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Three-dimensional anthropometric study of the facial morphology of black African Senegalese: 3D photogrammetric approach

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ABSTRACT

Introduction: Anthropometric features are important in determining gender and ethnic groups. The aim of this 3D photogrammetric study was to assess the face of Senegalese subjects.
Material and methods: A total of 104 3D facial photographs taken with the Bellus 3D application were studied. Measurements were taken at various anthropometric points using Meshlab software. The acquired data were recorded and processed using Jamovi software version 1.8.4.0. Correlations between the quantitative variables were tested and only one with a significance of p 0.05 was retained.
Results: Overall, measured distances were higher in men. A statistically significant difference between men and women was found for nose width (p0. 001), face width ($p < 0.005$) and face height (p0. 0002). Conclusion: 3D anthropometric analysis shows a fairly significant sexual dimorphism, with males having greater facial and nasal proportions. A leptoprosopic (long) facial shape and a mesorrhine nose were maintained.

1. Introduction

All humans have similar facial features with different proportions and characteristics from face to face.[1] The morphometric parameters, interocular distance, facial index and nasal index, are helpful in identifying the different ethnic groups.[2,3] Anthropometric analysis of the face has many applications, including human identification, forensic medicine, orthodontics, and plastic and reconstructive surgery.[2] In criminal investigations, digital image identification is becoming increasingly important due to the growing use of surveillance cameras.[4] They often record faces that can be useful in describing a crime scene or a suspect involved in a terrorist attack. The face is one of the most important aspects that reflect the individuality of a person.[5] Thus, the identity of a person can be determined from the face using methods of morphological comparison, comparison of anthropometric indices or the technique of superimposition.[6,7]

Several anthropometric studies of the face have been conducted worldwide.[8–10] Sex-specific estimates can be made by morphological examination of features significantly associated with sex. Most work on melanoderm individuals in Africa has used 2D photo-analysis.[11,12]

Using a two-dimensional approach to anthropometrically assess the noses of Nigerian subjects, Omotoso et al. found a platyrrhine nose and true sexual dimorphism as a function of nose height.[12] Although two-dimensional (2D) photography is widely used, it is subject to limitations related to changes in illumination, variations in camera angle and distance from the subject. In addition, 2D photography is time-consuming and can be affected by the interaction between the subject and the examiner.[13,14] With the advent of the facial scanner in recent years, anthropometric facial analysis has become easier and faster, and the disadvantages of traditional instruments have been greatly reduced. The aim of this study was to evaluate the face of Senegalese melanodermic subjects using 3D anthropometry.

2. Materials and methods

This descriptive study was conducted in the Department of Odontology, Faculty of Medicine, Pharmacy and Odontology, Dakar, Senegal. Participants were informed of the purpose of the study and free and

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informed consent was obtained from all.

Inclusion criteria were Senegalese melanoderm subjects aged 16–45 years.

Subjects with severe skeletal classes II and III, ongoing orthodontic treatment, congenital dental malocclusions and orthognathic or cosmetic plastic surgery were excluded from the study.

2.1. Collection procedure

An iPhone Xs Apple was used, mounted on a fixed tripod at a height of 60 cm and 30–45 cm from the subject. The Bellus 3D dental pro ® application is activated by selecting the "Full head" option. The subject's face is centered until the green light is activated. A visual and voice display guides the subject's movements (Fig. 2).

2.2. Data acquisition

After acquisition in 3D, the obj file obtained on Bellus 3D was imported into the 3D analysis software Meshlab version 2020. Measurements were taken at the level of the eyes, nose, lips and zygomatic bone (Fig. 1). The different points and landmarks used are defined in Table 1 and 2.

2.3. Statistical analysis

Data were analysed using Statistical Package for the Social Sciences version 19 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics such as mean, standard deviation and percentage were used. Comparison of means was done with a Student's t-test, where $P < 0.05$ was considered statistically significant.

3. Results

104 3D images of subjects aged 16–45 years were analysed, including 58 men and 46 women. Table 3 shows the average distances for the face, and labial dimensions. For the enR-exL distance, the mean value was higher in women (29.2 ± 2.12 mm) than in men (28.85 ± 2.23 mm). The same trend was found for enL-exR distance: 29.0 ± 2.26 mm in women versus 28.3 ± 3.13 mm in men (Table 4).

Comparison of the means with Student's t-test shows a statistical difference for the exR-exL and enR-enL distance. In the nasal region (alR-alL, n-sn, n-prn, sn-prn), the mean values found were higher in men than in women. The T-test for the comparison of the mean values for the width of the nose alR-alL showed a statistically significant difference of $p < 0.001$. In the labial region (chR-chL, cphR, cphL, sto-li, ls-li), the mean distances found were higher in men overall. A statistically significant difference was found for the distances chR-chL and cphR-cphL (Table 2).

For the distance sn-ls, the T-test showed no statistically significant difference ($p < 0.068$) depending on gender. For the facial measures n-gn, zy-zy and sn-gn, the mean values were higher in men than in women (Table 3). A clinically significant sexual dimorphism in favour of males was observed for all measured distances. The clinical difference was a mean difference between males and females of more than 3 mm. Males had a broader and longer face than females.

Nose and face shape were defined by calculating a nasal index al-al/n-sn and a facial index (n-gn/zy-zy), respectively. A leptotropic long face (long) and a medium sized nose (mesorrhine) were observed.

4. Discussion

Anthropometric analysis of the distance between the eyes, the bridge of the nose, the corners of the mouth, the ears and the chin makes it possible to characterise a person. The nose, one of the most important characteristic features of the face, helps to determine a person's sex, age, ethnicity and race.[12] In this three-dimensional study, the Bellus 3D dental Pro application was used for the photos. It has the advantage of significantly reducing the interactions between the examiner and the subject as well as the distortion phenomena observed in 2D images. The measurements taken at the level of the different faces show that the faces

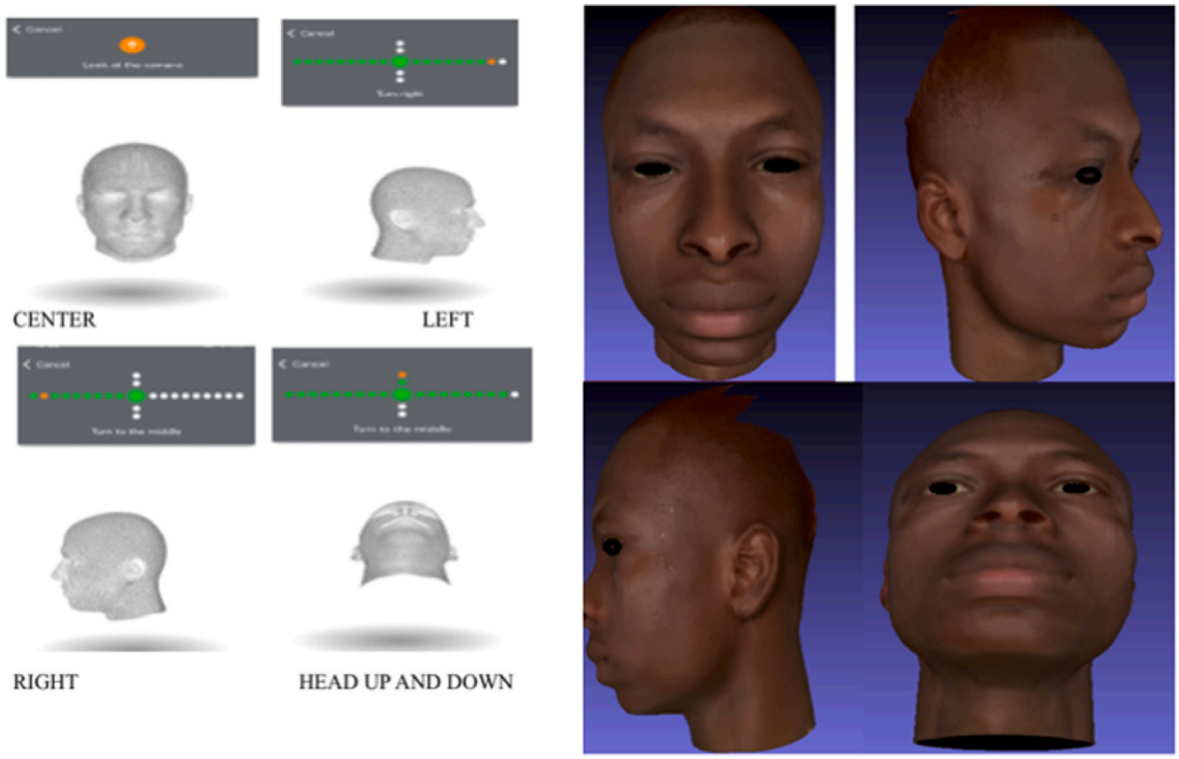

Fig. 1. 3D acquisition by Bellus 3D dental Pro.

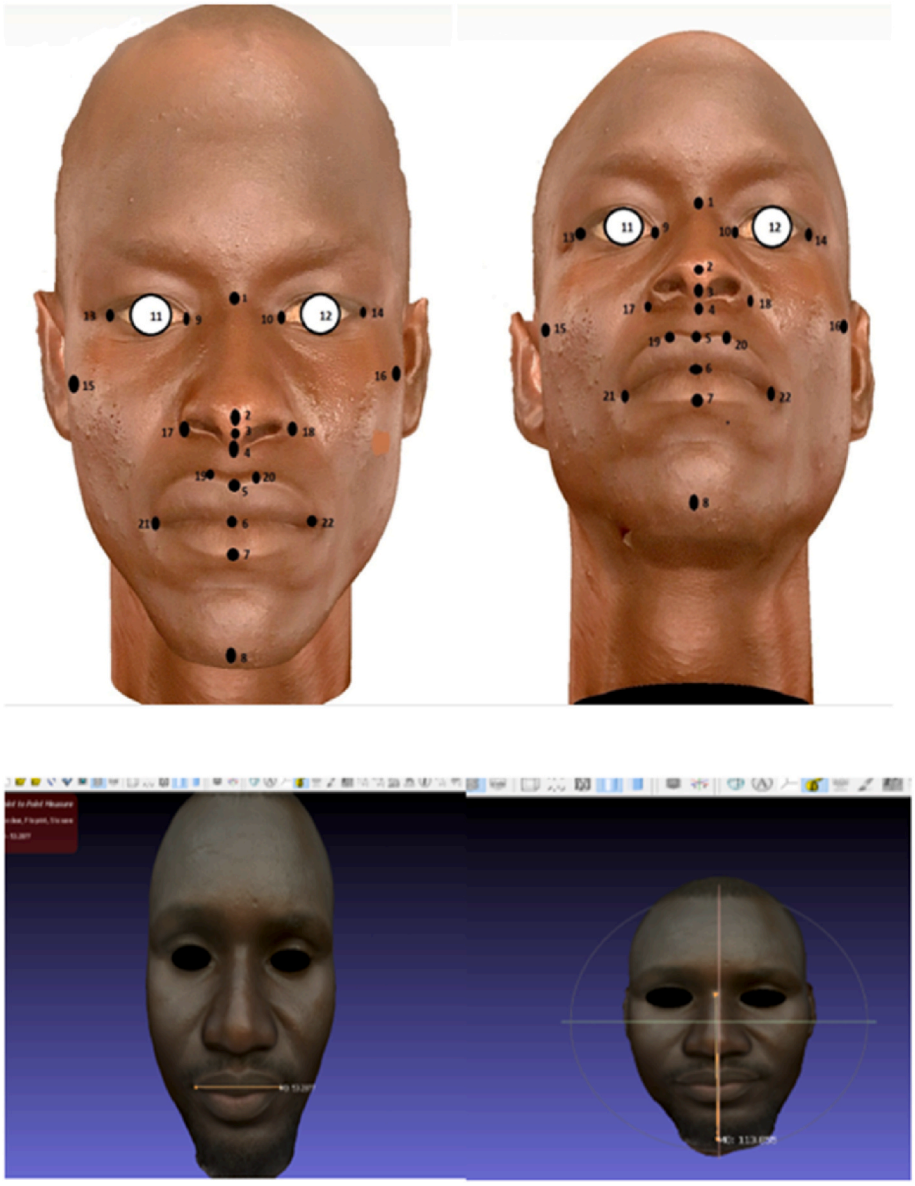

Fig. 2. Three-dimensional facial image with anthropometric landmarks.

of the men were wider than those of the women. The mean values of the distances ex-ex, en-en, enR-exR, enL-exL, pR-pL were respectively 87.9 mm, 32.7 mm, 29 mm, 29 mm, 59.9 mm for women and 89.4 mm, 3.5 mm, 28.5 mm, 28.3 mm, 61.9 mm for men. Comparison of the mean values with Student's test shows a statistically significant difference between women and men in distance (Table 1).

In the nasal region, the mean distances of al-al, -n-sn, n-prn, sn-prn were 37.2 mm, 48.6 mm, 39.1 mm and 16.6 mm for females and 41 mm, 50.2 mm, 40.6 mm, 7.8 mm for males.

Overall, the analysis of the nose showed that the nose length (al-al, sbal-sn) was greater in males than in females, with statistically significant differences (Table 1).

This sexual dimorphism was also found in the Turkish study by Ozdemir et al. where the nasal width al-al was 38.4 ± 0.44 in males and 34.8 ± 0.29 in females.[15]

Other studies conducted in Korean,[16] African-American (42.1 ± 2.92 for men; 38 ± 2.91 for women) and Italian-Caucasian (37.33 ± 2.66 for men and 34.72 ± 2.49 for women) populations confirm the findings of this study.[9,16,17] In terms of nasal height n-sn, the mean value found of 50.2 ± 3.86 for men and 48.6 ± 0.58 for women differs from that found in a northern Italian population (57.43 ± 3.93 for men and 54.07 ± 3.68 for women).

This nasal sex difference could be due to the higher body mass and oxygen demand of males. The nasal index, the ratio of width to height of the nose, was 82% for men and 76.8% for women. Five nasal types are described for the index: hyperleptorrhine (40–54.9%), leptorrhine (55–69.9), mesorrhine (70–84.9%), platyrrhine (85–99.9%) and hyperplatyrrhine above 100%.[9,12] In this study, both men and women had an average nose and thus a mesorrhine type.

Overall, three types of human nose are described in the literature according to their shape: leptorrhine (long and narrow or Caucasian), mesorrhine (medium-sized or Asian) and platyrrhine (broad and flat or African).[12] Omotoso et al. found a platyrrhine nasal shape in Nigerian black African subjects. Their nasal index was 94.64% in males and 90.33% in females.[12]

In Egyptian subjects, Hegazy et al.[18] found a mesorrhine nasal form in males (71.46%) and a leptorrhine form in females (64.56%). In the Turkish population, the leptorrhine form (narrow nasal type) was more common in men (70%) and women (78%).[19]

The mean values obtained for the nasal tip (sn-prn), 17.8 mm in men

Table 1
Landmark and definitions.

Landmark	Definitions	Numero
Endocanthion (enR, enL)	Inner commissure of the right eye fissure Inner commissure of the left eye fissure	9–10
Exocanthion (exR, exL)	outer commissure of the right eye fissure outer commissure of the left eye fissure	13–14
Nasion (n)	Midline point located at the root of the nose.	1
Pupille (p)	Point in the center of the pupil	11–12
Alare (al)	The most lateral point of each wing contour	17–18
Pronasale (prn)	The most prominent point of the tip of the nose, identified in lateral view	2
Subnasale (sn)	The point where the upper lip joins the columella	4
Columella (c)	The most inferior and anterior point of the nose	3
Labiale superius (ls)	Midpoint of the upper vermilion line	5
Labiale inferius (li)	Midpoint of lower vermillion line	7
Stomion (sto)	Imaginary point at the crossing of the vertical facial midline and the horizontal labial fissure	6
Christa philtri (cphR, cphL)	Junction between the vermilion of the upper lip and philtral ridge".	19–20
Cheilion (chR, chL)	The point where the outer edges of the vermilion and lower vermilion meet at the level of the of the mouth	21–22
Pogonion (Pog)	The most anterior projecting point in the midline on the chin.	8
Zygion (zy)	Most lateral point of the zygomatic arch	15–16
Sellion	The most intruded part of the nose in Frankfurt horizontal plane, that is, the intersection between the nose and the forehead.	
Gnathion	The lowest point on the intersection between the mid-sagittal plane and the chin in Frankfurt horizontal plane	
L - R	R= Right, L = Left	

Table 2
Soft Tissue landmarks used in this study.

en-en	Endocanthion to endocanthion	Inter-canthal distance
pR-pL	center of the pupil right to center of the pupil left	Inter-pupillary distance
al-al	Alare to alare	Nasal width
se-sn	Sellion to subnasale	Nasal height
ex-ex (R, L)	Exocanthion to exocanthion	Biocular (lateral canthal) width
Sn-prn	Subnasale to pronasale	Nasal tip
sn-c	Subnasale to highest point of columella	Columellar length
Sn-ls	Subnasale to labia superius	Cutaneous upper labial height
sn-sto	Subnasale to stomion.	Overall upper labial height
cphs-cphs	Crista philtri superior to crista philtri superior	Lower prolabial width
sn-cphi	Subnasale to crista philtri inferior	Midpoint of columella base to inferior point of philtral column
ac-cphi	Alar curvature to crista philtri inferior	acial insertion of alar base to inferior point of philtral column
Cphi-ch	Crista philtri inferior to chelion	Inferior point of philtral column to the most lateral point of the vermilion cutaneous junction of the upper lip
zy-zy	Maximum facial breadth	
n-prn	Nasal bridge length	
n-sn	Nose heigh	
Sn-ls	Philtrum length	
Sn-gn	Lower face height	
ls-sto	Upper vermilion height	
Facial index		n-gn/zy-zy
Nasal index		al-al/n-sn

and 16.6 mm in women, differ from the values obtained in the study by Amini F et al.,[20] which was conducted in Persian subjects (20 mm in men and 19.3 mm in women). The labial region is essential for the evaluation of facial morphology. The mean values of the distances ch-ch, cph-cph,

Table 3
T-test comparison between senegalese Males and Females (distances in millimeters; mm).

	Mean SD		
	F	M	P-value
al-al	37.2 (3.32)	41.0 (3.24)	0.001*
n-sn	48.6 (3.22)	50.2 (3.86)	0.026
en-en	32.7 (2.83)	33.5 (5.14)	0.039
ex-ex	87.9 (3.24)	89.4 (4.10)	0.06
n-prn	39.1 (3.53)	40,6 (3.45)	0.028
sn-prn	16.6 (2.31)	17.8 (2.64)	0.014
en**R**-ex**L**	29.2 (2.12)	28.5 (2.23)	0.067
en**L**-ex**R**	29.0 (2.26)	28.3 (3.13)	0.117
p**R**-p**L**	59.9 (7.29)	61.9 (6.50)	0.129
ch-ch	46.91 (4.03)	49.92 (5.33)	0.002
cph-cph	11.03 (1.75)	12.74 (1.66)	0.001
sn-ls	7.54 (1.50)	8.30 (2.51)	0.068
ls-sto	10.10 (1.89)	11.00 (2.45)	0.031
zy**R**-zy**L**	117.9 (7.76)	122.0 (6.81)	0.005
n-gn	107.1 (8.12)	111.7 (6.91)	0.002
sn-gn	60.2 (5.37)	63.3 (6.53)	0.009
sto-li	13.5 (1.63)	14.3 (1.75)	0.02

Table 4
Facial and nasal index.

	(%) Males	(%) Females
al-al/n-sn	82	76.8
n-gn/zy -zy	91	90

sn-ls, ls-sto, sto-li were 46.9 mm, 11.03 mm, 7.54 mm, 10.10 mm; 13.5 mm in females and 49.92 mm; 12.74 mm, 8.30 mm, 11 mm, 14.2 mm in males. The labial index Ls-li/ch-ch, the ratio of labial height to labial width, was 51% in men and 50% in women. These results contrast with the study by Yu Han yang et al. in a Chinese population, where the labial index was 34.31% in females and 31.85% in males.[21]

The calculation of the n-gn/zy-zy facial index is often used to determine the face type according to the classification of Martin and Saller.[22]

The latter distinguishes five face types according to the value of the facial index:

- hyperleptoprosopic (very long face, index; 93.0%)
- leptoprosopic (long face, index 88–92.9%.)
- mesoprosopic (round face; index 84–87.9%)
- euriprosopic (wide face, index 79–83.9%)
- hypereuriprosopic (extremely wide face, index; 78.9%).

In this study, the facial index was 90% in women and 91% in men, resulting in a leptoprosopic long face in both men and women.

These results differ from the study by Raymond SM et al. on Ghanaian subjects, where the facial index was 102% in women and 104% in men. The authors conclude that the face is very long and hyperleptoprosopic.[22]

The method used in this study is inexpensive and easy to perform thanks to the Bellus 3D photogrammetry application available on the iPhone X and iPad Pro. The limitations of the present study are that it was conducted on a specific population with a limited sample. Therefore, further studies should be conducted on other populations in other geographical locations and with larger samples that include additional variables to learn more about facial morphology.

5. Conclusion

The present study revealed significant sexual dismorphism. Males had higher mean scores for all variables measured. A long leptoprosopic

face and medium mesorrhine nose were maintained for this study population.

Declaration of competing interest

All authors who participated in the redaction of this article did not report any conflict of interest.

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