of accuracy and success ***(Harsha and Jayaraj, 2015; Alzapur et al., 2017)***. While skeletal analysis remains a cornerstone of forensic investigations, alternative methods, such as analyzing lip prints, have gained attention due to their unique and individualized patterns. Lip prints, unlike skeletal features, can provide additional data points for identification, complementing traditional forensic approaches. Because every individual's lip print is distinct and remains constant, it might add some value to sex identification, even among twins. Since lip

prints have distinct labial pattern grooves, they are an essential supplementary tool in criminal investigations ***(Alzapur et al., 2017; Azadeh et al., 2017; Debta et al., 2018)***. Forensically, lip prints are termed Cheiloscopy. According to scientific literature, their applicability is comparable to fingerprints ***(Fonseca et al., 2014; Harsha and Jayaraj, 2015; Alzapur et al., 2017)***. Also, males were shown to have longer and broader lips than females. This variant can assist in narrowing the search gap in forensics and criminal investigations ***(Fonseca et al., 2014; Azadeh et al., 2017; Debta et al., 2018)***.

According to the National Institute of Standards and Technology, the Suzuki and Tsuchihashi system is the most commonly utilized approach in the forensic classification of lip prints, even though at least six other systems of lip-print classification have been documented ***(Prabhu et al., 2013; Gabriel et al., 2019)***. The lip prints can be examined manually or digitally, but the digital process of evaluating lip-print photos allows for improved visibility, recognition, and pattern recording ***(Gabriel et al., 2019)***.

In Suzuki and Tsuchihashi's system, lips' grooves are typed and compared. The examiners can classify the pattern as Type I (vertical), Type I' (prime), Type II (branched), Type III (reticular), or Type IV (undetermined). Identifying lip-print types using cellophane tape and white paper has been successfully used. This method has been mentioned in many scientific research works. Additionally, researchers have studied the patterns linked with gender and have raised the potential that gender might be determined from lip prints ***(Suzuki and Tsuchihashi, 1970; Vahanwala and Parekh, 2000; Joe et al., 2018)***.

Using quadrants (Q1–Q4) to analyze lip print patterns enhances the granularity and precision of forensic identification. Dividing the lip surface into quadrants allows for a more detailed examination of the distribution and type of grooves, which may vary across different regions of the lips. This approach facilitates the identification of unique or dominant patterns that might otherwise be overlooked when considering the lips as a single unit.

The rationale for using quadrants is supported by the work of ***Suzuki and Tsuchihashi (1970)***, who emphasized the importance of localized analysis in their classification system. Quadrant-based analysis has been shown to improve the accuracy of pattern identification, especially in partial lip prints recovered at crime scenes. For example, a print fragment from a specific quadrant can be compared to known patterns within that region, narrowing down potential matches more effectively. Additionally, examining variations in lip print patterns across quadrants provides valuable data for understanding population-specific trends and individual variability. This method has been employed in previous studies ***(Kesarwani and Choudhary, 2021)***, highlighting its utility in distinguishing individuals based on partial or incomplete lip prints.

Karl Landsteiner discovered the blood group system in 1901. Based on the matching plasma antigen, the ABO system further divides blood group types into A, B, AB, and O categories ***(Debta et al., 2018; Farhud, 2018)***. Frequent evidence left at any crime scene can be used for forensic identification. This includes blood remnants, lip prints, and fingerprints. Utilizing these three distinct types of evidence is crucial since attempting to identify a person by other methods, such as DNA analysis, is a sophisticated and expensive process that is challenging to use in every situation ***(Sandhu et al., 2017)***. While research articles comparing and linking each of these three variables; lip print, fingerprints, and ABO system in a few studies ***(Sandhu et al., 2017; Iftikhar, 2023)***, correlations between them need a large number of the study population in addition to inter-population comparisons. A relatively large sample size was chosen for this study to improve the correlation between these three variables among the Egyptian and Saudi populations.

THE AIM OF THE WORK

This study investigates the correlation between lip print patterns, fingerprint types, and ABO blood groups among adult populations in Egypt and Saudi Arabia. The

objective is to determine if these biometric markers exhibit significant associations that could enhance forensic identification methods. The study also aims to explore population-specific patterns and their implications for forensic science.

SUBJECTS AND METHODS

Subjects:

The current study was conducted on 400 participants (equally divided between nationalities and sexes). The participants were recruited from the regular attendants of the Dammam Poison Control Centre pre-employment clinic. All subjects were referred to analyze their blood and urine samples for drugs or substances of abuse as requested by their working administrations. Every participant was aware of the current work aims, and their free consent was obtained to join the research. Their participation was free of personal information disclosure, financial incentives, or further contact from the researchers.

Inclusion criteria: All young Egyptian or Saudi adults (males and females) aged 20 to 35 to avoid age-related lip pathology and to minimize age-related variations in lip prints and fingerprint patterns. This age range was chosen based on findings that lip prints and fingerprints remain stable during adulthood ***(Makesh-Raj et al., 2016)***. Participants with no visible scars, lesions, or deformities on the lips or fingers were approved, ensuring unaltered biometric markers ***(Suzuki and Tsuchihashi, 1970)***. All individuals were inquired about known hypersensitivity reactions to cosmetics, drugs, or materials used in lip print collection, and if any allergy was disclosed, the subject was not allowed to share in the study.

Exclusion criteria: All participants with any form of lip pathology, such as scars, lesions, or deformities, which might distort lip print patterns ***(Kesarwani and Choudhary, 2021)***. Individuals with lesions, scars, or deformities on their right index finger that could alter fingerprint patterns. Subjects with chronic dermatological conditions, such as psoriasis or eczema, that could affect fingerprint patterns. Those who declined to provide informed consent or had incomplete lip print, fingerprint, or blood grouping data were excluded.

Ethical Approval:

The Ethics Committee of the Faculty of Medicine, Alexandria University *(#4266),* and the *Saudi MOH Institutional Ethics Review Board (#MD-FM-07)* approved this study and ensured its adherence to the Declaration of Helsinki guidelines. All participants were informed about the study's aims. Their informed consent was obtained. Data privacy measures were taken to ensure safe handling of sensitive biometric information.

Participants were informed of their right to withdraw from the study at any stage without providing a reason. This assurance was communicated during the informed consent process. Withdrawal had no consequences or impact on their access to routine healthcare services. Participants were provided with a unique identification code rather than personal identifiers to facilitate this, ensuring ease of withdrawal without compromising confidentiality.

Data confidentiality was protected through anonymization, secured data storage, and digital data encryption. Participants were provided detailed written and verbal explanations of the study objectives, procedures, and data usage. They signed an informed consent form affirming their understanding and agreement. The consent form explicitly outlined confidentiality protections and their right to withdraw.

Lip-print collection:

After cleaning and letting them dry for a minute, the subject's lips were uniformly covered in red-colored lipstick. The entire area of both lips was covered with cellophane tape applied to the lips in their typical resting position after two minutes of even placement and application of the lipstick. The cellophane strip was carefully removed and sufficiently adhered to the white paper without wrinkling to preserve a permanent record. Every lip print was divided into four quadrants (Q1-Q4), arranged from upper right to lower right. The lip prints were digitalized by scanning the papers and analyzed following Suzuki and Tsuchihashi's classification ***(Suzuki and Tsuchihashi, 1970)***, which two researchers did independently.

Fingerprint Collection:

The right index finger's imprint was digitally collected using a digital fingerprint scanner attached to a computer. Digitalization was performed using a universal serial bus (USB) reader with a high image quality, wide capture area, and excellent optical fingerprint scanning technology reliability.

After using an alcohol swab to clean the right index, the participants were instructed to roll the tip of their fingers across the digital fingerprint scanner, ensuring that the complete fingerprint pattern covered the optical scanner of the reader. Next, the operator verifies that the digital print is complete and readable. External pressure was avoided to prevent print smudging. Fingerprints were categorized as whorl patterns (including central pocket), plain or tented arches, or loops (radial, ulnar, or double loop) using Michael Kuchen's classifications.

Tsuchihashi and Michael Kuchen's classifications were used to analyze and interpret the digitalized lip and fingerprint patterns ***(Cummins and Midlo, 1963; Vahanwala and Parekh, 2000)*** **(Table 1)**.

ABO Blood Grouping:

According to the standard laboratory procedures, blood grouping was performed on all participants and documented in their medical records. ABO blood grouping was conducted using the standard agglutination method. Blood samples were collected from participants and tested with anti-A, anti-B and anti-D sera. The agglutination reactions were observed and recorded to determine the blood group (A, B, AB, or O) and the Rh factor (positive or negative). This method is widely accepted for its reliability and simplicity in clinical and forensic applications ***(Li and Guo, 2022)***.

Statistical Analysis:

The study results were analyzed using SPSS software 2023 for Windows, version 29.0.2.0, Armonk, NY. A correlation between lip-print and fingerprint patterns and gender variation was analyzed using the Pearson correlation test. The p-values for the association tests (chi-square tests) were estimated using Monte Carlo simulations to provide a p-value derived from a Monte Carlo simulation method, a computational technique used to approximate the probability of different outcomes. This method is often employed when the exact p-value is challenging to calculate analytically, allowing for an estimation based on random sampling. A significant MCp value (≤0.05) refers to a statistically significant association between the variables being studied. The sample was stratified by age and gender to ensure balanced representation within each group. Participants were categorized into age subgroups (20–25, 26–30, 31–35 years) and gender (male and female) for analysis. Stratification ensured that correlations between biometric markers and demographic variables could be accurately assessed.

Potential confounders, such as age, gender, and nationality, were accounted for during the analysis. Adjustments were made using multivariate techniques to isolate the relationships between lip print patterns, fingerprint types, and ABO blood groups. Monte Carlo p-values were used to ensure accurate statistical analysis in cases where the chi-square test assumptions were not met, such as small expected cell frequencies. This method approximates the p-value through random sampling, providing robust results for evaluating associations between variables. A statistically significant result was defined as MCp ≤0.05.

RESULTS

The study analyzed the distribution of lip-print patterns, fingerprint patterns, and ABO blood groups among 200 Egyptians and 200 Saudis males and females. The age range of participants was 20 to 35 years.

Table (1) describes lip print and fingerprint types based on Tsuchihashi and Michael Kuchen's classifications. The **tables (2-5)** provide a comprehensive overview of the distribution of Egyptian and Saudi males and females according to lip prints, fingerprint patterns, and ABO blood groups. The data was divided according to the studied lip print quadrants (Q1, Q2, Q3, Q4) in all fingerprint types and a summary of blood group distributions across the studied populations.

Table (2) shows notable distributions among Egyptian males in the Loop type of fingerprints. The highest of which was in the

subcategory of the Ulnar, Radial, and Double loop categories, followed by the plain whorl. Significant associations were found in Q2 ($\chi2$ = 61.987, ^{MC}p = 0.012). A significant correlation existed between blood group distribution and the fingerprint pattern ($\chi2$ = 73.491, ^{MC}p = 0.002). The Ulnar Loop fingerprint pattern was most frequently associated with the III lip-print variant in all quadrants. Most of the studied population had blood group A, particularly in the plain whorl and the ulnar Loop categories.

Table (3) displays the distribution of lip-print patterns, fingerprint patterns, and ABO blood groups among the studied Egyptian Females. Like Egyptian males, Ulnar Loop patterns were dominant, followed by Plain Whorl and Double Loop. Significant associations were found in Q2 ($\chi2$ = 55.129, ^{MC}p = 0.031) and Q4 ($\chi2$ = 53.879, ^{MC}p = 0.027), as well as in blood group distribution ($\chi2$ = 73.481, ^{MC}p = 0.003). The data shows that blood group A was the most common group among adult Egyptian females, followed by Blood group O.

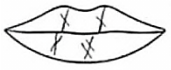
Table (4) displays all categories studied in Saudi Males. The Ulnar Loop pattern was predominant, followed by Double Loop and Plain Whorl. Significant associations were observed in Q1 ($\chi2$ = 56.123, ^{MC}p = 0.037) and Q2 ($\chi2$ = 57.987, ^{MC}p = 0.017), and in blood group distribution ($\chi2$ = 73.491, ^{MC}p = 0.002). A notable distribution was seen in the IV lip pattern, especially in the Radial Loop and Double Loop categories in all quadrants.

Saudi Females' criteria were presented in **table (5)**.

The most common patterns were Ulnar Loop, Double Loop, and Plain Whorl. Significant associations were present in Q2 ($\chi2$ = 52.129, ^{MC}p = 0.029) and Q4 ($\chi2$ = 53.879, ^{MC}p = 0.027), and in blood group distribution ($\chi2$ = 73.481, ^{MC}p = 0.003). The data indicates a high incidence of IV lip-print variants with the Double Loop and Central Pocket Whorl patterns. The most prevalent blood groups among Saudi females were Blood Groups A and O.

As for ABO Blood Groups among Egyptian Males and Females, the most common blood groups were A and O, with A being the most frequent among Egyptian males and females. The percentage distribution shows a higher blood group A prevalence among Egyptian males than females. Saudi males and females had a similar trend, with a high prevalence of blood group A in both males and females but with a higher percentage of blood group B in males than females. The data also shows a relatively high occurrence of blood group O in both populations **(Table 6)**.

Table (1): Description of Suzuki and Tsuchihashi's classification of lip prints and Michael Kuchen's fingerprint classifications.

Type	Description	Shape
Lip Prints		
Type I	Clear-cut, vertical grooves across the lip.	
Type I′	The grooves are straight but only span half the width of the lip, as opposed to the entire width.	
Type II	The grooves diverge along their course.	
Type III	Intersecting grooves.	
Type IV	The grooves are reticulate.	
Type V	The grooves do not belong to any of the types above and cannot be morphologically distinguished; hence, they are termed undetermined.	

Fingerprints		
Loop	Prints that recurve back on themselves to form loops. Variants include Plain loop, Central pocket loop, Lateral pocket loop, and Twinned loop.	
Arch	Wave-like patterns. Variants include Plain arch and Tented arch.	
Whorl	Circular or spiral patterns. Variants include Plain, Central pocket, Double loop, and accidental.	

Table (2): Distribution of Egyptian Males (N=200), according to Lip Prints (Variants and Quadrants), Right Index Fingerprint Patterns, and ABO Blood Groups.

Lip Print Variant	Plain Arch (n=12)	Tented Arch (n=8)	Ulnar Loop (n=90)	Radial Loop (n=15)	Double Loop (n=22)	Plain Whorl (n=35)	Central Pocket Whorl (n=18)	Test of Significance
Q1								
I	0 (0%)	0 (0%)	5 (5.6%)	0 (0%)	1 (4.5%)	2 (5.7%)	1 (5.6%)	$\chi2 = 48.321$, $^{MC}p = 0.115$
I'	1 (8.3%)	1 (12.5%)	20 (22.2%)	1 (6.7%)	2 (9.1%)	7 (20%)	2 (11.1%)	
II	2 (16.7%)	2 (25%)	18 (20%)	1 (6.7%)	2 (9.1%)	8 (22.9%)	1 (5.6%)	
III	3 (25%)	3 (37.5%)	**30 (33.3%)**	2 (13.3%)	5 (22.7%)	10 (28.6%)	3 (16.7%)	
IV	6 (50%)	2 (25%)	17 (18.9%)	11 (73.3%)	12 (54.5%)	8 (22.9%)	11 (61.1%)	
Q2								
	10 (83.3%)	0 (0%)	7 (7.8%)	0 (0%)	1 (4.5%)	3 (8.6%)	2 (11.1%)	$\chi2 = 61.987$, $^{MC}p = 0.012$*
I'	2 (16.7%)	1 (12.5%)	22 (24.4%)	1 (6.7%)	4 (18.2%)	6 (17.1%)	2 (11.1%)	
II	1 (8.3%)	1 (12.5%)	24 (26.7%)	0 (0%)	3 (13.6%)	9 (25.7%)	3 (16.7%)	
III	2 (16.7%)	2 (25%)	**28 (31.1%)**	2 (13.3%)	5 (22.7%)	12 (34.3%)	3 (16.7%)	
IV	7 (58.3%)	4 (50%)	16 (17.8%)	12 (80%)	10 (45.5%)	8 (22.9%)	10 (55.6%)	
Q3								
I	0 (0%)	1 (12.5%)	7 (7.8%)	0 (0%)	1 (4.5%)	3 (8.6%)	2 (11.1%)	$\chi2 = 47.891$, $^{MC}p = 0.114$
I'	1 (8.3%)	0 (0%)	19 (21.1%)	1 (6.7%)	2 (9.1%)	7 (20%)	1 (5.6%)	
II	2 (16.7%)	2 (25%)	20 (22.2%)	2 (13.3%)	5 (22.7%)	9 (25.7%)	2 (11.1%)	
III	3 (25%)	2 (25%)	**26 (28.9%)**	2 (13.3%)	5 (22.7%)	12 (34.3%)	3 (16.7%)	
IV	6 (50%)	3 (37.5%)	18 (20%)	10 (66.7%)	9 (40.9%)	4 (11.4%)	10 (55.6%)	
Q4								
I	1 (8.3%)	0 (0%)	9 (10%)	0 (0%)	2 (9.1%)	4 (11.4%)	1 (5.6%)	$\chi2 = 55.321$, $^{MC}p = 0.097$
I'	1 (8.3%)	1 (12.5%)	19 (21.1%)	0 (0%)	3 (13.6%)	6 (17.1%)	2 (11.1%)	
II	2 (16.7%)	1 (12.5%)	25 (27.8%)	1 (6.7%)	4 (18.2%)	10 (28.6%)	1 (5.6%)	
III	2 (16.7%)	2 (25%)	**29 (32.2%)**	3 (20%)	6 (27.3%)	11 (31.4%)	3 (16.7%)	
IV	6 (50%)	4 (50%)	8 (8.9%)	11 (73.3%)	7 (31.8%)	4 (11.4%)	11 (61.1%)	

Blood Groups								
A	2 (16.7%)	1 (12.5%)	**35 (38.9%)**	1 (6.7%)	5 (22.7%)	15 (42.9%)	3 (16.7%)	$\chi2 = 73.491$, $^{MC}p = 0.002$*
B	1 (8.3%)	1 (12.5%)	20 (22.2%)	0 (0%)	4 (18.2%)	7 (20%)	2 (11.1%)	
AB	1 (8.3%)	2 (25%)	10 (11.1%)	1 (6.7%)	2 (9.1%)	6 (17.1%)	1 (5.6%)	
O	8 (66.7%)	4 (50%)	25 (27.8%)	13 (86.7%)	11 (50%)	7 (20%)	12 (66.7%)	

*$\chi2$: Chi-square test, ^{MC}: Monte Carlo. p: p-value for the relation between the right index and different parameters in the female Egyptian group. *: Statistically significant at $p \leq 0.05$.*

Note: Monte Carlo p-values were used to ensure accurate statistical analysis in cases where the chi-square test assumptions were not met, such as small expected cell frequencies. This method approximates the p-value through random sampling, providing robust results for evaluating associations between variables. A statistically significant result was defined as $MCp \leq 0.05$.

Table (3): Distribution of Egyptian Females (N=200), according to Lip Prints (Variants and Quadrants), Right Index Fingerprint Patterns, and ABO Blood Groups.

Lip Print Variant	Plain Arch (n=6)	Tented Arch (n=12)	Ulnar Loop (n=110)	Radial Loop (n=8)	Double Loop (n=18)	Plain Whorl (n=45)	Central Pocket Whorl (n=11)	Test of Significance
Q1								
I	1 (16.7%)	0 (0%)	7 (6.4%)	0 (0%)	1 (5.6%)	2 (4.4%)	2 (18.2%)	$\chi2 = 50.156$, $^{MC}p = 0.145$
I'	0 (0%)	1 (8.3%)	27 (24.5%)	1 (12.5%)	2 (11.1%)	8 (17.8%)	1 (9.1%)	
II	1 (16.7%)	2 (16.7%)	20 (18.2%)	1 (12.5%)	2 (11.1%)	10 (22.2%)	1 (9.1%)	
III	2 (33.3%)	4 (33.3%)	**35 (31.8%)**	2 (25%)	5 (27.8%)	15 (33.3%)	3 (27.3%)	
IV	2 (33.3%)	5 (41.7%)	21 (19.1%)	4 (50%)	8 (44.4%)	10 (22.2%)	4 (36.4%)	
Q2								
I	12 (100%)	0 (0%)	23 (20.9%)	1 (12.5%)	4 (22.2%)	7 (15.6%)	2 (18.2%)	$\chi2 = 55.129$, $^{MC}p = 0.031$*
I'	1 (16.7%)	0 (0%)	23 (20.9%)	1 (12.5%)	4 (22.2%)	7 (15.6%)	2 (18.2%)	
II	1 (16.7%)	1 (8.3%)	28 (25.5%)	0 (0%)	4 (22.2%)	10 (22.2%)	2 (18.2%)	
III	2 (33.3%)	2 (16.7%)	**30 (27.3%)**	2 (25%)	5 (27.8%)	13 (28.9%)	4 (36.4%)	
IV	2 (33.3%)	7 (58.3%)	29 (26.4%)	5 (62.5%)	5 (27.8%)	15 (33.3%)	3 (27.3%)	
Q3								
I	0 (0%)	1 (8.3%)	10 (9.1%)	0 (0%)	1 (5.6%)	4 (8.9%)	1 (9.1%)	$\chi2 = 51.123$, $^{MC}p = 0.135$
I'	1 (16.7%)	0 (0%)	22 (20%)	1 (12.5%)	3 (16.7%)	6 (13.3%)	1 (9.1%)	
II	1 (16.7%)	2 (16.7%)	24 (21.8%)	2 (25%)	5 (27.8%)	11 (24.4%)	2 (18.2%)	
III	2 (33.3%)	3 (25%)	31 (28.2%)	2 (25%)	4 (22.2%)	14 (31.1%)	3 (27.3%)	
IV	2 (33.3%)	6 (50%)	23 (20.9%)	3 (37.5%)	5 (27.8%)	10 (22.2%)	4 (36.4%)	
Q4								
I	1 (16.7%)	0 (0%)	12 (10.9%)	0 (0%)	2 (11.1%)	5 (11.1%)	1 (9.1%)	$\chi2 = 53.879$, $^{MC}p = 0.027$*
I'	1 (16.7%)	1 (8.3%)	22 (20%)	0 (0%)	3 (16.7%)	7 (15.6%)	2 (18.2%)	
II	1 (16.7%)	1 (8.3%)	27 (24.5%)	1 (12.5%)	4 (22.2%)	12 (26.7%)	2 (18.2%)	
III	2 (33.3%)	2 (16.7%)	**33 (30%)**	2 (25%)	4 (22.2%)	14 (31.1%)	2 (18.2%)	
IV	1 (16.7%)	8 (66.7%)	16 (14.5%)	5 (62.5%)	5 (27.8%)	7 (15.6%)	4 (36.4%)	

Blood Groups								
A	3 (50%)	1 (8.3%)	**45 (40.9%)**	1 (12.5%)	5 (27.8%)	12 (26.7%)	3 (27.3%)	$\chi2 = 73.481$, $^{MC}p = 0.003$*
B	1 (16.7%)	1 (8.3%)	25 (22.7%)	0 (0%)	4 (22.2%)	12 (26.7%)	2 (18.2%)	
AB	1 (16.7%)	3 (25%)	12 (10.9%)	1 (12.5%)	2 (11.1%)	7 (15.6%)	1 (9.1%)	
O	1 (16.7%)	7 (58.3%)	28 (25.5%)	6 (75%)	7 (38.9%)	14 (31.1%)	5 (45.5%)	

*$\chi2$: Chi-square test, ^{MC}: Monte Carlo. p: p-value for the relation between the right index and different parameters in the female Egyptian group. *: Statistically significant at $p \leq 0.05$.*

Note: Monte Carlo p-values were used to ensure accurate statistical analysis in cases where the chi-square test assumptions were not met, such as small expected cell frequencies. This method approximates the p-value through random sampling, providing robust results for evaluating associations between variables. A statistically significant result was defined as $MCp \leq 0.05$.

Table (4): Distribution of Saudi Males (N=200), according to Lip Prints (Variants and Quadrants), Right index Fingerprint Patterns, and ABO Blood Groups.

Lip Print Variant	Plain Arch (n=14)	Tented Arch (n=9)	Ulnar Loop (n=80)	Radial Loop (n=12)	Double Loop (n=25)	Plain Whorl (n=42)	Central Pocket Whorl (n=18)	Test of Significance
Q1								
I	0 (0%)	1 (11.1%)	6 (7.5%)	0 (0%)	1 (4%)	2 (4.8%)	1 (5.6%)	$\chi2 = 56.123$, $^{MC}p = 0.037$*
I'	1 (7.1%)	1 (11.1%)	24 (30%)	1 (8.3%)	2 (8%)	8 (19%)	3 (16.7%)	
II	2 (14.3%)	2 (22.2%)	16 (20%)	1 (8.3%)	3 (12%)	9 (21.4%)	1 (5.6%)	
III	3 (21.4%)	2 (22.2%)	**30 (37.5%)**	3 (25%)	6 (24%)	12 (28.6%)	3 (16.7%)	
IV	8 (57.1%)	3 (33.3%)	4 (5%)	7 (58.3%)	13 (52%)	11 (26.2%)	10 (55.6%)	
Q2								
I	14 (100%)	0 (0%)	21 (26.3%)	1 (8.3%)	5 (20%)	6 (14.3%)	2 (11.1%)	$\chi2 = 57.987$, $^{MC}p = 0.017$*
I'	1 (7.1%)	0 (0%)	21 (26.3%)	1 (8.3%)	5 (20%)	6 (14.3%)	2 (11.1%)	
II	1 (7.1%)	1 (11.1%)	22 (27.5%)	0 (0%)	5 (20%)	10 (23.8%)	3 (16.7%)	
III	2 (14.3%)	1 (11.1%)	**27 (33.8%)**	2 (16.7%)	6 (24%)	13 (31%)	3 (16.7%)	
IV	10 (71.4%)	7 (77.8%)	10 (12.5%)	9 (75%)	9 (36%)	13 (31%)	10 (55.6%)	
Q3								
I	0 (0%)	1 (11.1%)	7 (8.8%)	0 (0%)	1 (4%)	4 (9.5%)	2 (11.1%)	$\chi2 = 54.891$, $^{MC}p = 0.114$
I'	1 (7.1%)	0 (0%)	20 (25%)	1 (8.3%)	3 (12%)	6 (14.3%)	2 (11.1%)	
II	1 (7.1%)	2 (22.2%)	23 (28.8%)	2 (16.7%)	6 (24%)	12 (28.6%)	2 (11.1%)	
III	3 (21.4%)	2 (22.2%)	**28 (35%)**	2 (16.7%)	5 (20%)	13 (31%)	3 (16.7%)	
IV	9 (64.3%)	4 (44.4%)	2 (2.5%)	7 (58.3%)	10 (40%)	7 (16.7%)	9 (50%)	
Q4								
I	1 (7.1%)	0 (0%)	12 (15%)	0 (0%)	2 (8%)	5 (11.9%)	1 (5.6%)	$\chi2 = 55.321$, $^{MC}p = 0.097$
I'	1 (7.1%)	1 (11.1%)	18 (22.5%)	0 (0%)	4 (16%)	6 (14.3%)	3 (16.7%)	
II	1 (7.1%)	1 (11.1%)	22 (27.5%)	1 (8.3%)	5 (20%)	12 (28.6%)	2 (11.1%)	
III	2 (14.3%)	2 (22.2%)	**29 (36.3%)**	2 (16.7%)	6 (24%)	13 (31%)	2 (11.1%)	
IV	9 (64.3%)	5 (55.6%)	9 (11.3%)	9 (75%)	8 (32%)	6 (14.3%)	10 (55.6%)	

Blood Groups								
A	4 (28.6%)	2 (22.2%)	**40 (50%)**	1 (8.3%)	5 (20%)	12 (28.6%)	3 (16.7%)	$\chi2 = 73.491$, $^{MC}p = 0.002$*
B	1 (7.1%)	1 (11.1%)	15 (18.8%)	1 (8.3%)	5 (20%)	7 (16.7%)	3 (16.7%)	
AB	1 (7.1%)	2 (22.2%)	11 (13.8%)	1 (8.3%)	2 (8%)	8 (19%)	1 (5.6%)	
O	8 (57.1%)	4 (44.4%)	14 (17.5%)	9 (75%)	13 (52%)	15 (35.7%)	11 (61.1%)	

*$\chi2$: Chi-square test, ^{MC}: Monte Carlo. p: p-value for the relation between the right index and different parameters in the female Egyptian group. *: Statistically significant at $p \leq 0.05$.*

Note: Monte Carlo p-values were used to ensure accurate statistical analysis in cases where the chi-square test assumptions were not met, such as small expected cell frequencies. This method approximates the p-value through random sampling, providing robust results for evaluating associations between variables. A statistically significant result was defined as MCp ≤ 0.05.

Table (5): Distribution of Saudi Females (N=200), according to Lip Prints (Variants and Quadrants), Right Index Fingerprint Patterns, and ABO Blood Groups.

Lip Print Variant	Plain Arch (n=8)	Tented Arch (n=10)	Ulnar Loop (n=90)	Radial Loop (n=12)	Double Loop (n=28)	Plain Whorl (n=35)	Central Pocket Whorl (n=17)	Test of Significance
Q1								
I	1 (12.5%)	0 (0%)	5 (5.6%)	0 (0%)	1 (3.6%)	3 (8.6%)	2 (11.8%)	$\chi2 = 50.156$, $^{MC}p = 0.145$
I'	0 (0%)	1 (10%)	20 (22.2%)	1 (8.3%)	2 (7.1%)	6 (17.1%)	2 (11.8%)	
II	1 (12.5%)	2 (20%)	15 (16.7%)	1 (8.3%)	3 (10.7%)	8 (22.9%)	2 (11.8%)	
III	3 (37.5%)	3 (30%)	**30 (33.3%)**	2 (16.7%)	7 (25%)	11 (31.4%)	3 (17.6%)	
IV	3 (37.5%)	4 (40%)	20 (22.2%)	8 (66.7%)	15 (53.6%)	7 (20%)	8 (47.1%)	
Q2								
I	8 (100%)	0 (0%)	21 (23.3%)	1 (8.3%)	4 (14.3%)	7 (20%)	2 (11.8%)	$\chi2 = 52.129$, $^{MC}p = 0.029$*
I'	1 (12.5%)	0 (0%)	21 (23.3%)	1 (8.3%)	4 (14.3%)	7 (20%)	2 (11.8%)	
II	1 (12.5%)	1 (10%)	24 (26.7%)	0 (0%)	5 (17.9%)	10 (28.6%)	3 (17.6%)	
III	2 (25%)	2 (20%)	**27 (30%)**	1 (8.3%)	8 (28.6%)	12 (34.3%)	4 (23.5%)	
IV	4 (50%)	7 (70%)	18 (20%)	10 (83.3%)	11 (39.3%)	6 (17.1%)	8 (47.1%)	
Q3								
I	1 (12.5%)	1 (10%)	6 (6.7%)	0 (0%)	1 (3.6%)	2 (5.7%)	1 (5.9%)	$\chi2 = 51.123$, $^{MC}p = 0.135$
I'	1 (12.5%)	0 (0%)	20 (22.2%)	1 (8.3%)	2 (7.1%)	5 (14.3%)	1 (5.9%)	
II	1 (12.5%)	1 (10%)	25 (27.8%)	2 (16.7%)	5 (17.9%)	9 (25.7%)	2 (11.8%)	
III	2 (25%)	2 (20%)	**30 (33.3%)**	1 (8.3%)	9 (32.1%)	13 (37.1%)	2 (11.8%)	
IV	3 (37.5%)	6 (60%)	9 (10%)	8 (66.7%)	11 (39.3%)	6 (17.1%)	11 (64.7%)	
Q4								
I	1 (12.5%)	0 (0%)	9 (10%)	0 (0%)	3 (10.7%)	5 (14.3%)	1 (5.9%)	$\chi2 = 53.879$, $^{MC}p = 0.027$*
I'	1 (12.5%)	1 (10%)	18 (20%)	0 (0%)	4 (14.3%)	7 (20%)	1 (5.9%)	
II	1 (12.5%)	1 (10%)	28 (31.1%)	1 (8.3%)	5 (17.9%)	11 (31.4%)	2 (11.8%)	
III	2 (25%)	2 (20%)	**30 (33.3%)**	2 (16.7%)	8 (28.6%)	9 (25.7%)	3 (17.6%)	
IV	3 (37.5%)	6 (60%)	5 (5.6%)	9 (75%)	8 (28.6%)	3 (8.6%)	10 (58.8%)	

Blood Groups								
A	3 (37.5%)	1 (10%)	**40 (44.4%)**	1 (8.3%)	5 (17.9%)	10 (28.6%)	3 (17.6%)	$\chi2 = 73.481$, $^{MC}p = 0.003$*
B	1 (12.5%)	1 (10%)	20 (22.2%)	1 (8.3%)	4 (14.3%)	7 (20%)	2 (11.8%)	
AB	1 (12.5%)	2 (20%)	15 (16.7%)	1 (8.3%)	3 (10.7%)	8 (22.9%)	2 (11.8%)	
O	3 (37.5%)	6 (60%)	15 (16.7%)	9 (75%)	16 (57.1%)	10 (28.6%)	10 (58.8%)	

*$\chi2$: Chi-square test, ^{MC}: Monte Carlo. p: p-value for the relation between the right index and different parameters in the female Egyptian group. *: Statistically significant at $p \leq 0.05$.*

Note: Monte Carlo p-values were used to ensure accurate statistical analysis in cases where the chi-square test assumptions were not met, such as small expected cell frequencies. This method approximates the p-value through random sampling, providing robust results for evaluating associations between variables. A statistically significant result was defined as $MCp \leq 0.05$.

Table (6): Distribution of the Studied Populations (N=400), according to Sex and Blood Groups.

Blood Groups	Egyptian Males (n=100)	Egyptian Females (n=100)	Saudi Males (n=100)	Saudi Females (n=100)
A	38 (38%)	34 (34%)	27 (27%)	29 (29%)
B	22 (22%)	26 (26%)	33 (33%)	23 (23%)
AB	10 (10%)	12 (12%)	12 (12%)	19 (19%)
O	30 (30%)	28 (28%)	28 (28%)	29 (29%)
Total	100 (100%)	100 (100%)	100 (100%)	100 (100%)

DISCUSSION

The correlations of lip print patterns, fingerprint types, and ABO blood groups among any population offer valuable insights for forensic applications, especially in settings with limited access to advanced forensic technologies. These relationships can be utilized in various scenarios to aid in personal identification, for example, crime scene investigations, mass casualty events, and profiling unknown suspects ***(Sandhu et al., 2017)***.

Establishing personal identification in crime scenes and major accidents or catastrophes is tricky. The most uncomplicated and accepted procedure for individual identification is fingerprint analysis; hence, establishing a correlation between fingerprints and other parameters like lip print patterns is fundamental, particularly in regions where high-quality forensic technology is limited ***(Kulkarni et al., 2012; Adamu, 2013)***. Additionally, the importance of such correlations will expand through the capacity to predict blood types based on fingerprint and lip patterns ***(Kathuria, 2023)***.

In the current study, the Egyptian male participants exhibited a higher incidence of ulnar loop fingerprint pattern, predominantly associated with blood group type A. A notable correlation was found between the double loop and central pocket whorl fingerprint patterns with blood group O. In Egyptian females, the ulnar loop pattern was the most common. It was mainly associated with blood groups A, and O. Saudi Males displayed a notable correlation between the central pocket whorl pattern and blood group O, along with a significant presence of double loop patterns among individuals with the blood groups O and A. Meanwhile, the central pocket whorl and double loop patterns in Saudi females were strongly associated with blood group O, consistent with the trend observed in Saudi males.

According to the most prevalent fingerprint pattern in the current study, Saudi and Egyptian populations have a prevalent ulnar loop pattern. The current finding is consistent with ***Iftikhar et al. (2023)***, whose results from their study group (N=1300) revealed that the loop pattern was the most common, with 278 (50.55%) males exhibiting it, followed by the arches ***(Iftikhar et al., 2023)***.

Aziz et al. (2019) revealed that, Egyptian males (63.3%), females (53.3%), and Malaysian males (40%) had a prevalent Ulnar loop fingerprint pattern. In contrast, Malaysian females' plain whorl and ulnar loops were equally distributed (33.3% each). ***Kathuria et al. (2023)*** reported that, loop fingerprint patterns were recorded in most of

their studied Indian population, followed by whorl, arch, and composite. 46% of the participants exhibited Type I patterns, followed by Type IV lip print variants. ***Omuruka et al. (2019)*** revealed that, out of the 450 Nigerian participants, the loop Fingerprint was the most often captured fingerprint from both the left and right index fingers.

Blood group A was the most common in the current investigation across all sexes in the Egyptian nationality, and blood group O was more common among the Saudi group. ***Bashwari et al. (2001)*** reported that, most of the Saudi participants in their study were of blood group O (N=57396), followed by blood group type. ***Sarhan et al. (2009)*** reported that, the ABO blood grouping frequencies were 56.8% for Group O, 33.4% for Group A, 6% for Group B, and 3.8% for Group AB among their study population from Southwest Saudi Arabia.

Our findings revealed a higher prevalence of blood group A among Egyptians and blood group O among Saudis, contrasting with some earlier studies **(*Bashwari et al., 2001; Aziz et al., 2019)***. These differences may be attributed to a combination of genetic and environmental factors. Genetically, variations in blood group distribution can result from population-specific allele frequencies influenced by historical migrations, genetic drift, and natural selection. For example, the predominance of certain blood groups in a population may reflect evolutionary adaptations to regional diseases or environmental conditions ***(Lendabo et al., 2024)***.

Environmental factors such as dietary habits, lifestyle, and exposure to specific pathogens might also shape the distribution of blood groups over generations. For instance, blood group O has been associated with resistance to severe forms of malaria, which might explain its higher prevalence in regions with historical exposure to the disease. Conversely, blood group A may confer advantages in areas with other environmental pressures ***(Cooling, 2015)***. These findings underscore the importance of considering genetic and environmental influences when interpreting blood group distributions across populations. Further research integrating genomic and environmental data is necessary to elucidate the underlying mechanisms driving these patterns.

Elshafie et al. (2022) evaluated the correlation between blood grouping and fingerprint patterns (ABO and Rhesus factor) among 394 Sudanese participants. Of whom, 111 (28.2%), 63 (15.9%), 13 (3.3%), and 207 (52.5%) had blood group A, blood group B, blood group AB and blood group O, respectively. As for the fingerprint patterns, 2476 (62.84%) were loop patterns, 1278 (32.44%) were arches, and 186 (4.72%) were whorls.

A study by ***Rastogi et al. (2023)*** identified blood group B as the most common, comprising 37.7% of the studied population, followed by blood group O at 29.8%, blood group A at 23.0%, and blood group AB at 9.5%. Regarding fingerprint patterns, loops were the most frequent, accounting for 55.9%, followed by whorls at 34.9%, arches at 6.0%, and composite patterns at 3.1%. The distribution of fingerprint patterns between males and females was similar, with no statistically significant difference (p=0.11). However, a statistically significant association was observed between fingerprint patterns and ABO blood groups (p=0.0003), whereas the association between fingerprint patterns and Rh blood groups was non-significant (p=0.08) ***(Rastogi et al., 2023)***.

According to ***Fayrouz et al. (2012)***, the most common fingerprint patterns were loop, whorl, and arch, whereas blood groups O and A were the most prevalent types among the Libyan students studied.

This opposed research results on a Pakistani population, whose results proved that the whorls and arches were the most common fingerprint types among the studied Pakistani females. Still, such findings can be argued due to the small population of the research ***(Rastogi and Pillai, 2010)***.

A research work reported that a correlation between blood group types and lip print variants did not exist among their study group ***(Karim and Gupta, 2014)***.

In the current study, Egyptian male participants with blood group type A mostly had an ulnar loop and plain whorl fingerprint

patterns. Similarly, blood group O was prevalent in individuals with double-loop and central pocket whorl fingerprint patterns. ***Narayana et al. (2016)*** reported that, females had the highest whorls and arches, while males had the highest loops. All blood types had loops as the predominant blood type, except for group A, which had whorls dominance.

Type I lip-print pattern (32%) was the most frequent type among Indian males, and type I' (28%) was the most frequent lip mark among Indian females ***(Alzapur et al., 2017)***.

The current study identified a prevalent type IV lip print occurrence among Egyptian males with blood group O, particularly in quadrants Q2 and Q4. Blood group A was more common than other blood group types among those with lip print variant I, especially in Q1 and Q4. In Egyptian females, lip print variant IV was predominantly linked to blood group O. Saudi males had type IV lip print commonly associated with a relatively high prevalence of blood group type O across all quadrants, especially notable in Q1 and Q2. Variant I individuals show higher occurrences of blood group A, particularly in Q1. Saudi females with variant IV had a relatively high prevalence of blood group O across all quadrants, especially in Q2, Q3, and Q4. In contrast, variant I lip prints in Saudi females show higher occurrences of blood group A, particularly in Q2 and Q4. Some researchers reported that the lip-print variant II was prevalent among male and female Indian participants ***(Kesarwani and Choudhary, 2021; Gondivkar et al., 2009)***.

In contrast, others noted that type III was the most recorded variant among the studied populations ***(Multani et al., 2014)***.

Similar to our findings, ***Aziz I. et al. (2023)*** reported that blood groups A and O prevailed, representing 26.67% of their studied population, while group AB accounted for only 16.67%. Lip print pattern type II was the most common, observed in 23.33% of cases, followed by Type III (20.00%), while type I was the least common (16.67%). The loops were the most prevalent fingerprints at 46.67%, whorls at 30.00%, and arches at 23.33%. Their analysis revealed statistically significant associations between lip prints and fingerprints with gender ($\chi^2 = 7.128$, df = 3, P<0.001) and between lip prints and fingerprints with blood group ($\chi^2 = 5.454$, df = 3, p=0.001). Suggesting that gender and blood group types may influence the distribution of lip print and fingerprint patterns.

In a study conducted by ***Nandan et al. (2015)***, although the overall correlation between lip prints and fingerprint patterns was statistically insignificant, a significant association was found between the Type III lip print pattern and the loop fingerprint pattern (P=0.05) using Chi-square analysis.

Limitations of the study:

Including participants from two culturally distinct populations, Egyptians and Saudis, enhances the generalizability of our findings. By analyzing biometric markers across these diverse groups, the study provides insights that can be applied beyond the studied populations. This diversity allows for identifying potential population-specific patterns while revealing broader trends that could affect forensic applications in similar regions. Additionally, it highlights the importance of considering cultural, socioeconomic, regional, and genetic diversity within the studied groups in biometric research to develop universally applicable forensic methodologies.

CONCLUSION

This study establishes significant correlations between lip print patterns, fingerprint types, and ABO blood groups among Egyptian and Saudi populations. Key findings include the predominance of lip print Types III and IV and the frequent occurrence of ulnar loop fingerprints, particularly linked to blood groups A and O. These correlations provide valuable insights for forensic identification, particularly in resource-limited settings where advanced technologies like DNA profiling may not be readily available.

The study highlights the potential of these biometric markers as complementary tools in forensic investigations, aiding in suspect profiling and victim identification. However, the findings also emphasize the need for further research with more diverse populations to validate these associations and

explore additional genetic and environmental factors influencing these traits.

In summary, the integration of lip prints, fingerprints, and ABO blood group data represents a promising avenue for improving forensic methodologies, particularly in culturally and geographically distinct populations like those in Egypt and Saudi Arabia.

List of Abbreviations:

- **Q (Q1-Q4):** Lip Quadrant (Arranged from upper right to lower right)
- **$\chi 2$:** Chi-square test
- **^{MC}p:** Monte Carlo test

A significant ^{MC}p value (≤0.05) is a statistically significant association between the variables.

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