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Sexual dimorphism in the lip print pattern and size among Ugandan, Kenyan and Somali population

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ABSTRACT

Background: Lip prints are essential identification tools in forensics. Lip prints are individually unique and inheritable which makes them possible for personal identification.
Aim: We studied sexual differences in print patterns and sizes among Ugandans, Kenyans and Somalis.
Method: In this descriptive study of 180 adults (60 from each country) clear lip print impressions were made on clean pieces of white plain papers. Lip prints were divided into quadrants and we used Suzuki and Tsuchihashi (1974) classification to study the patterns. Lip length and width were measured in centimeters.
Results: Lip print Type I and I' were dominant in a range of 60–100% in both males and females of all countries. Kenyans had more of Type II (males 26%; females 40%) while Somalis exhibited more of Type IV males 56%; females 46%. However, Ugandans had the least number of Type IV pattern 6.6% males and 13% females. There was no Type V in all the participants. Statistical analysis using a 2-way ANOVA showed statistical significance in the lip print patterns among the different population groups. In the male subjects, Ugandans had wider lips (5.48cm ± 0.50) while Kenyans had longer lips (5.14cm ± 0.85). In the females group; Ugandans had wider lips (4.99cm ± 0.59) while Kenyans had longer lips (4.36cm ± 0.71). Statistically significant difference was observed between the means of lip sizes.
Conclusion: This study shows that the lip print pattern and lip size varied significantly among the different population groups. This variation can help to narrow the search gap in criminal investigations and forensic purposes.

Introduction

Lip prints are vital in criminal inquiries and forensic investigations. Lip prints are individually unique and heritable which makes them possible for personal identification [1]. Fingerprinting and DNA tests are often used in the estimation of sex and ancestry. However, less known techniques such as lip prints need to be employed to increase on the chances of person identification [2,3]. Lip prints have shown prospective in sex identification because they remain stable over time and because they are exclusively unique to every person including twins [4]. Though still having some controversy on validity and reliability of methods used, lip print identification has been proposed as a supplementary tool for crime investigation because of the anatomical uniqueness of the labial grooves [5]. In comparison to fingerprints, lip prints have been considered unique to all individuals [6]. In dermatoglyphics (formation of body ridges) lip prints can serve as genetic indications of many congenital anomalies [7]. Recent studies have shown that the resemblance of lip print patterns of a child is closer to the mother (57.89%) than the father (42.22%) [1].

Anatomically lips are unique in that their patterns can recover even after injury or changes resulting from minor trauma. In addition, for situations such as major trauma, lip patterns may not easily recover due to scar formation. Similarly, surgical treatment rendered to correct pathological conditions on the lips may affect their normal size and shape, and later change the groove pattern [8].

Most investigators do not consider looking for lip prints at the crime scene and yet these are essentially a good source of variation amongst persons. A mere lip print can for example help to draw conclusions on the individuals sex, the kind of cosmetics used, occupational trait at the crime scene among others [3].

It is much more likely to find lip prints in rape scenarios and crime scenes where there has been usage of glass; for instance, in burglary [7,9]. Because lips are often moisturized by saliva, this increases on the chances for lip prints to be left on items such as glass, plates, paper, cigarette butts, clothes, and the skin [10]. The challenge has been that whenever a lip smear is discovered at the crime scene it is often ignored as being a fingerprint that is unrecognizable. It is ideal to appreciate that lip prints

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recovered at crime scenes are potential sources of information.

It should also be remembered that criminals have now realized that finger imprints left at the crime scene can be used to identify them. Therefore, with intentions of hiding their identity, criminals may use gloves to avoid leaving fingerprint marks. As a result of that, several other means should be employed to solving crimes [6]. Research studies and information regarding lip print is rather scarce in Africa. It was therefore the goal of this research to study the differences in lip print pattern and size among samples of people from Uganda, Kenya and Somalia.

Methods and materials

Study design and participants

The study was conducted among Kampala International University students of 20–30 years in Ishaka-Bushenyi district of Uganda. Ethical approval was obtained from Institutional Research and Ethics Committee of KIU (BSCAN/0001/131/DF). The researchers educated participants about the study purposes, methods to be used, benefits of the research and each of them was required to give informed consent before recruitment into the study. A Sample Size Calculator [11] was used with an error margin of 5%, population size of 10,000, and response distribution of 14% which gave us a sample size of 182. This was approximated to 180 participants who consisted of 60 participants from each country, equally distributed by sex (30 males and 30 females).

Sample collection procedure

Each participant was given their own lip stick and required to clean their lips with tissue before application of lip stick. To ensure that lipstick was spread evenly, each person was tasked to smile with their lips wide and gently rub the upper and lower lip together.

Each person was required to keep their mouth relaxed and loosely closed. A plain white paper was placed gently on the lips. A small even pressure was applied on the paper to hold it in place for about 3 s. The paper was then removed from the lips carefully. Two samples were collected from each participant to ensure quality prints. The subject's unique serial number was written on the top corner of the paper for identification.

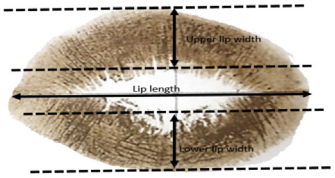
After lip print collection, the strip of paper was divided into four quadrants right upper quadrant (RUQ), left upper quadrant (LUQ), right lower quadrant (RLQ) and left lower quadrant (LLQ). A magnifying hand lens was used to view the lip print pattern on each quadrant of the samples collected.

The length and width of each of the sample was measured in centimeters using a ruler to obtain the size of lip print for each participant according to Abrishami et al. [12].

Our study followed classification of lips patterns according to Tsuchihashi [13] as shown below;

1) Type I: Vertical grooves (run across the entire lips).
2) Type I′: Similar to type I, (but they do not cover the entire lips).
3) Type II: Branched grooves.
4) Type III: Intersected grooves.
5) Type IV: Reticular grooves.
6) Type V: These grooves belong neither to type I–IV above nor can be differentiated morphologically.

Lip size measurements



Lip length and width were recorded in centimeters
Lip width= upper lip width + lower lip width

Inclusion and exclusion criteria

Participants who had scars, inflammation, trauma, congenital anomaly of the lips were excluded from the study. Any person that was known to be allergic or hypersensitive to lipstick was also excluded from the study [3].

Statistical data analysis

Data were analyzed using 2-way ANOVA to determine whether there was an interaction between the means of the group variables. Tukey multiple comparison tests were run to confirm where the difference between groups occurred. Statistical analysis was carried out at 95% confidence interval and significant difference was considered when $P \leq 0.05$.

Results

From this study, lip print pattern Type I and I' were the most dominant among the study population (i.e. 92% and 82% respectively). Table 1 below shows how the lip print patterns were distributed in the study population. Kenyans had more of Type II than Ugandans and Somalis i.e. 11%, 4% and 6% respectively. Somalis exhibited more of Type IV (17%). There was no Type V in all the participants. Statistical analysis using 2-way ANOVA was P = 0.0008.

Post Hoc test using Tukey's test showed that the significant difference existed among Type I' as shown in Table 1 below.

Table 2 below shows adjusted p values from Tukey's multiple comparison test among male lip print patterns. There was significant difference in lip print pattern Type IV between males from Somalia and Kenya (p = 0.0038) and males from Uganda and Somalia (p = 0.0009) as shown in Table 2 below.

Table 3 below shows adjusted p values from Tukeys multiple comparison test among female Lip print patterns. There was a statistical

Table 1
Types of Lip print patterns between males and females from the study population.

	Uganda			Kenya			Somalia		
	Male n = 30	Female n = 30	P-Value	Male n = 30	Female n = 30	P-Value	Male n = 30	Female n = 30	P-Value
I	27(90)	25(83)	0.060	30(100)	28(93)	0.082	26(86)	30(100)	0.078
I'	28(93)	24(80)	0.031*	22(73)	19(63)	0.015*	24(80)	30(100)	0.019*
II	5(16.6)	3(10)	0.243	8(26)	12(40)	0.244	5(16)	7(23)	0.734
III	2(6.6)	3(10)	0.923	7(23)	5(16)	0.233	6(20)	1(3.3)	0.055
IV	2(6.6)	4(13)	0.862	4(13)	5(16)	0.723	17(56)	14(46)	0.234
V	0	0	>0.99	0	0	>0.99	0	0	>0.99

* Significant difference (P < 0.05).

Table 2
P-values showing relationship of lip print patterns between males from the study population.

Male lip print pattern	Uganda vs Kenya P -value	Somalia vs Kenya P -value	Uganda vs Somalia P -value
I	0.9841	>0.999	0.9998
I'	0.4579	0.2309	>0.999
II	0.3320	0.8625	0.9998
III	0.9436	0.9974	>0.999
IV	>0.999	0.0038*	0.0009*
V	>0.999	>0.999	>0.999

* Significant difference ($P < 0.05$). vs = versus.

Table 3
P-values showing relationship of lip print patterns between females from the study population.

Female lip print pattern	Uganda vs Kenya P-value	Somalia vs Kenya P-value	Uganda vs Somalia P-value
I	0.766	>0.999	0.9977
I'	0.122	0.2641	>0.999
II	0.076	0.8118	0.9997
III	0.597	0.9885	>0.999
IV	0.997	0.0127*	0.0039*
V	>0.999	>0.999	>0.999

* Significant difference ($P < 0.05$). vs = versus.

difference in female lip print pattern Type IV from Somalia and Kenya ($p = 0.0127$) and similarly between females from Uganda and Somalia ($p = 0.0039$) as shown in Table 3 below.

Table 4 below shows variation in the Lip print pattern from four different lip quadrants among males and females from the study population. Patterns I and I' were the most common patterns in all the quadrants of both males and females.

In the RUQ Type IV was dominant among Somalis males and females. The LUQ was dominated by Type II and IV from Kenya and Somalia. In the RLQ and LLQ Type III and Type IV pattern was found mostly to be dominant in males of Somalia. Ugandans generally lacked Type III and IV in their RUQ.

Chi-square test indicated no statistical difference between lip print patterns among quadrants when compared between countries; $P \leq 0.05$.

Measurement of lip length and width

Determination of technical error of measurement (TEM)

We determined TEM by use of results obtained from two independent examiners. The measurements were taken at one-week interval and recorded separately. We used the formulae below to calculate the technical error of measurement [14].

$$TEM = (\sum \text{Deviation}^2)/2N$$

$$\text{Relative TEM} = (\text{TEM}/\text{VAV}) \times 100$$

That is;

Deviation = difference in measurements from the two independent examiners but results obtained from the same person.

VAV (variable average value) = Arithmetic mean of both means of test one and two.

The result for the relative TEM are tabulated in Table 5 below. The relative TEMs for lip length and width among Ugandans was 0.07% and 0.1% respectively; among Kenyans it was 0.06% and 0.27% and among Somalis 0.7% and 0.11% respectively.

Lip length and width

Table 5 below shows that among males; Ugandans had wider lips (5.48 ± 0.50) followed by Somalis (4.97 ± 0.49) then Kenyan (4.17 ± 0.64). The lip length was longer in Kenyans (5.14 ± 0.85) and of about an equal length among Ugandans and Somalis.

Likewise, among females; Ugandans had averagely wider lips (4.99 ± 0.59) than Kenyans and Somalis. The lip length was longer among Kenyans followed by Ugandans and shorter among Somalis.

Table 6 below shows adjusted p-values after multiple comparisons using Tukey's test.

Table 4
Variation of lip print patterns by quadrants between males and females in the study population.

		Uganda		Kenya		Somalia	
Region	Lip pattern	Male (%) n = 30	Female (%) n = 30	Male (%) n = 30	Female (%) n = 30	Male (%) n = 30	Female (%) n = 30
RUQ	I	24(80)	25(83)	30(100)	27(90)	20(66)	30(100)
	I'	30(100)	24(80)	30(100)	27(90)	24(80)	30(100)
	II	3(10)	0(0)	4(13)	10(33)	5(16)	6(20)
	III	0(0)	0(0)	4(13)	7(23)	7(23)	0(0)
	IV	0(0)	0(0)	0(0)	6(20)	14(46)	14(46)
	V	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
LUQ	I	24(80)	24(80)	30(100)	30(100)	20(66)	30(100)
	I'	22(73)	23(76)	21(70)	24(80)	24(80)	30(100)
	II	5(16)	0(0)	7(23)	7(23)	7(23)	7(23)
	III	0(0)	2(6)	0(0)	3(10)	5(16)	0(0)
	IV	0(0)	2(6)	3(10)	7(23)	13(43)	12(40)
	V	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
RLQ	I	30(100)	21(70)	30(100)	30(100)	25(83)	30(100)
	I'	30(100)	21(70)	30(100)	27(90)	24(80)	28(93)
	II	0(0)	3(10)	8(26)	7(23)	6(20)	6(20)
	III	0(0)	0(0)	4(13)	6(20)	7(23)	0(0)
	IV	3(10)	11(36)	5(16)	6(20)	14(46)	9(30)
	V	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
LLQ	I	30(100)	30(100)	30(100)	30(100)	26(86)	30(100)
	I'	30(100)	18(60)	24(80)	24(80)	23(76)	21(70)
	II	4(13)	3(10)	8(26)	7(23)	9(30)	6(20)
	III	3(10)	8(26)	0(0)	5(16)	6(20)	0(0)
	IV	9(30)	0(0)	9(30)	4(13)	11(36)	10(33)
	V	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

Key: LUQ: Left upper quadrant; RUQ: Right upper quadrant; LLQ: Left lower quadrant; RLQ: Right lower quadrant.

Table 5
Reliability test for lip length and width measurement among the study population.

Uganda	Test one	Test two	Mean difference	P value
Length (cm)				
N	60	60		
Mean ± SD	4.425 ± 0.87	4.4565 ± 0.81	−0.0315	0.252
VAV	4.44075			
∑Deviation	−0.63			
Relative TEM (%)	0.07			
Width (cm)				
N	60	60		
Mean ± SD	5.235 ± 0.58	5.195 ± 0.56	0.04	0.219
VAV	5.215			
∑Deviation	0.8			
Relative TEM %	0.10			
Kenya	**Test one**	**Test two**	**Mean difference**	**P value**
Length (cm)				
N	60	60		
Mean ± SD	4.75 ± 0.85	4.72 ± 0.94	0.03	0.237
VAV	4.735			
∑Deviation	0.6			
Relative TEM (%)	0.06			
Width (cm)				
N	60	60		
Mean ± SD	4.37 ± 0.50	4.43 ± 0.51	−0.06	0.101
VAV	4.4			
∑Deviation	−1.2			
Relative TEM%	0.27			
Somalia	**Test one**	**Test two**	**Mean difference**	**P value**
Length (cm)				
N	60	60		
Mean ± SD	4.005 ± 1.08	4.1 ± 1.13	−0.095	0.103
VAV	4.0525			
∑Deviation	−1.9			
Relative TEM (%)	0.7			
Width (cm)				
N	60	60		
Mean ± SD	4.64 ± 0.63	4.68 ± 0.66	−0.04	0.234
VAV	4.66			
∑Deviation	−0.8			
Relative TEM%	0.11			

Table 6
Descriptive statistics for lip length and width from the study population.

	Ugandans	Kenyans	Somalis	ANOVA
Male				
Length/cm	4.63 ± 0.85	5.14 ± 0.85	4.62 ± 1.25	P = 0.002
Width/cm	5.48 ± 0.50	4.17 ± 0.64	4.97 ± 0.49	P = 0.033
Females				
Length/cm	4.18 ± 0.95	4.36 ± 0.71	3.24 ± 0.34	P = 0.004
Width/cm	4.99 ± 0.59	4.47 ± 0.41	4.12 ± 0.39	P = 0.041

The table shows that there was statistical difference in lip length of females from Uganda and Somalia as well as Kenya and Somalia. It also shows that there was statistical difference among lip width of males from Uganda and Kenya as well as those from Kenya and Somalia as shown in the table below. Statistical difference was considered at $P < 0.05$.

Discussion

The present study was carried out to examine gender differences in anthropometric measurement of lip size and lip print patterns in a sample of the East African population.

Anthropometric measurement can be used in assessing gender differences among others. In order to ascertain the degree of reliability of our methods, we determined the technical error of measurement (TEM) and relative TEM (%TEM) as shown in Table 5. The values for relative TEM were within acceptable values. From our results the estimate for the first (intra-examiner) and second tests (inter-examiner) were within acceptable range. The acceptable ranges for Relative TEM using anthropometric levels for intra-examiner is <1.5% and inter-examiner <2.0% [14,15]. This therefore implies that human errors in lip size measurements in our study were minimum. The lower the TEM obtained, the better the reliability [16]. Similar methods of lip measurements were used to compare the size of lips of Persian men in Mashhad with men living in India, which showed similarity [12].

From this study, we observed that lip print patterns were unique to all individuals and that their distribution in each lip quadrant varied. This conforms to previous studies by Ghimire et al., and Ahmed et al., that no two lip prints pattern are seen to be exactly alike, even among twins [7,17,18].

A similar study that described in detail the lip-print patterns of both males and females at Almadinah Almonawarah province in Saudi Arabia confirmed that the lip-print pattern are unique for each individual even among twins and family relatives [19]. Another study among 955 Egyptian revealed that the lip print for each individual was unique and that the complete vertical pattern was the commonest type among males and females. It was also shown that sex could not be distinguished using lip print pattern [20]. In addition, lip print patterns between parents and biological offspring in families of 31 Malay students as well as the distribution of different types of lip print showed that the highest pattern lip pattern was type I (29.84%) and the least was type V (1.61%). There was a positive resemblance in lip print patterns among family members [21]. We attributed differences in lip print patterns to ethnic and racial difference.

This also study observed that Type I and I' were predominant among the study population as shown in Table 1. A study among 200 adults from Marathi population in central India, showed that Type I (30.63%) was the most predominant lip print pattern and that the patterns were stable when followed for a period of six-months [22,23].

We attributed the differences in lip pattern to genetic and environmental factors such as temperature differences in the region.

We also observed that the Somalis were distinguished with presence of Type IV in their lower lip quadrants, Kenyans had more of Type III while Ugandans generally lacked Type III and IV in their right upper quadrant as shown in Table 4. Statistical analysis showed no significant difference in lip print pattern participants except Type IV which was significantly different among Somalis and Kenyans as well as among Ugandans and Somalis.

In a previous study of 200 residents of Mangalore in India, it was shown that among females, Type I' was the highest recorded followed by Type II, Type III, Type IV, Type I and Type V with statistically significant differences in lip print patterns. It was shown that the distribution of lip prints was dissimilar for males and females, in the lower medial lip, as well as upper and lower lateral segments [24]. Our findings were rather not in agreement with a study by Vignesh et al. [25] and Jeergal et al. [24] that there was statistical difference in lip print pattern by gender among the Indian population.

The variation could have been due to small sample sizes and perhaps they did not determine post-hoc test to show where the difference occurred like we found it existed among pattern Type IV with in the study population.

Generally, variations in lip print patterns from our study can be explained by ethnic and racial difference and environmental factors. A study in Egypt which is equally hot like Somalia, showed dominance of Type I and IV pattern [18]. We also associated the difference in lip pattern to a number of factors such as; relaxation of lip muscles and grooves on the lips that provide advantaged routes for saliva. The upper lip is also more hydrated than lower lip and the continuousness of lips with adjacent skin lines [26].

Lip print patterns can be in a database for all individuals in a given area with intentions to serve as reference in civil litigations and criminal cases.

Table 7
Showing adjusted p values of lip size and length among the participants.

	Uganda vs Kenya	Uganda vs Somalia	Kenya vs Somalia
Length/cm			
Female	0.839	0.0108*	0.0019*
Male	0.250	0.999	0.2369
Width/cm			
Female	0.236	0.0201	0.5174
Male	0.0002*	0.2501	0.0359*

* Significant difference ($P < 0.05$).

This is possible because lip prints remain stable overtime. A study analyzed lip print patterns among 116 Saudi females who were compared to their lip prints taken 3 years earlier. Statistical analysis showed no significant difference in the frequency of pattern detected between old and new lip prints ($P > 0.05$) [27].

Table 6 shows results on lip size showed that male participants had longer and wider lips as shown in Table 7. Similar studies on lip anthropometrics in India have showed men to have more lip width [12].

A study that evaluated the influence of gender on the upper lip length showed that the length was significantly shorter in females than males [28]. A similar study on sex variations of mouth and lips dimensions showed that the mouth width, width of the philtrum, total lip height, and lip volumes were significantly larger in men than in women ($p < 0.01$) [29]. Another study that evaluated labial morphology and gender-related differences in healthy young adults showed that the lower lip was thicker than the upper lip [30]. Our study was in agreement with a previous study on morphometric analysis of facial features i.e. head, eyes, orbits, nose, lips, and mouth, and ears which showed statistical difference between adult males and females [31,32]. We also observed that there was a statistical difference in lip sizes between males from Uganda and those from Kenya and Somalia. A study on assessment morphological data upper lips of 1500 healthy children in Chengdu, Western China showed that the width of the upper lip was statistically significant ($p = 0.02$) [33]. We attribute this to ethnicity difference, nutrition, environmental differences and genetic uniqueness. However, small sample size could also have affected the difference in statistical analysis.

Conclusion

Lip print pattern can be used in forensic identification purposes because of their individual uniqueness. It was also shown that the male subjects had longer and wider lips than the females. This variation can help to narrow the search gap in criminal investigations and forensic purposes. We recommend similar investigations among different age groups using large sample sizes.

Conflict of interest

All authors declare that there exists no conflict of interest in this study.

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