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CHEILOSCOPY: EXPLORING THE GENDER AND AGE PATTERNS IN LIP PRINTS*

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Lip prints, like fingerprints, possess unique characteristics that can be utilized as biometric data for identification and gender determination. Using the forensic examination technique known as cheiloscopy, 23 distinctive features of lip prints have been identified. This study employs the Suzuki and Tsuchihashi classification system to investigate the correlation between five types of lip print patterns, gender, and age. The study's sample consists of 100 random and voluntary participants, equally divided into 50 women and 50 men. Feature extraction focused on seven distinctive characteristics and their frequencies. The study also explored the presence of any unique, previously undefined features. The findings indicate that lip print characteristics vary based on age and gender. While the study suggests that lip prints could be a useful tool in crime investigation, it highlights the need for further research with larger sample sizes.

KEYWORDS: lip print, cheiloscopy, trace evidence, forensics, biological data.

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Introduction

Today, new applications are often needed in studies in the field of forensic sciences. Trace evidence, in which biological data are used, is very important, especially in criminal investigations, as it has the quality of personal identity. As long as the traces are not exposed to a physical or chemical effect on the surface they come into contact with, they can be visible or invisible on that surface (Ristenbatt et al., 2022; Sharma et al., 2013; Randhawa et al., 2011). In addition to the characteristic structure of these traces and the detection of fingerprints of individuals, personal biological properties can also be reached through biological evidence. Although all these traces are unique to the person, they continue to find a place for identification in security systems and criminal investigations (Ristenbatt et al., 2022; Gupta et al., 2011). The examination method performed in order to benefit from the distinctive features of lip prints as forensic evidence is referred to as "Cheiloscopy" in the literature. This area has emerged in order to determine the identities of people and to analyze their specific features from lip prints (Bhattacharjee and Kar, 2024).

In this sense, lip prints can also be evaluated within the scope of evidence. Lip prints, like fingerprints, can be found on any surface. The surfaces that the lips touch heavily can be listed as places such as cigarette butts, glasses, and under spoons (Fonseca et al., 2019; Padmavathi et al., 2013, p. 123).

In order to use the lip prints in identification, it is necessary to examine the anatomical and cellular structure of the lip. In the light of this information, as with all biometric data, it is very important to make the data functional so that it can be classified according to their basic similarities, classified and easily accessed and compared when needed (Augustine et al., 2008, p. 44). In the literature, four different classification systems have been found for lip prints. The first of these is the "Martin Santos Classification (1967)". This classification system basically divides lip prints into two classes. The first of these are "simple" prints. Simple prints are consisting of uniform fractures. The second of the basic classes are "compound" prints, which consist of several different types of fractures. The third classification system is the "Suzuki Classification (1970)". In the classification system made by Suzuki, lip prints are divided into four classes according to their natural fractures (Uzomba et al., 2023). The fourth classification system is the "Suzuki and Tsuchihashi Classification (1971)", also developed by Suzuki in collaboration with Tsuchihashi. This classification considers lip prints in six different types. (Pallivathukal et al., 2024; Tsuchihashi, 1974). The most accepted and verified classification system in the literature is the Suzuki and Tsuchihashi System. The classification System of Suzuki and

Tsuchihashi is shown in Table 1. In order to distinguish the features of each groove type, it is necessary to make the visual distinction correctly (Fig 1).

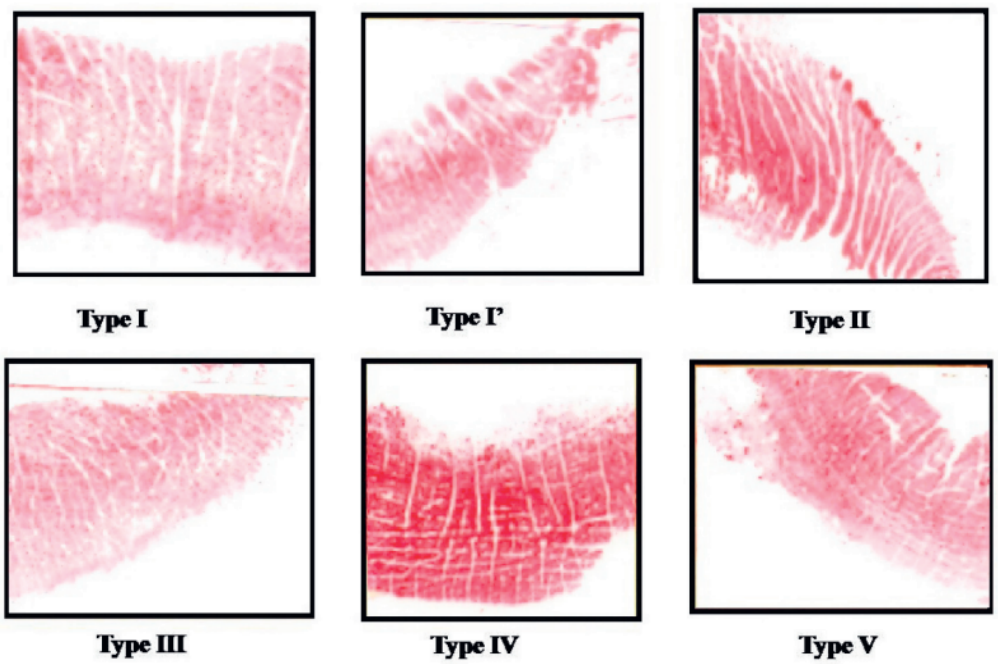
Table 1

Suzuki and Tsuchihashi's classification system

Classification	Groove Type
Type I	Whole vertical grooves
Type Ia	Whole non-vertical grooves
Type II	Branched grooves
Type III	Intersecting grooves
Type IV	Reticulate grooves
Type V	İrregular grooves

Figure 1

Different pattern types of lip prints (Kautilya et al., 2013)



In addition to the classification of lip prints, distinctive characters are very important. In a previous study, 23 types of distinctive characters were identified (Kaur andThakar, 2023; Kasprzak, 1990). In the study of Kasprzak (1990), lip prints taken from 1500 people have been examined and 23 different characters have been determined. These characters have been divided into 7 main groups based on their similarities and differences in terms of direction and shape. In this regard, Table 2 shows the characters and their groups. In addition, in the mentioned study, 400 lip prints were examined in detail in order to determine the number of distinctive characters they have. The number of distinctive characters detected in 400 lip prints was stated as 456,215 in total. As a result of this research, the number of distinguishing characters on a lip print appears to be 1145.5 on average (Kasprzak, 1990).

The formation of the characters in the lip marks begins to be seen in the uterus from the sixth week and does not change after birth unless exposed to strong physical external factors. (Reshma and Don, 2020) In this regard, the numbers determined in the studies prove that lip prints are biometric data, but also reveal how useful data they are in identification.

In addition to the classification feature of the lip prints, obtaining from the surface and the permanence of the surfaces were also investigated. In the study conducted by Segui et al. (2000) the availability of comparable traces on different surfaces was investigated. In this study, aluminium, cobalt oxide, and magnetic powders were applied on white ceramic, black ceramic, clear glass, green glass, white cloth, and white paper, respectively, and experiments were carried out for 2 hours, 1 day, 15 days and 30 days. Successful results were obtained up to 30 days on glass and ceramic surfaces, and up to 1 day later on paper. Despite this, positive results could not be obtained on the fabric surface. (Segui. et al., 2000, p. 45)

The lip prints found at the crime scene may not always be visible. This situation shows that there is a need for methods to make lip prints visible, just like the methods of developing fingerprints (Bano and Prabu, 2021). However, while developing the method, it is necessary to act according to the characteristics of both tissues. For example, while fingerprints are formed as a result of the secretions of sweat and sebaceous glands under the skin, the secretion that keeps lip prints at the crime scene is saliva (Herrera et al., 2013, p. 115).

In the examination of lip prints, it is important to know the distinguishing features in order to be able to classify and compare, except in the way it is obtained from the surface. The person who will examine the lip print should know what to look for on it. For this, 23 types of distinctive characteristics were determined with the prints taken from 1500 people (Kasprzak, 1990, pp. 145-151). Although they

were defined in 23 different ways, these features were gathered in 7 main groups that were similar in shape but differed in direction (Table 2). This classification study by Karsprzak (1990) shed light on many studies as the most comprehensive study in the literature.

Table 2

Distinctive characters in lip print (Karsprzak,1990)

Order No.	Group	Name
1	Eyes	eye
2		double eye
3	Lines	hook
4		bridge
5		line
6	Spots	dot
7		group of dots
8	Figures	triangle like
9		rectangle like
10		pentagonal arrangement
11		hexagonal arrangement
12	Type of Bifurcation	simple top bifurcation
13		simple bottom bifurcation
14		closing top bifurcation
15		closing bottom bifurcation
16		branch-like top bifurcation
17		branch-like bottom bifurcation
18		star-like bifurcation
19	Type of Fence	crossing lines
20		fence
21		double fence
22	Type of openning	delta-like opening
23		simple opening

It is important to determine the characteristics of the person, such as gender and age range, while identifying from the evidence and creating a personal profile. There have been many studies in the literature on identification with lip prints (Randhawa, 2011, p. 45). In a study by Malik and Goele (2011), the discrimination of 5 lip print types in determining gender was investigated according to Tsuchihashi (1974)'s classification system. As a result of the study carried out with 50 women and 50 men between the ages of 20-30, no two lip marks are alike, Type I and Ia are the most common in women; Types IV and V have been observed to occur most frequently in men. Sharma et al. (2009) conducted another study with 20 women and 20 men.

In this study, it was observed that Type I, Ia and Type II were more common in women, and Type III and Type IV in men. It has also been observed in the study that no fingerprints are alike. Gupta et al. (2011) found that each person's lip print was unique in the group of 73 men and 73 women between the ages of 18-30. The classification was made according to the classification of Suzuki and Tsuchihashi (1971). When the general pattern between all lip parts of the research subjects was evaluated, it was found that the intersecting pattern was common in women with 27.7%, and the branching pattern was common in men with 28.1%. Dongarwar et al. (2013) conducted a study with 20 women and 20 men, and it was concluded that no lip prints are alike and that lip prints can be used in determining gender and identity.

In all of the above studies, it has been the subject of investigation whether gender estimation can be made from lip prints depending on the classification system of Suzuki and Tsuchihashi. As a common result of the studies, it was concluded that Type-I and Type-Ia classes were predominantly found in women, and Type-III and Type-IV classes were predominantly found in male characters. While reaching this result, feature evaluation was made according to the total number of people. In this study, two separate evaluations were made according to both the total number of people and the average of the total number of features.

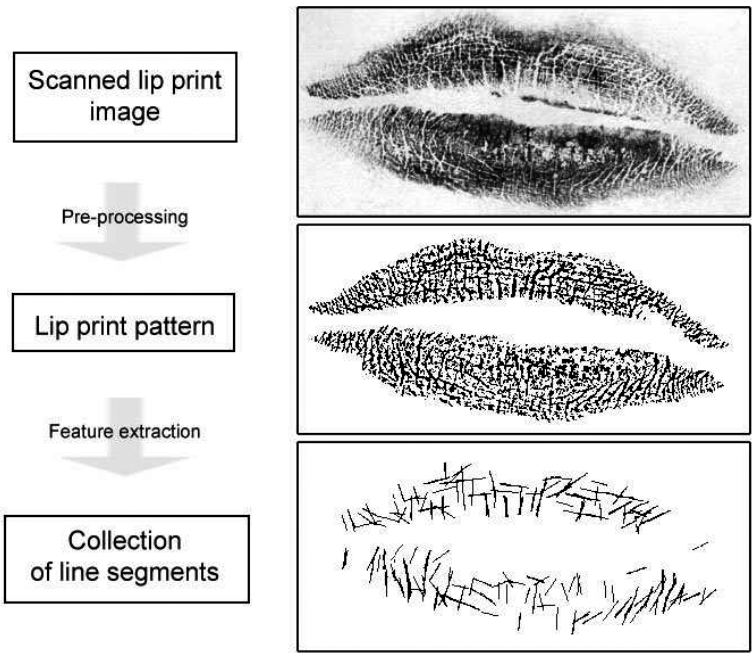
Highlighting the features of lip prints is a complex process (Karki, 2013; Travieso et al., 2019). In order to highlight the features, it is done by removing the parts needed on a photograph from the other parts (Fig 2). (Nixon and Aguado, 2008, p. 69; Smacki et al., 2011, pp. 1-5). By processing the image on the trace, the fractures on the lip are separated and the other parts are removed and the distinctive characters on the trace are made selective. (Smacki and Wrobel, 2011, p. 1; Rachana et al., 2012, pp. 394-395) Also, the same method was used in this study.

Recent studies have explored various aspects of lip print analysis, highlighting its forensic significance from multiple perspectives. George et al. (2016) examined the hereditary characteristics and familial inheritance patterns of lip prints with-

in a Malaysian population. Badiye and Kapoor (2016) investigated morphological variations of lip print patterns among diverse population groups in Central India, emphasizing geographical influences. Kaul et al. (2017) assessed variations in lip print patterns across different ethnic groups in India, focusing on racial and regional distinctions. Manjusha et al. (2017) studied the potential relationship between lip print patterns and Type 2 diabetes. Fonseca et al. (2019) provided contemporary perspectives on lip print identification, underscoring its role in modern forensic identification. Lastly, Ayuba et al. (2019) explored sexual dimorphism in lip print patterns among Ugandan, Kenyan, and Somali populations, proposing their potential use in forensic gender determination. Collectively, these studies underline the continuous advancements and expanding forensic relevance of lip print analysis.

Figure 2

Feature extraction process from lip print (Smacki and Wrobel)



Materials and Methods

Experiments were conducted under standard laboratory conditions, maintaining a temperature range of 20–25 °C and relative humidity between 40–60%, as commonly recommended in forensic biometric identification studies. Close-up photography was employed to facilitate clear identification of distinguishing lip print characteristics. A

matte, dark-colored lipstick (dark red) was uniformly applied using sterile disposable brushes to ensure hygienic conditions and prevent cross-contamination. Transparent transfer bands with high adhesive properties were utilized to obtain intact and clearly detailed lip prints, subsequently transferred onto matte high-quality paper selected due to its reduced reflectivity and superior readability. Throughout the procedures, latex examination gloves and face masks were worn to further maintain sample integrity and researcher safety. Adobe Photoshop CC software was utilized for enhancing lip print clarity, using standard image enhancement techniques such as brightness and contrast adjustments. Manual feature extraction was performed using transparent acetate sheets (0.1–0.2 mm thickness), placed directly onto the computer screen to accurately trace and document distinguishing lip print characteristics.

The sample in the study is completely random and consists of 100 volunteers. In the first stage of the study, lip prints taken from volunteers were taken with a lip print form. Then, all of the traces taken were classified according to the classification criteria of Suzuki and Tsuchihashi and the applicability and validity of the classification method was tested.

Accordingly, feature extraction was performed on 7 distinctive characteristics, and the frequency of features was determined by examining them one by one.

In addition, it was investigated on the lip prints whether there is a distinctive features different from the defined features. Then, it was examined whether gender could be determined depending on the classification on the traces. Phyton 3 was used for statistical analysis of the study.

Sample Group:

The sample consists of 100 volunteers and is completely random. While selecting the sample, it was aimed that the gender distribution be equal and the age distribution range as wide as possible. The distribution of the sample from which lip prints were taken according to gender and age is shown in Table 3. The youngest age in the sample is 7, and the oldest is 73. The mean age of the sample was 30.92 and its standard deviation was 10.24.

Table 3

Distribution of the sample by age

Age Group	0-20	21-29	30-39	40-49	50(+)	Total
Number	3	60	17	15	5	100

Results

All of the lip prints taken from the sample were classified in order to determine the applicability and validity of the classification methods. As a result of the study, it has been determined that the most valid and applicable system is Suzuki and Tsuchihashi's classification system. The distribution of lip prints according to the classification system is shown in Table 4.

Table 4

Distribution of the sample by Tsuchihashi's classification system

Groove Type	Frequency	Percentage (%)	Cumulative Percentage (%)
Type-I: Whole vertical grooves	33	33,0	33.0
Type-Ia: Whole non-vertical grooves	17	17.0	50.0
Type-II: Intersecting Grooves	25	25.0	75.0
Type-III: Branched grooves	13	13.0	88.0
Type-IV: Reticulate grooves	7	7.0	9.0
Type-V: Irregular grooves	5	5.0	100.0
Total	100	100.0	100.0

Feature extraction was performed for all of the lip prints taken from the sample. The feature count was made on the basis of 7 main groups to determine the distinguishing characters. Feature counting continued until all 23 features defined in the subgroups were identified. According to Kasprzak's classification, all 23 features could be detected on the lip prints. In addition, the presence of an unidentified special character on the lip was examined and no other distinctive character was found.

Apart from this, it was also examined whether the total number of distinctive characters differed according to gender and age distribution. Descriptive statistics about the total number of distinctive characters are given in Table 5. The lip print with the minimum number of features detected in the table belongs to a 60-year-old female sample, and the lip print with the maximum number of features identified in the table belongs to a 40-year-old female sample (Table 5).

Table 5

Descriptive statistics for the total number of distinctive characteristics

Measure	N	Min	Max	Mean	Standard Deviation	Coefficent of Variation
Total	100	404	1455	913.10	238.085	0.260
Valid N (listwise)	100					

Table 6 presents the distribution of the total number of features by gender, while Table 7 shows the distribution by classification. Analyzing the data reveals a correlation between the total number of features and gender, as well as between the features and classification (Fig 3). The research indicates that the sample population varies according to gender and lip print types within a 95% confidence interval.

Table 6

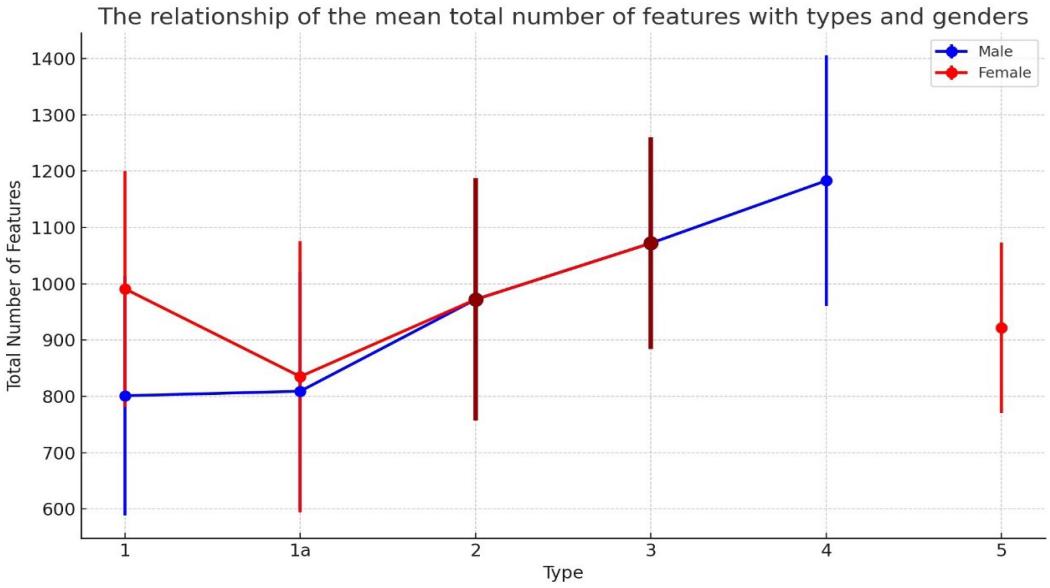
Statistical information of total number of gender-related distinctive characteristics

Measure	N(number)	Min	Max	Mean	Standart Deviation	Coefficent of Variation
Male	50	526	1434	991	209.458	0.211
Female	50	404	1455	835	241.164	0.288
Valid N (listwise)	100					

Fig 3, 4, and 5 illustrate that, based on the average total number of features, there is a significant increase in the number of features in males compared to females in groups II and IV. Type IV features are exclusively observed in males, while Type V features are only present in females. Table 6 further demonstrates that the average total number of characteristics is higher in males than in females across the different types.

Figure 3

The relationship of the mean total number of features with types and genders



In the evaluation of the types according to the total number of features, it was seen that the highest number of features was in Type IV, followed by Type III, Type II and Type IV, respectively. (Table 7, Fig 5). Apart from that, as shown in Fig 5, the mean of the total number of features and the log scale of the relationship between the types are also shown (Fig 6).

The CV (Coefficiant of Variation) value should be checked to see if the standard deviation is acceptable. Formula is shown as:

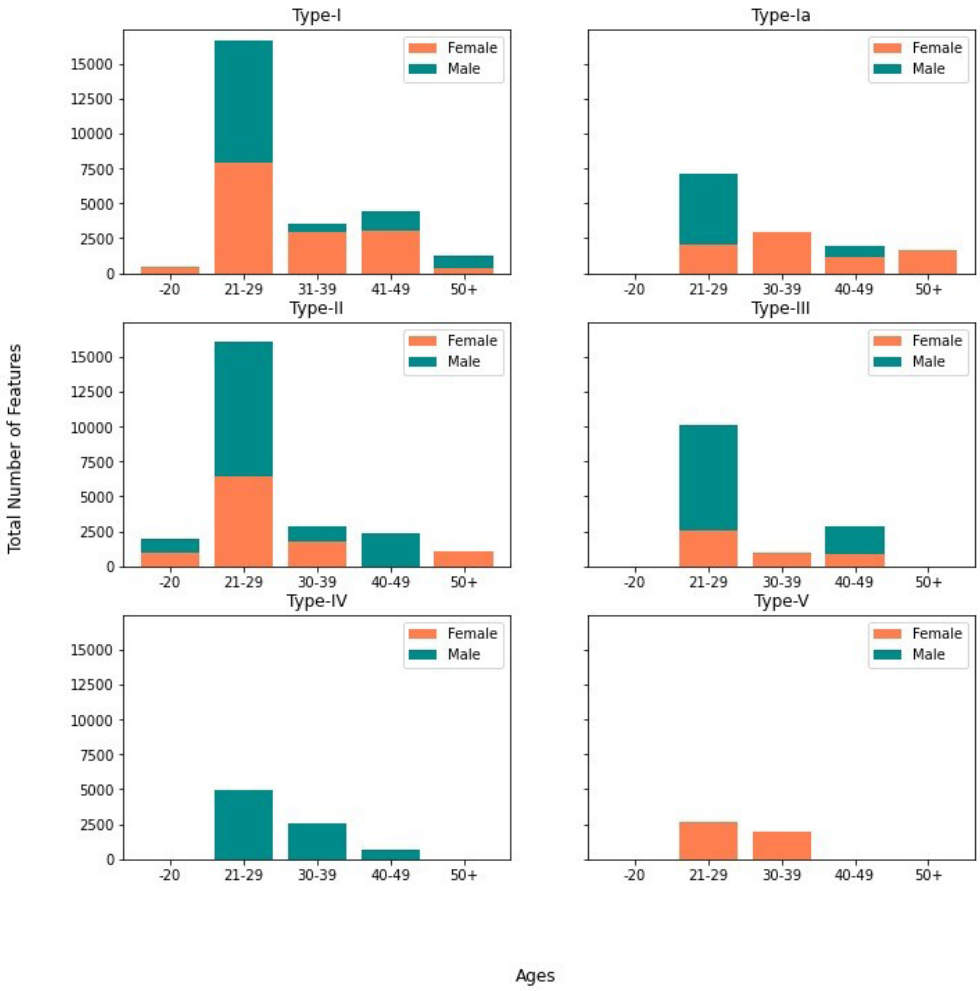
$$CV = \frac{SD}{Sample\ Mean} \text{ X } 100 \qquad (1)$$

CV measures the variability of a data set relative to its mean. It is calculated by dividing the standard deviation (SD) of the data set by the mean and then multiplying by 100. The CV is typically expressed as a percentage.

In this formula, the standard deviation quantifies the spread or variability of the data set, while the mean represents a central measure. Higher CV values indicate greater variability in the data set, while lower CV values indicate less variability. The CV is used as a measure to compare different data sets and evaluate the extent of variability (Table 5-8)(Doulah, 2018).

Figure 4

Total number of gender-related, age-related and type-related features



Apart from this, an age-related evaluation of the total number of characters was also made. In this context, the volunteers were divided into 5 different age groups (20 and below, 20-29, 30-39, 40-49, 50 and above), and the minimum and maximum number of features, mean and standard deviation values were calculated according to the groups (Table 8). According to these data, the relationship between total characteristics, gender, and age was evaluated. Accordingly, it is seen that the total number of characteristics of the sample population between the ages of 20-30 is higher than that of other age groups (Figure 7).

Table 7

Descriptive statistics based on the classification variable of total distinctive characteristic numbers

Measure	N	Min	Max	Mean	Standart Deviation	Coefficent of Variation
Type I	33	404	1455	801	212.147	0.265
Type Ia	17	428	1369	809	211.902	0.261
Type II	25	511	1293	972	215.421	0.221
Type III	13	712	1313	1072	188.031	0.175
Type IV	7	717	1434	1183	222.306	0.188
Type V	5	703	1118	922	151.264	0.164

Figure 5

Relation between total feature numbers and types (I, Ia, II, III, IV, V)

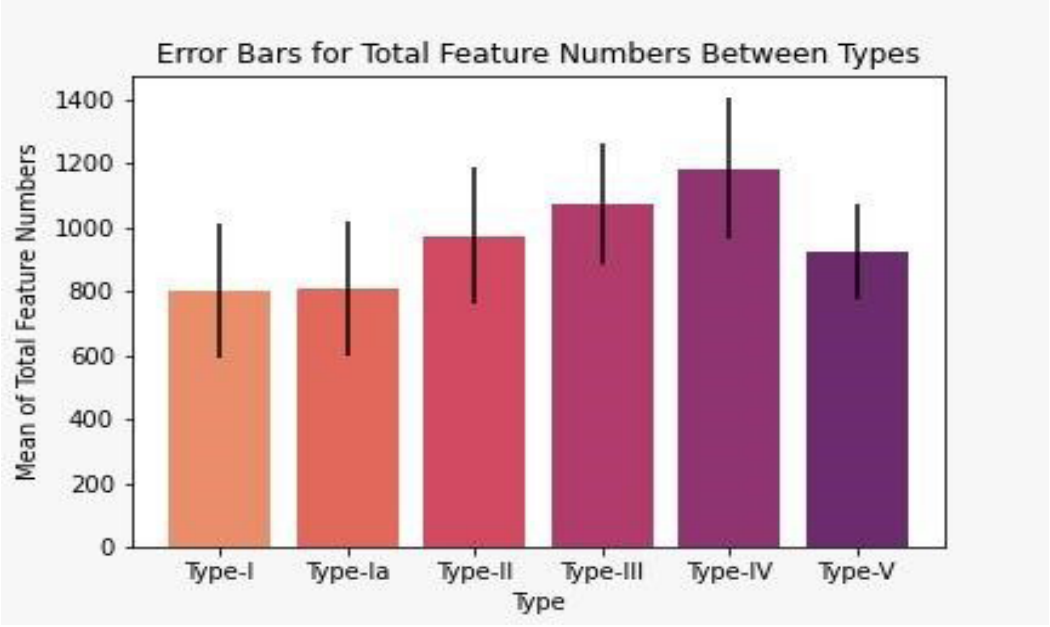


Figure 6

Relation between total feature numbers and types (log scale)

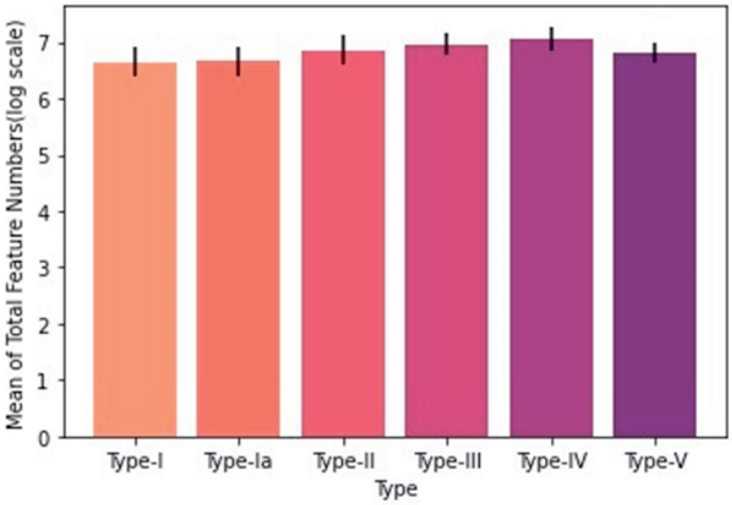


Table 8

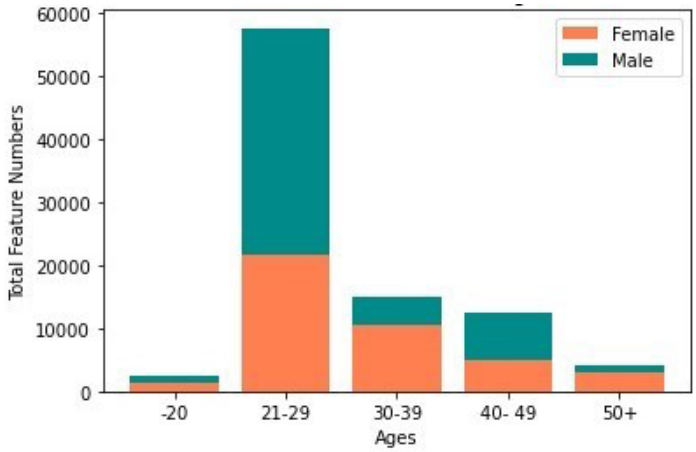
Age-related descriptive statistics of total distinctive characteristic numbers

Measure	N	Min	Max	**Mean**	**Standart Deviation**	**Coefficent of Variation**
20(-)	3	468	1027	818	305.241	0.373
21-29	60	467	1369	961	224	0.233
30-39	17	511	1434	874	255.673	0.292
40-49	15	428	1455	825	242.337	0.294
50(+)	5	404	1027	798	238.782	0.299
Valid N (listwise)	100					

Statistical analysis was performed separately according to the total number of individuals and the average of the total number of features. Accordingly, in parallel with the literature, with a 95% confidence interval, the relationship between characteristics of gender and type was evaluated with the chi-square test when it comes to the number of individuals. In addition, the mean of the total number of features (According to the total number of Type I, Ia, II, III, IV, V) was also evaluated with ANOVA test.

Figure 7

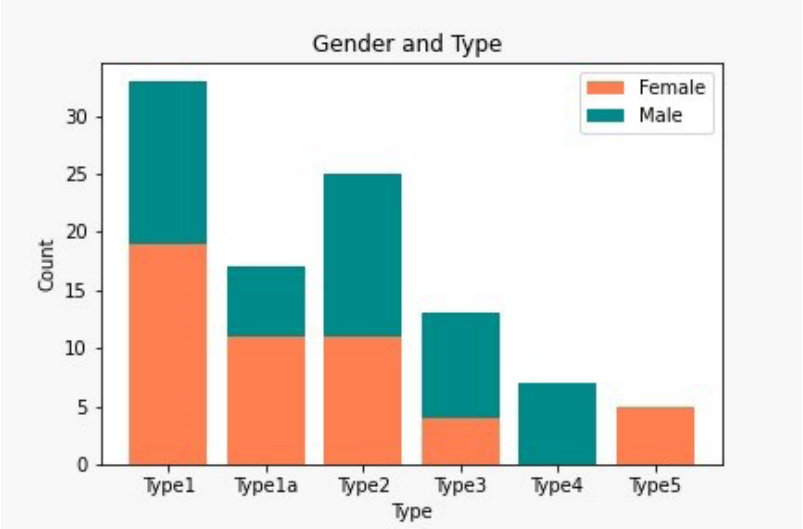
Relation between total feature numbers, gender, and age interval



As stated before, it has been suggested in previous studies that Type-I, Type-Ia, and Type-II are predominantly found in women, and Type III and Type IV are predominantly found in men, depending on the number of individuals. The data obtained for the control of this information is shown in Fig 8 and gave results in parallel with the literature.

Fig 8

Relation between number of individuals, gender, and type (I, Ia, 2, 3, 4 and 5)



Discussion

Physical and biological evidence is very important in identification. Any feature that can be measured on the body can be classified as biometric data. Therefore, in terms of the number of features they contain, when the lip prints are examined, it has been determined that they have been measurable, classifiable, and had dissimilar features. As a result of the studies in the literature, it has been statistically revealed that lip prints can be used in identification and can be evaluated as evidence in different types of crimes.

In this study on the use of lip prints as biometric data, the feature extraction method is applied on traces, which is simplified. After the features to be examined were revealed, they were classified; the number and types of distinctive features were determined and compared with each other. As a result of these examinations, it has been concluded that the most valid and applicable classification method is the six-class classification system of Suzuki and Tsuchihashi. In terms of the classification, 23 distinctive features defined by Kasprzak were scanned on the lip prints. As a result of this examination, all 23 features were found on the lip prints, and 23 separately defined features were reclassified as 7 main groups and sub-features of these groups, taking into account their similarities (Kasprzak, 1990, pp. 145-151). Except for the 23 identified features, another feature was not defined and could not be determined.

When looking at other studies in the literature, analyzes were made by comparing the number of individuals with other features (gender, type, age, etc.) In this study, in parallel with the literature, it has been seen that lip print patterns have been unique to the individual [2]. The each and total number of types in each sample differ from each other (Type I, Ia, II, III, IV, and V). This finding increases the possibility of using lip prints as trace evidence.

Apart from this, the mean of the total number of features (including Type I, Ia, II, III, IV, V) was proportioned to the age and gender variables, and the One-Way ANOVA test was applied with a 95% confidence interval. When the relationship between gender and types was evaluated, it was seen that the p value was less than 0.05. (P value=0.006). In this case, it can be said that there is a significant relationship between gender and types. It can be said that this finding is compatible with the literature. Considering the relationship between age and types, the p value was found to be greater than 0.05 (p=0.161) In this case, it can be said that there was no significant relationship between age and types in the current sample. In a previous study with 500 samples, it has been seen that no significant results have been obtained between the types and the age groups under 20 years old and over 40 years

old [2]. Compared to this study, the effect of factors such as age group differences and sample size may be in question. Also, it may be difficult to establish a relationship between lip print and age due to the changes in the lip prints of the individuals in the developmental age and the deformations over time.

Moreover, chi-square analysis was performed for the number of people, gender and age assessment. While the relationship between the number of people and gender was significant (p value less than 0.05), no significant relationship was found between the number of people and age groups (p value = 0.90).

When all the features were examined, it was seen that the distinctive features differed depending on gender. Especially according to the mean value of total features (all types), the fact that Type IV is seen only in men, Type V only in women. It can be said that there is a difference between the genders in terms of the total mean of features between the types.

As a result of the study, although it can be said that lip prints are a suitable tool to be used in crime investigation, because it is unique. Also, it has been seen that clearer results can be obtained by expanding the research by increasing the number of samples. Apart from age and gender, comparisons can also be made between different races. Research in the context of gender can be deepened and the number of samples in different age groups can be increased. All these studies can be supported by genetic and biochemical analyzes.

Conclusion

Lip prints are one of the types of trace evidence that can be found at a crime scene. However, obtaining fingerprints is often easier than obtaining lip prints. Most research has focused on accurately capturing fingerprints, leaving a gap in the literature regarding studies on lip prints. Additionally, it is not always possible to find clear prints at a crime scene. It is crucial to act quickly to prevent the prints from disappearing and to collect samples accurately.

In this study, photography was used as it is seen as a method that crime scene investigators and law enforcement officers can use to detect prints quickly, easily, and economically. One of the limitations of the study is the lack of information in the literature about whether clear images can be obtained using chemicals similar to those used for fingerprinting. Understanding the chemical composition of the lipstick used for lip prints and whether another chemical could be used to capture the print accurately would enable faster and more accurate sample collection.

In the long term, the aim is to analyze the clarity of lip prints using the chemicals mentioned in the literature. This study also aims to pave the way for the development of lip print detection methods and to inspire new research that will fill the gap in this field. Future studies may focus on developing sensors for the rapid detection of lip prints at crime scenes, adapting fingerprint detection methods for lip prints, chemically analyzing lipsticks that enhance lip print visibility, and establishing a national and international lip print database.

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