FORENSIC CORRELATION OF LIP PRINTS PATTERNS AND SEX DETERMINATION AMONG ADULT EGYPTIANS: LIP PRINT VERSUS LIP DIMENSION

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ABSTRACT

Background: Cheiloscopy, often known as "human lip recognition," is one of the most intriguing new topics in forensic and criminal investigations**. Methodology:** 120 healthy Egyptians (69 males and 51 females) were included, lip prints were taken using the lipstick tap method, and four lip dimensions were taken using caliber. Lip prints were classified into six types (Type I, I′, II, III, IV, and Type V). **Results:** sex was identified using lip print patterns and lip dimensions at an accuracy of 84 %. For males alone, type II was the most predominant type followed by type I′ then type IV, III and type V respectively, for females, type I was the most predominant type followed by type I′. **Conclusion:** Lip print patterns are a hopeful tool in sex determination among Egyptians put in the hand of a forensic investigator. Besides other tools, further studies are needed on larger samples and to compare with other populations using the same method to construct sex-identifying models using lip prints.

Keywords: lip print, Egyptians, lip dimensions, sex identification

INTRODUCTION

Cheiloscopy is a trustworthy method for determining a person's true identity. Its use as evidence may be hampered by the lack of data regarding a group or gender. Analysis and assessment of such data across a range of population groupings are thus now vitally necessary **(Sharma et al., 2014).** Lip prints are genetically unique and inherited, allowing for personal identity. Lip prints have the potential for sex identification because they are stable and unique even in twins. According to many pieces of literature, their applicability is comparable to fingerprints **(Adserias-Garriga et al., 2018; Alzapur et al., 2017; Fonseca et al., 2014b)**. Sexual dimorphism plays an important role in identifying and reducing missing person lists. Several physical measures, including the pelvis, **have been evaluated and utilized to determine** sexual dimorphism, with varying degrees of success. In addition, males' lips are usually wider and longer than females', this variant can assist in narrowing the gap in forensics and criminal investigations **(Best et al., 2018; Fonseca et al., 2014a; Memarian et al., 2017).**

Although there are many different systems for classification of lip print, the National Institute of Standards and Technology has acknowledged Suzuki & Tsuchihashi's system as the standard and the most widely used method in the latest literature **(Fonseca et al., 2019; Prabhu et al., 2013).** The digital method of evaluating lip print photos allows for improved visibility, recognition, and pattern recording **(Fonseca et al., 2019).** Additionally, researchers have studied the patterns linked with gender and have raised the potential that gender might be determined from lip prints **(Abdel Aziz et al., 2016; Suzuki and Tsuchihashi, 1970; Vahanwala and Parekh, 2000).** For Egyptians, Previous researchs have been done to determine sex from various bone components, such as maxillary

nasal sinus measurements **(Amin and Hassan, 2012)**, talus measures. **(Abd-elaleem et al., 2012)**, small bones of the hand **(Eshak et al., 2011)**, vertebrae **(Ramadan et al., 2017b, 2017a)**, and patella and foot dimensions **(Abdel Moneim et al., 2008)**, however, few researchers tried to test the sexual dimorphic role of lip print. Unfortunately, these studies either included small samples, used a different methodology or didn't add lip dimensions **(Abdel Aziz et al., 2016; Ragab et al., 2013; Shokry et al., 2017)**. Therefore, this research analyzes the predominant patterns of lip print among the adult Egyptian population and the relation between these lip patterns and lip dimensions and sex identification in sexual dimorphism.

MATERIALS AND METHODS

1.1 The Study Population:

The study comprised of 120 healthy Egyptians (69 (57.5%) males and 51 (42.5%) females), their ages from 18–24 years. All subjects agreed and gave Informed consent first.

1.2. Inclusion & Exclusion criteria:

healthy participants with healthy lips are included. Lips must be free from any pathologies, deformities or abnormalities for example; lip-piercing, cleft lip, surgical lesions, or dried lips cut marks.

1.3. Recording the lip dimensions:

The following lip dimensions were measured **(Hamzah et al., 2012) (figure 1):**

– **Lip width:** It was determined the width of the oral aperture from the right to the left cheilion.

– **Lip length:** both lips height taken in the midline from labrale inferior to labrale superior.

– **Upper lip length:** the upper lip height taken in the midline from labrale superior to stomion.

– **Lower lip length:** the lower lip height taken in the midline from stomion to labrale inferior.

The subjects' lip measurements were taken directly using a standard sliding caliper. Each measurement was repeated two times.

1.4. Recording the lip prints:

For hygienic reasons, a wet tissue was provided to clean the lips. To prevent blurring of the lip print, the lipstick was evenly put on the participant's lips using a lip brush in a single motion. It was given 30 seconds to dry. On the subject's lips, transparent cellophane tape was applied with sufficient pressure. The subjects were instructed to unwind while the lip prints were being taken. After carefully removing the tape, a blank sheet of A4 paper was placed on top of it. Details were written on the paper that had the subject's lip prints on it (serial number and date).

One assistant collected all of the lip prints and coded them all while recording the name and sex of each individual. To minimize errors when interpreting the study's findings, the sex of the lip prints wasn't disclosed to the examiner.

1.5. Classifications used:

In this study, we followed the classification of patterns of the lines on the lips proposed by Suzuki and Tsuchihashi **(SUZUKI and TSUCHIAHASHI, 1971; Tsuchihashi, 1974)** (**figure 2**).

- Type I: Long vertical (Clear-cut vertical grooves that run across the lips).
- Type I$^{\circ}$: Short vertical (Partial length groove of Type I).
- Type II: Branched grooves (Branching Y-shaped pattern).
- Type III: Intersected grooves (Criss-cross/'x' pattern grooves).
- Type IV: Reticular pattern (Grooves that forms rectangular shape).
- Type V: Mixed/Indefinite (Grooves that do not fall into any of the above categories, a combination of two or more patterns and/or cannot be differentiated morphologically/ undetermined).

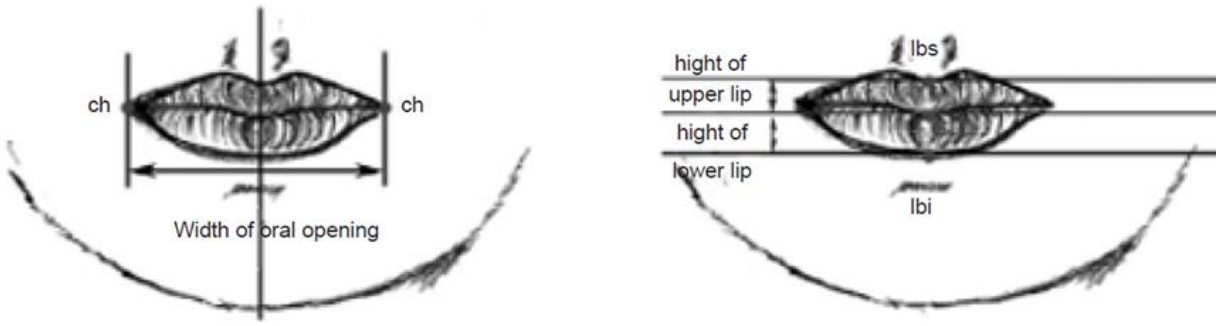


Figure 1: Method of Recording the lip dimensions (Hamzah et al., 2012).

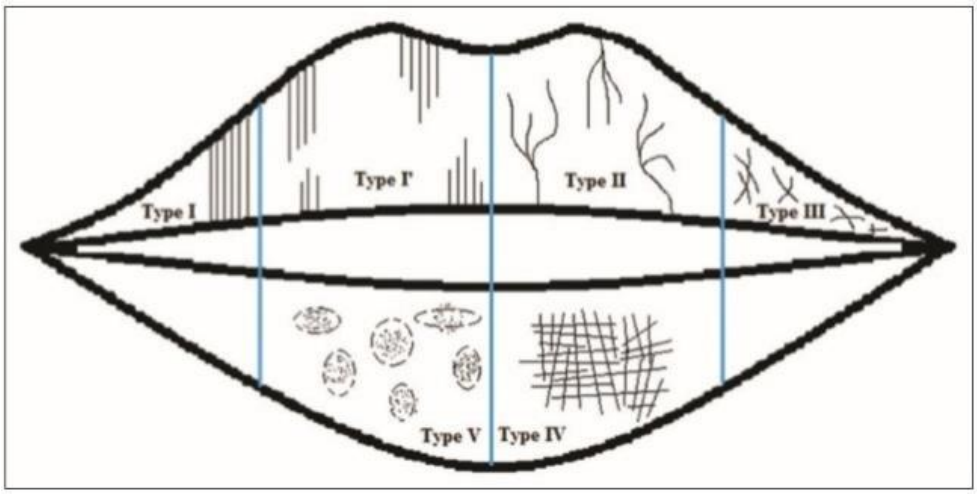


Figure2. Lip print Types according to classification of Suzuki and Tsuchihashi **(Hamzah et al., 2018).**

1.6. Examination of the prints:

The lip print was divided into four sections **(Eldomiaty et al., 2014; Gupta et al., 2011; Kapoor and Badiye, 2017; Tsuchihashi, 1974)**: right upper, left upper, right lower, and left lower. Each part was examined using a magnifying lens to detect the pattern of each part.

Ethical approval:

The study was approved by the ethical committee of the faculty of medicine, Alexandria university; code: 0305582

Statistical analysis

The IBM SPSS software package, version 24.0, was used.

Number and percentage were used to describe qualitative data. The Chi-square test was used to compare differences in categorical variables between several groups. The mean and standard deviation were used to characterize quantitative data.

The independent t-test was used to compare two independent population data.

Results from significance tests are expressed as two-tailed probability. At the 5% level, significance of the results was determined.

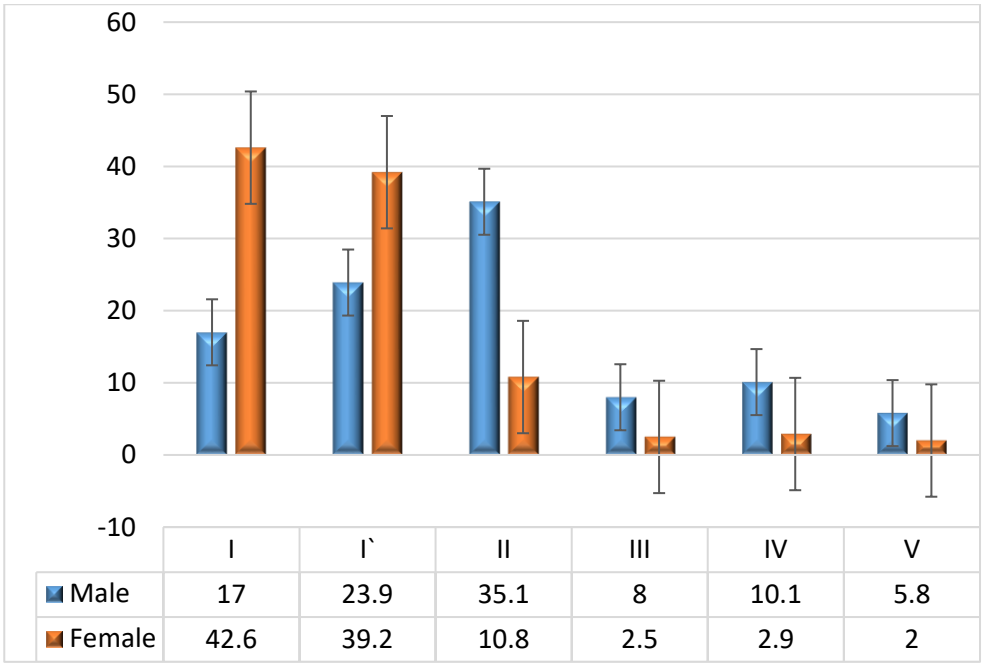
RESULTS

In the current study, 120 participants were involved; males were 69 subjects (57.5%) with a mean age of 20.22 years (18-24 years), while females were 51 subjects (42.5%) with a mean age of 20.08 years (18-23 years).

Lip print types:

In the current study, the sexual difference in lip print types was obvious and significant; type I and type **I′** were highly significant more prevalent in females than males (P value = 0.0001), while the other types were significantly more prevalent in males than females (P value < 0.05*), however, type V was more prevalent in males but non-significant (p= 0.06).

For males alone, the most predominant type was type II, followed by type I′, then IV, III, and V, respectively. For females, the most predominant type was type I, followed by type I′, then type II **(figure 3).**



	I	I`	II	III	IV	V
Male	17	23.9	35.1	8	10.1	5.8
Female	42.6	39.2	10.8	2.5	2.9	2

Figure (3): Comparison between males and females regarding the total lip types.

When discussing each area alone, the upper lip right area showed a significant prevalence of Type I in females and a significant predominance of type II and IV in males. Also Type I and **I′** were significantly predominant in the upper lip left area in females and type II and III for males **(table 1).** In addition, the lower lip, in its right area, for females, type I and **I′** were significantly predominant with a significant predominance of type II in males, while in the left area, the significant sex difference was only in type I and type II. Although all patterns are exhibited in both sexes, types from III to V are rarely found in females and may not be present in some female areas **(table 2).**

Regarding the overall distribution of lip print types over the different lip areas; type I and **I′** were the commonest for the studied sample, and type I was more significant (P > 0.05) to be found in the upper lip right area, while types **I′ and** II were more significant (P > 0.05) to be found in the upper lip left area and the lower lip right area respectively **(figure 4).**

Lip dimensions:

Regarding lip dimensions, Males and females exhibited statistically significant differences (p <0.05) in lip width and lower lip length. In contrast, the upper lip and whole lip length were non-significant **(table 3).**

Table (1): Comparison between males and females lip print types in the upper lip areas.

	Male		Female		X^2
	No	%	No	%	**p-value**
Right lip					
I	17	24.6	28	54.9	0.0021*
I`	17	24.6	18	35.3	0.056
II	15	21.7	0	0.0	0.001*
III	6	8.7	4	7.8	0.236
IV	9	13.0	0	0.0	0.021*
V	5	7.2	1	2.0	0.207
Left lip					
I	8	11.6	14	27.5	0.038*
I`	24	34.8	30	58.8	0.029*
II	19	27.5	4	7.8	0.002*
III	10	14.5	0	0.0	0.011*
IV	3	4.3	1	2.0	0.236
V	5	7.2	2	3.9	0.355
Total	69		51		

***P= 0.001, highly significant**

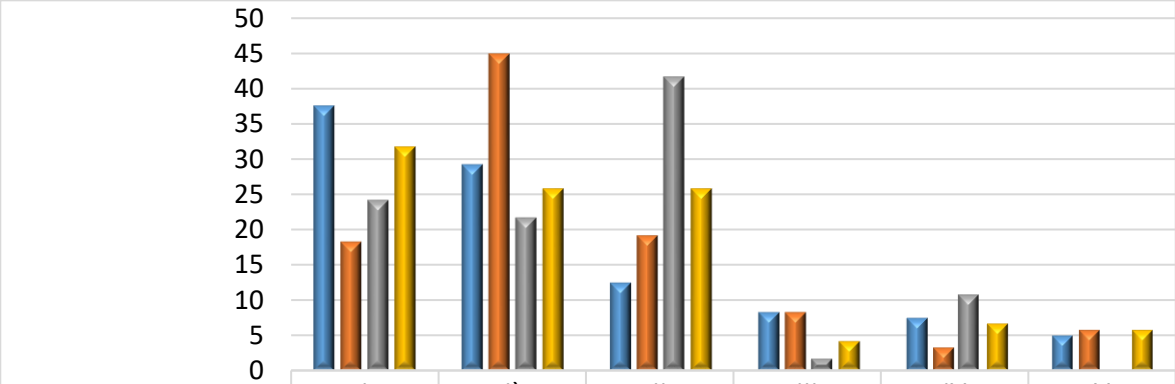
Table (2): Comparison between males and females regarding lip print types in the lower lip areas.

	Male		Female		X^2
	No	%	No	%	**p-value**
Right lip					
I	9	13.0	20	39.2	0.0311*
I`	9	13.0	17	33.3	0.017*
II	40	58.0	10	19.6	0.001*
III	2	2.9	0	0.0	0.365.
IV	9	13.0	4	7.8	0.107.
Left lip					
I	13	18.8	25	49.0	0.0013*
I`	16	23.2	15	29.4	0.221
II	23	33.3	8	15.7	0.0135*
III	4	5.8	1	2.0	0.411
IV	7	10.1	1	2.0	0.071
V	6	8.7	1	2.0	0.307
Total	69		51		

***P= 0.001, highly significant**

Table (3): Comparison between males and females regarding lip measurements.

	Male	Female	p-value
Lower lip length	0.60-1.40	0.50-1.20	6.908
Range	1.00	0.91	0.010*
Mean	0.17	0.20	
S.D.			
Upper lip length	0.60-1.10	0.50-1.10	0.763
Range	0.76	0.74	0.384
Mean	0.13	0.14	
S.D.			
Length of both lips	1.30-2.40	1.30-2.30	0.660
Range	1.84	1.79	0.418
Mean	0.28	0.30	
S.D.			
Lip Width	4.20-6.40	4.40-5.70	10.480
Range	5.23	4.96	0.002*
Mean	0.51	0.37	
S.D.			



	I	I`	II	III	IV	V
Right upper lip	37.5	29.2	12.5	8.3	7.5	5
Left upper lip type	18.3	45	19.2	8.3	3.3	5.8
Right lower lip	24.2	21.7	41.7	1.7	10.8	0
Left lower lip	31.7	25.8	25.8	4.2	6.7	5.8

Figure (4): Comparison of different lip types in the different lip sites.

In the current study, sex can be determined by using different lip prints types in each lip area by using the following equation:

Y= 1.664-(0.051* U.right)-(0.039*U.left)-(0.077*L.Right)-(0.064*L.left)

If the detected type were from 1-5, it would be substituted with the same number, but if the type was I`, it would be substituted with 0; if $y \geq 1.5$, the subject was female, while if $Y < 1.5$, the subject was male.

In addition, another equation was constructed to detect sex from both lip print types and lip dimensions as the following;

Y= 3.429-(0.487*lower lip length)-(0.227* lip Width)-(-0.065*U.right)-(0.061*U.left)-(0.07*L.Right)-(0.067*L.left)

If the detected types were from 1-5, it would be substituted with the same number, but if the type was I`, it would be substituted with 0; if y ≥ 1.5, the subject was female, while if Y < 1.5, the subject was male. The accuracy of the first equation (using only lip print) was 60.0% **(table 4)**, while the accuracy of the second equation (using both lip print type and lip measurements) was 84.0% **(table 5).**

Table (4): Multiple logistic regression analysis for the Type of lip to predict the sex.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.664	.082		20.385	0.01*
Upper Right	-.051-	.031	-.163-	-1.628-	0.106
Upper Left	-.039-	.029	-.132-	-1.357-	0.178
Lower Right	-.077-	.034	-.202-	-2.257-	0.026*
Lower Left	-.064-	.026	-.214-	-2.467-	0.015*

a. Dependent Variable: Sex

Table (5): Multiple logistic regression analysis for significant lip dimensions and Type to predict the sex.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.429	.462		7.416	.0001*
Lower lip	-.487-	.219	-.186-	-2.225-	.028*
Width	-.227-	.093	-.216-	-2.433-	.017*
Upper Right	-.065-	.034	-.187-	-1.917-	.05*
Upper Left	-.061-	.033	-.180-	-1.812-	.037*
Lower Right	-.070-	.036	-.165-	-1.964-	.05*
Lower Left	-.067-	.031	-.189-	-2.148-	.034

a. Dependent Variable: Sex

DISCUSSION

Cheiloscopy, often known as "human lip recognition," is one of the most intriguing new topics which find its way into forensic and criminal investigations **(Sharma et al., 2009, Kapoor and Badiye, 2017).**

The current study found that there was a statistically significant variation in lip print patterns between males and females; this approved sexual dimorphism of lip print pattern was following many authors **(Abdel Aziz et al., 2016; Alzapur et al., 2017; Bai et al., 2018; Bajpai, 2011; Domiaty et al., 2010; Hamzah et al., 2018, 2012; Jeergal et al., 2016; Kapoor and Badiye, 2017; KRISHNAN**

et al., 2016; Nagalaxmi et al., 2014; Ragab et al., 2013; Sharma et al., 2009, 2014; Suryagopan et al., 2020; Topczyłko et al., 2018; Vahanwala et al., 2005) for different populations **(table 6).** This sexual difference was partially approved in only patterns of upper lips by **(Raj et al., 2016)** in their work for the Indian population.

In contrast, the gender difference correlation was not possible by **Shokry et al., 2017**, although their work included an Egyptian sample, they used different print classification (Renaud Classification) and different lip areas (they divided the print into 6 partitions including the margins which may be narrow and non-obvious). Numerous studies approved lip prints' sexual, discriminatory value for the Indian population as seen in Table (6). However, **(Alzapur et al., 2017; Sandhu et al., 2012, and Srinivasulu et al., 2020)** disagreed on the sexual difference in lip print patterns among Indian populations. **Ramalingam et al., (2014)** Also disproved any significant sexual difference, however, their work's sample size was very small (20 females and 20 males).

In addition, for all samples of this study, type I and type I′ was the most frequently observed pattern, while for each sex alone, the most predominant pattern was different. For males alone, the most predominant type was type II, followed by Type I′, then type IV, III, and V, respectively; for females, the most predominant type was type I, followed by type I′, then type II. In accordance **(Topczyłko et al., 2018)** proved that II, III, and VI were highly distributed among males and patterns I, I' and II among females. Also, many studies showed that the predominant pattern in males differed from females; **(Suryagopan et al., 2020, Bajpai, 2011, Vahanwala et al., 2005)** reached to fact that type III predominated among the males then type IV and I' in females. **(Krishnan et al., 2016)** also concluded that, for Indian females, type I and I′ were predominant, and for Indian males, type IV was the most predominant. On the other hand, other studies showed that one type was prevalent in both sexes; type I' **(Jeergal et al., 2016)**, type I (Peeran et al., 2015) among Libyan, type I **(Alzapur et al., 2017; Raj et al., 2016; Sandhu et al., 2012; Srinivasulu et al., 2020)** among Indian populations. In Egyptian studies **(Shokry et al., 2017, Ragab et al., 2013),** groove type A (complete vertical as type I in our study) was the highest pattern ever observed in both Egyptian males and females. However, both results are partially accepted in our study (as type I is more prevalent in females than males). This might be explained by the different applied method (Renaud Classification). They divided the print into 6 partitions, including the margins, which may be narrow and non-obvious. In contrary to this study, **(Mishra et al., 2009; Sivapathasundharam et al., 2001)** documented that the most prevalent type in the Indian population is type III **(Patel et al., 2010),** have shown that the most prominent lip print type for all individuals was type II and for males and females, type I and type II were the most prominent respectively. **Domiaty et al., (2010)** discovered that type IV predominated in both males and females in their examination of the Saudi Arabian population. In Indian populations **(Bindal et al., 2009; Verma et al., 2013)** revealed that the most common pattern in both sexes was type II.

When discussing each area alone, the upper lip right area showed a significant prevalence of Type I in females and a significant predominance of type II and IV in males. Also Type I and **I′** were significantly prevalent in the upper lip left area in females and type II and III in males. In addition, the lower lip, in its right area, for females, type I and type **I′** were significantly predominant with a significant predominance of type II in males, while in the left area, the significant sexual difference was only in type I and type II, this demonstrates that the lip prints distribution varies depending on the segment of the lip for both sexes. **(Abdel Aziz et al., 2016)** Partially approved these results for Egyptians, they showed a significant male and female difference in only lower lip areas., this difference in results could be due to their small sample size (30 females and 30 males). **Jeergal et al., (2016)** revealed that many lip sites, including the lateral segments of both lips and the medial lower lip segment, exhibit statistically significant sexual differences in the patterns of lip print. The only lip print region, where males and females did not differ statistically significantly from one another, was the medial part of the upper lip.

Regarding lip dimensions, Males and females showed statistically significant differences in lip width and lower lip length ($p < 0.05$), while upper

lip and whole lip length were non-significant. **Hamzah et al. (2012)** approved this result, who reached that the lip width and the lower lip height showed significant differences between the sexes.

Furthermore, sex could be determined at an accuracy of 84.0% using lip print patterns and measurements. However, the Accuracy decreased to 60 % if lip print patterns were used alone. This result follows

Finally, Although there are significant restrictions, lip prints show promise as an additional method to identify a person's sex. Therefore, forensic odontologists must approach bite marks with some suspicion and always acknowledge their limitations **(Bajpai, 2011).**

Table (6): previous studies for sex identification using lip print patterns among different populations

Study	Year	Population	Common Type		Accuracy %
			Males	Females	
Current Study	2022		II	I	60-84
Suryagopan	2020		III, IV	I, I'	
Bai et al.	2019	Indian	II	I and II	80%
Hamzah et al	2018	Malays	IV	II	Not calculated
Topczyłko et al.	2018	Poland	II and III	I, I'	72
Shokry et al.	2017	Egyptian	I	I	Non-significant
Kapoor and Badiye	2017	Indian	I	III	Not calculated
Alzapur et al.	2017	Indian	I	I and II	Not calculated
KRISHNAN et al.	2016	Indian	I and I'	IV	Not calculated
Jeergal et al.	2016	Indian	I'	I'	Not calculated
Abdel Aziz et al.	2016	Egyptian	II and III	III	68.3%
Raj et al.	2016	Indian	I	I	Not calculated
Nagalaxmi et al.	2014	Indian	III	I	81.67%
Sharma et al.	2014	Indian	III and IV	I and I'	81%
Hamza et al.	2012	Malaysian	III	I and I'	63.6 – 77.3
Bajpai et al	2011	Indian	III	I and I’	73.7
Patel et al.	2010	Indian	I	II	Not calculated
Sharma et al.	2009	Indian	IV	I and I'	90%
Vahanwala et al.	2005	Indian	III	I and I.'	Not calculated

CONCLUSIONS

Lip print patterns is a hopeful tool in sex determination among Egyptians put in the hand of the forensic investigator. Besides other tools, further studies are needed on larger samples and to compare with other populations using the same method to construct sex-identifying models using lip prints.

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Conflict of interest: the first author (Dr Nazih Ramadan) is an associate editor in the Egyptian journal of forensic sciences and applied toxicology

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الملخص العربي

العلاقة الطبية الشرعية بين أنماط بصمات الشفاة وتحديد الجنس للمصريين البالغين: مقارنة بين بصمات الشفاة وأبعاد الشفاة

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يعتبر موضوع الاستعراف علي الشفاة البشرية وبصماتها والذي يطلق عليه علم الكيلوسكوبي من أهم الموضوعات المثيرة للاهتمام في الطب الشرعي و فحوصات الجريمة.

يدخل ضمن هذه الدراسة 120 من المصريين البالغين الأصحاء (69 من الرجال و 51 من النساء) وتم اخذ بصمات الشفاة منهم باستخدام احمر الشفاة واللاصق كما تم اخد ابعاد الشفاة باستخدام مقياس مدرج وذلك بعد أخذ الموافقة المستنيرة منهم. وقد توصلت هذه الدراسة الي انه يمكن الاستعراف علي الجنس عن طريق بصمات الشفاة وابعاد الشفاة بدقة بلغت 84 % وكان النمط الثاني من أنماط بصمات الشفاة هو الأكثر شيوعا في الرجال والنمط الأول هو الأكثر شيوعا في النساء. ويمكن ان نستنتج من هذه الدراسة أن بصمات الشفاة تعتبر أداة مفيدة لتحديد الجنس توضع في يد محقق الطب الشرعي بالإضافة الي باقي الأدوات الأخرى . واوصت الدراسة بإجراء مزيد من البحث والدراسة علي عدد اكبر من الأشخاص والمقارنة مع عينات من شعوب مختلفة مع تثبيت طريقة القياس للوصول الي نماذج ومعادلات لتحديد الجنس باستخدام بصمات الشفاة