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Photogrammetric Study of Facial Dimensions among Adults Resident in Cross River State, Nigeria

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Abstract

AIM: The current study used photogrammetry to measure the facial dimensions of young, healthy adult residents in Cross-River State.

METHODOLOGY: Over the course of five months, 126 subjects (61 males and 65 females) from Cross-River State, Nigeria, were included in this study. Photographs were taken using a digital camera (Nikon Digital Camera D5300, Japan) with the subjects at a distance of 120 cm from the lens using 640 X 480 pixels. Photo markings with anatomical points of reference, the measurements taken were; Facial height (Tr -Gn), Cranial width (Eur -Eul) Facial width (T -T) Nasal width (Ail -Ail) Intercanthal distance (Enr -Enl) Nasal height (N -Prn) Nasion-gnathion distance (N -Gn) Binocular distance (Exr -Exl) Inter commissural width (Chr -Chl) Subnasale-gnathion distance (Sn -Gn). The measurements were done using Corel Draw (x7) program.

RESULTS: Findings from the study revealed that the Mean±SD values for the male subjects facial dimensions were; Facial height 113.71±10.00, Cranial width 64.06±7.02, Facial width 79.25±8.10, Nasal width 29.65±3.62, Intercanthal distance 20.29±2.46, Nasal height 25.88±3.22, Nasion-gnathion distance 72.81±6.75, Binocular distance 64.08±11.25, Inter commissural width 36.51±4.76, Subnasale-gnathion distance 40.14±5.16. while those for the females were Facial height 95.03±11.55, Cranial width 53.43±6.63, Facial width 65.65±8.24, Nasal width 24.31±2.58, Intercanthal distance 17.06±2.92, Nasal height 21.27±4.36, Nasion-gnathion distance 60.39±7.44, Binocular distance 51.23±9.80, Inter commissural width 30.51±3.71, Subnasale-gnathion distance 32.79±4.40. The test for equality of variance between male and female individuals from Cross River showed a statistically significant difference in the mean values. This research demonstrated that males from Cross River State exhibited higher values of facial dimensions compared to females.

CONCLUSION: The utilization of non-invasive photogrammetry facilitated efficient measurement of facial parameters, ensuring the convenience and time-saving of participants in this study. This effort contributed to establishing normative values for facial measurements among the people of Cross River. While acknowledging the need for further studies, it is important to note that this work remains valuable in its current scope.

Keywords:
Photogrammetry**,** Noninvasive photogrammetry, Facial dimensions, Cross River

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INTRODUCTION

Numerous techniques have been employed to assess facial features, including cephalometric radiography (McIntyre & Mossey, 2003), computed tomography, laser scanning (AlKhatib, 2010), photogrammetry (Fernandez-Riveiro *et al*., 2003; Kale-Varlik, 2003; Anicy-Milosivecy *et al*., 2008; Malkoc *et al*., 2009; Anibor & Okumagba, 2010; Reddy *et al*., 2011; Wamalwa *et al*., 2011), craniofacial anthropometry (Kolar & Salter, 1997), and photogrammetry (Fernandez-Riveiro *et al*., 2003). Photogrammetry is the measurement of anthropometric features on photos. While in NHP and used the angle of facial convexity to describe technique that is easy to use. It also saves important time and keeps participants from experiencing inconvenience. It offers a lasting record of the contestants' genuine appearance (Wamalwa *et al*., 2011). The data obtained from the analysis of the angular photogrammetric profile can help orthodontists, maxillofacial and plastic surgeons, and other clinicians understand issues related to different soft tissue segments of the facial region. It can also aid in creating aesthetically pleasing treatment plans for patients since the

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photographs' outline remains unchanged and the soft tissue becomes incompressible on the bone. Geographically and genetically, populations differ in their craniofacial characteristics (Anibor & Okumagba, 2010).

As such, it is inappropriate to apply a single standard of anthropometric characteristics to a variety of racial and cultural groupings. Cross River is home to individuals from many ethnic backgrounds, and these groups differ in terms of their physical attributes.

One of the most advanced methods for human recognition is face recognition. Accuracy is on par with historically dependable biometrics, such as fingerprint and iris identification, in carefully regulated environments (Phillips *et al*., 2006). In less-controlled settings, accuracy is attenuated with variation in pose, illumination, and facial expression among other factors.

Human face digitization techniques need to take into account some factors, including the acquisition time of the model, the cost and simplicity of the equipment, and a realistic and exact reproduction of the form obtained. Non-contact approaches are especially intriguing for medical applications since contact with the probing devices during soft tissue measurement can distort the facial surface and introduce errors.

Currently, there are numerous approaches for recording and measuring the morphology of the craniofacial surface. These include more recent three-dimensional (3D) surface imaging devices in addition to direct anthropometry and digital photography (Naini *et al*., 2017). Facial asymmetry measurement techniques based on 3D imaging have gained popularity and established a virtual reality paradigm. Furthermore, 3D image processing techniques have made a significant contribution to the reduction of magnification mistakes caused by geometric distortions that frequently compromise traditional 2D-acquisition techniques. According to Hajeer *et al*. (2004), the use of 2D projections, which attempt to quantify 3D asymmetric objects, causes errors due to the imprecise nature of the reference points. The purpose of this study was to use photogrammetry to measure the facial landmarks of young, healthy adults in Cross River State.

MATERIALS AND METHODS

Study Design

Over five months, subjects from Cross River State, Nigeria, were included in this study, which employed an experimental design to determine the facial measurement of healthy adults in the region using photogrammetric analysis of facial parameters.

Study Population

Subjects from Cross River State who have also been resident in Cross River for a minimum of 10 years were selected at random to make up the study population. For this study, 126 Cross River State residents regardless of ethnicity participated between the ages of 18 and 30 years. The study did not include subjects with facial deformities or infections. Before any photographs were taken, volunteers gave their informed consent.

Positioning the Subject

All the subjects were allowed to sit comfortably with their heads held in their natural positions. The subjects were positioned according to a floor-marked line. On the other side, a mirror was positioned 120 centimeters in front of the participants to enable them take instructions for positioning and composure during photography. Before each recording, the subjects relaxed their lips and looked into the mirror, ensuring that the front view profile was taken in the natural head position (NHP).

Photo Capture

All photographs were taken with a digital camera (Nikon Digital Camera D5300, Japan) at a distance of 120 cm from the lens on the same straight line where the mirror is placed, in an area well-lit by incandescent light, and elevated to the subject's ear level to avoid face distortion and produce high-quality images.

Photographic Setup

Half of the viewfinder in the camera view was occupied by the subject's face. Shadow-free face illumination was achieved by positioning two light sources one meter (1m) apart on either side of the camera. The distance between the light source and the subject was comparable, and the light source was at the same level as the camera. A clear white curtain served as the background. For the subject's photos, a minimum acceptable camera resolution of 640 X 480 pixels was used because ultra-high resolutions would increase the difficulty of handling images and may not always provide more information about the picture.

Digital Photography Essentials

The software (Corel Draw x7™) tool used in this study is made to extract measurements of parameters from subjects' two dimensional (2D) photographs. Measurements were taken directly from digital photographs of the subjects, eliminating the need for rulers and protractors on printed images. The results were produced by the tool in a format that can be exported to databases and spreadsheets. The accessibility of low-cost, high-resolution digital cameras greatly enhanced the convenience and allure of digital photography.

All of the subjects' photographs were exported to the Corel Draw (x7) program, where the digital marking of the face's anatomical points of reference was done. To reduce the margin of error, a single operator took all the measurements in millimeters (mm). To g*et al*l the measurements, the following landmarks were made on the photographs: Right cheilion (Chr), Left cheilion (Chl), Right alare (Air), Left alare (Ail), Right extocanthion (Exr), Left ectocanthion (Exl), Right endocanthion (Enr), Left endocanthion (Enl), Trichion (tr), Right eurgon (Eur), Left eurgon (Eul), Left tragion (t), and Right tragion (t).

These points were used to trace and measure the following facial parameters: Tr-Gn (facial height), Eur-Eul (cranial width), T-T (facial width), Air-Ail (Nasal width), Enr-Enl (intercanthal distance), N-Prn (nasal height), N-Gn (nasion-gnathion distance), Exr-Exl (binoculardistance), Chr-Chl (mouth width), Sn-Gn (subnasal-gnathion distance). The figures below (Fig. 1, 2, 3 and 4) demonstrate the landmarks where facial measurements was carried out.

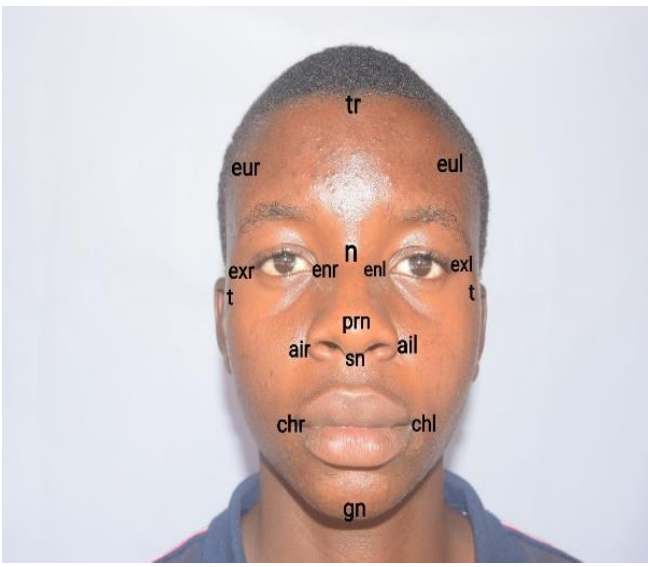

Fig. 1: The landmark used in the study

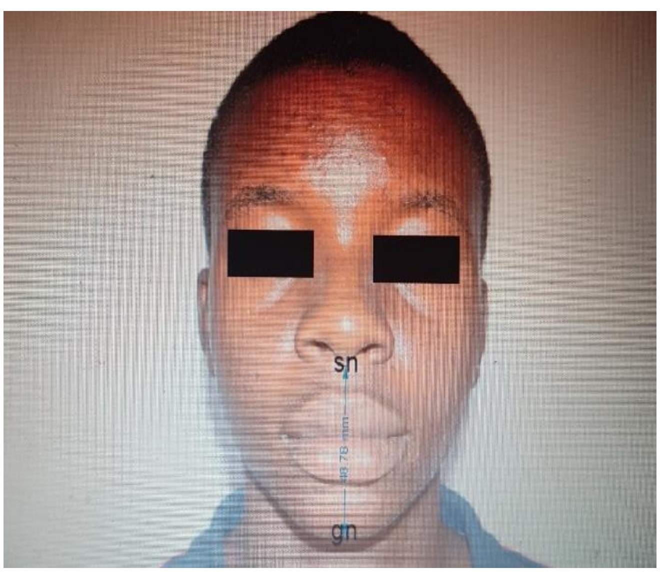

Fig. 2: Height measurement from the subnasal to the gnathion

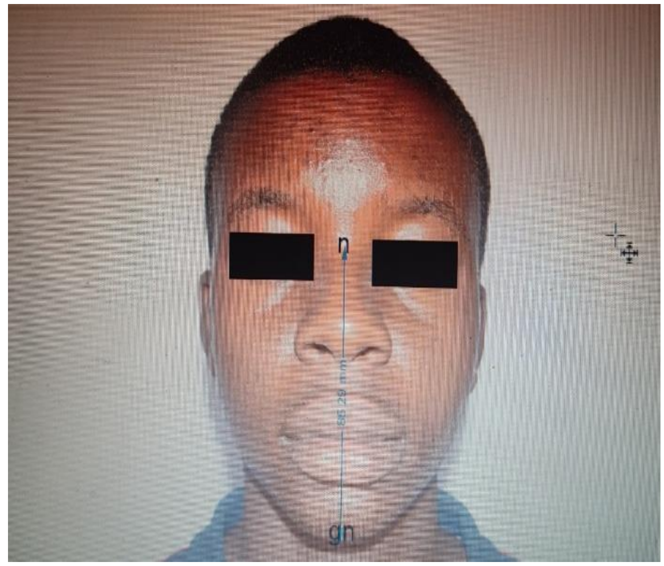

Fig. 3: Height measurement from the nasion to gnathion

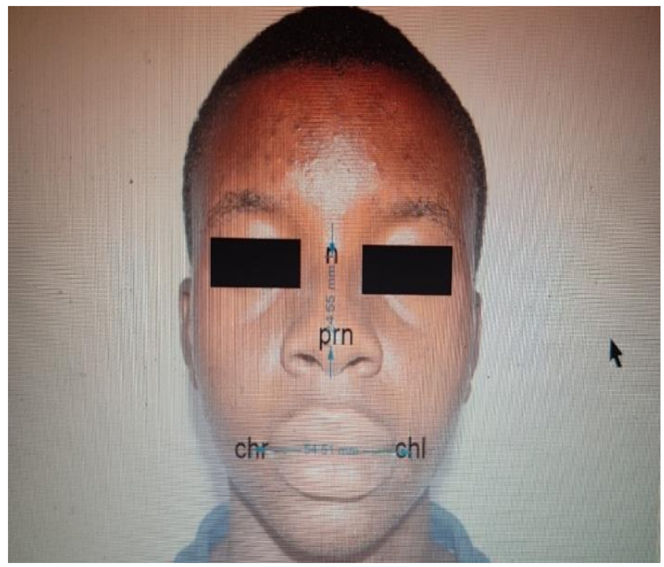

Fig. 4: Height measurement from nasion to pronasal and the length from the right cheilion to the left cheilion to measure length of the lips

RESULTS

One hundred and twenty-six (126) volunteers, ages 18 to 30, participated in the study. Measurements of the face were made. Before beginning additional testing, descriptive statistics were calculated for the male and female combined samples, including mean, minimum and maximum standard deviation, and standard error for all dimensions. These results are shown in tables 3.1 and 3.2

Table 1 shows values for Range, Maximum, Minimum, Mean±SD, and SEM for total Cross River residents used in the study, the Mean±SD values were Tr-Gn 104.07±14.29, Eur-Eul 58.58±8.64, T-T 72.23±10.62, Air-Ail 26.90±4.11, Enr-Enl 18.62±3.15, N-Prn 23.50±4.48, N-Gn 66.40±9.44, Exr-Exl 57.45±12.31, Chr-Chl 33.41±5.19, Sn-Gn 36.35±6.03.

Table 1: Descriptive statistics showing means and standard deviations for the total sample

Parameters	landmark	Mean±Standard Deviation
Facial height	Tr-Gn	104.07±14.29
Cranial width	Eur-Eul	58.58±8.64
Facial width	T-T	72.23±10.62
Nasal width	Air-Ail	26.90±4.11
Intercanthal distance	Enr-Enl	18.62±3.15
Nasal height	N-Prn	23.50±4.48
Nasion-gnathion distance	N-Gn	66.40±9.44
Binocular distance	Exr-Exl	57.45±12.31
Intercommissural width	Chr-Chl	33.41±5.19
Subnasale-gnathion distance	Sn-Gn	36.35±6.03

Key: *Tr-Gn (trichion-gnathion), Eur-Eul (right eurgon-left eurgon), T-T(tragion-tragion), Air-Ail(right alare-left alare), Enr-Enl (right entocanthion-left entocanthion), N-Prn (nasion-pronasal), N-Gn (nasion-gnathion), Exr-Exl (right ectocanthion-left ectocanthion), Chr-Chl (right cheilion-left cheilion),Sn-Gn (subnasal-gnathion)*

Table 2: Table 2. Descriptive statistics and paired samples t-test showing Mean±SD values for males and females

		SEX	Mean±SD	P
Facial height	Tr -Gn	M	113.71±10.00	<0.001
		F	95.03±11.55	
Cranial width	Eur -Eul	M	64.06±7.02	<0.001
		F	53.43±6.63	
Facial width	T -T	M	79.25±8.09	<0.001
		F	65.65±8.23	
Nasal width	Air -Ail	M	29.65±3.62	<0.001
		F	24.31±2.57	
Intercanthal distance	Enr -Enl	M	20.29±2.45	<0.001
		F	17.06±2.92	
Nasal height	N -Prn	M	25.88±3.22	<0.001
		F	21.27±4.36	
Nasion-gnathion distance	N -Gn	M	72.81±6.74	<0.001
		F	60.39±7.44	
Binocular distance	Exr -Exl	M	64.08±11.25	<0.001
		F	51.22±9.80	
Intercommissural width	Chr -Chl	M	36.50±4.75	<0.001
		F	30.51±3.70	
Subnasale-gnathion distance	Sn -Gn	M	40.14±5.15	<0.001
		F	32.77±4.40	

Key: *Tr-Gn (trichion-gnathion), Eur-Eul (right eurgon-left eurgon), T-T(tragion-tragion), Air-Ail(right alare-left alare), Enr-Enl (right entocanthion-left entocanthion), N-Prn (nasion-pronasal), N-Gn (nasion-gnathion), Exr-Exl (right ectocanthion-left ectocanthion), Chr-Chl (right cheilion-left cheilion),Sn-Gn (subnasal-gnathion)*

Table **2** shows values for mean, standard deviation, and standard error for the descriptive statistical data and comparison of the male and female facial measurement showing descriptive statistics and sexual dimorphism of male and female residents of cross river state used to conduct this study.

DISCUSSION

A total of 126 subjects (61 males and 65 females) resident in Cross Rivers, whose ages ranged from 18 to 30 and who willingly agreed participated in the current study The purpose of the study was to demonstrate sexual dimorphism on facial soft tissue profile and to provide normative data for facial measurement of facial soft tissues of males and females of Cross River using photogrammetry. The paired table t-test revealed that the dimensional measurements of Tr-Gn, Eur-Eul, T-T, Air-Ail, Enr-Enl, N-Prn, N-Gn, Exr-Exl, Chr-Chl, and Sn-Gn did not differ significantly.

The study computed the mean, standard deviation and standard error of mean. The results indicated that the Mean± standard deviation (Mean ±SD) intercanthal distance (En-En) for males is 20.29 ± 2.46 and for females is 17.06 ± 2.92, indicating that males have a greater intercanthal distance in the cross-river. Facial anthropometry data from a previous study by Hamid *et al*. (2021) revealed that the mean intercanthal length is higher in Saudi Arabian men than in females. Males in Chile have greater inter-cantal distance than females, with the mean ± SD being 30.3±5.04 for males and 30.3±4.37 for females, according to research on sexual dimorphism in the nose morphotype in adults (Pazos *et al*., 2008). The males exhibit a greater intercanthal distance, as indicated by all three values.

This study's inter-alar width (al-al) reveals that the mean ±SD for cross-river is 29.65±3.65 for males and 24.31±2.58 for females, indicating that males have a wider inter-alar width than females. A previous study by Hamid *et al*., (2021) revealed mean ± SD as (34.05 ± 2.9 for male and 32.03±2.9 for females), and (Pazos *et al*., 2008) revealed mean ± SD as (57.35±8.68 for male, 53.05±8.15 for female), further demonstrating that males in cross-river, Chilean, and Saudi Arabia have wider inter-alar widths than females.

The study's inter commissural width (Ch-Ch) revealed that the mean ± SD for cross-river is 36.51±4.76 for men and 30.51±3.71 for women. This indicates that men have a wider inter-commissural width than women. Previous research by Hamid *et al*. (2021) revealed that men have a wider inter-commissural width than women in cross-river and Saudi Arabia (52.00±3.5 for men and 42.42±3.1 for women).

The study's results on nasal length (N-Prn) revealed that the mean ± SD for males was 25.88 ± 3.22 and for females, it was 21.27 ± 4.36. Previous research (Pazos *et al*., 2008) revealed mean ± SD of 50.09 ± 5.88 for males and 46.86 ± 6.62 for females, indicating that males from Chile and the Cross River region have longer nasal lengths.

The present investigation examined the mean ± SD of the following: the inter-canthal distance (En-En), the inter-commissural width (Ch-Ch), the inter-alar width (Al-Al), the Subnasal-gnathion distance (Sn-Gn), and the following combinations of male and female: (20.29±2.46, 17.06±2.92 female), (36.51±4.76, 30.51±3.71 female), (29.65±3.62 male, 24.31±2.58 female), (40.14±5.16 male, 32.79±4.40 female), each. Additionally, this demonstrates that the mean standard deviation for males in Cross River is higher than that for females, which is consistent with earlier research on variations in facial anthropometric measurements among Nigeria's major ethnic groups: The landmarks measured for the Igbo people are En-En (35.58±3.03 male, 35.27±2.43 female), Ch-Ch (53.66±5.07 male, 52.49±3.29 female), Al-Al (43.50±5.18 male, 40.70±3.36 female), and Sn-Gn (71.33±6.81 male, 67.42±6.18 female), according to a 3-dimensional stereophotogrammetry analysis by Adekunle *et al*. (2021). En-En (35.68±3.16 male, 35.53±3.3 female), Ch-Ch (53.34±4.90 male, 51.04±4.52 female), Al-Al (43.05±3.18 male, 39.89±3.88 female), and Sn-Gn (69.41±6.23 male, 65.04±5.17 female) were the Yoruba mean ±SD values. En-En (35.75±3.54 male, 30.78±5.36 female), Ch-Ch (49.54±4.25 male, 56.41±6.31 female), Al-Al (41.73±2.62 male, 39.80±6.31 female), and Sn-Gn (68.32±5.65 male, 71.07±0.05 female) were the Hausa mean ± SD. According to his research, male Igbo, Yoruba, and Hausa had higher mean ±standard deviations overall, with the exception of the mean ±standard deviation of the Hausa in their intercommissural width (Ch-Ch) and subnasal gnathion (Sn-Gn), where the mean ±SD of the female was higher than the male.

The Subnasal-gnathion distance (Sn-Gn) mean ± SD in this study was 40.14±5.16 for males and 32.79±4.40 for females. However, a previous study by Okori *et al*., (2022) on photogrammetric analysis of facial soft tissue profile among adult residents of Cross River State, shows the Subnasal-gnathion distance (Sn-Gn) mean ± SD was 58.99±0.41 for males and 60.61±0.27 for females, which contradicts the results of this study by showing lower mean± SD in females than for males.

The results of this study indicated that the Subnasal-gnathion distance (Sn-Gn) mean ± SD for males was 40.14±5.16 and for females, 32.79±4.40. In contrast, Loveday *et al*. (2011) found that the Subnasal-gnathion distance (Sn-Gn) mean ± SD for males was 58.15±0.03 and for females, 56.97±0.03. This indicates that the mean ± SD for males was higher in both this study and the previous work by Loveday *et al*. (2011) than for females. According to the measurements above, the males have a higher mean± SD than the females. This means that in the areas where facial dimorphism is measured, the males are observed to have a higher mean ± SD in nasal length, inter canthal distance, and other parameters recorded in Cross River State, some other parts of Nigeria, such as Igbo, Yoruba, and Hausa, as well as other parts of the world, such as Chile and Saudi Arabia.

In conclusion, the goal of this study was to use photogrammetry to measure the facial landmarks of males and females in Cross River to produce an estimate for sexual dimorphism using facial characteristics.

This study was able to demonstrate that the facial landmarks of Cross River State males and females were sexually dimorphic with statistically significant differences as the males recorded higher Mean±SD values in all the measured dimensions except the T-T (tragion-tragion), parameters compared to females. Photogrammetry is a time-saving, safe, non-invasive, and expensive method. To verify the accuracy of the photogrammetric method used in this study and to expand the data pool, of the facial parameters of healthy adult residents of Cross River State, there is need for further research that will cut across the various ethnic groups in Cross River.

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