Aliyu et al.., J Biomed & App Sci FUD (2023) 2:1
www.jobas.fud.edu.ng
ISSN: 2814-3221 (print), ISSN: 2955-0874 (online)

JOBASFUD
Journal of Biomedical and Applied Sciences

RESEACH ARTICLE

ESTIMATION OF STATURE FROM FACIAL DIMENSIONS: USING 2D FACIAL IMAGES AMONG HAUSA ETHNIC STUDENTS OF THE FACULTY OF BASIC MEDICAL SCIENCES, BAYERO UNIVERSITY KANO

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ABSTRACT:
Background: The identification of a deceased person or any part of his remains, including the face, has become an important tool in forensic anthropology. Stature estimation provides a useful idea in narrowing down the investigation process. The aim of this study is to estimate stature from facial dimensions extracted from 2D facial images. **Materials and Methods:** Four hundred (400) participants (18-30 years), consisting of 200 males and 200 females were randomly selected. Brief questionnaires were administered to the participants to acquire their basic biometrics: age, sex, height, and weight. The face photo of each participant was captured, which was used to measure the facial dimensions using face art software (Developed by Anatomy Department, BUK). **Results:** The results showed that stature (height) can significantly ($p<0.05$) be estimated from different facial dimensions, and all the parameters correlated with stature ($p < 0.01$). The width of the nose (al-al) was the most correlated among all the facial dimensions. **Conclusion:** Formulae for estimation of stature from facial dimensions were obtained separately for males (y=a+mc) and for females (y=a+mc). Stature could be estimated from facial dimensions especially from the nasal width.
Keyword: Stature, Estimation, Facial dimensions, Hausa population.

Introduction

Stature estimation is an important tool in forensic examination, specifically when identifying an unknown, possibly decomposed, fragmented, and mutilated human individual; by the forensic pathologist (Lukpata *et al.*, 2016). It has a definite and proportional biological relationship with each part of the human body: head, face, trunk, and the extremities. This relationship helps forensic scientists to calculate stature from dismembered and mutilated body parts during forensic examinations. For such a calculation, two methods have been extensively used by the scientists all over the world (i.e., regression and multiplication methods), and it has been universally concluded that the regression analysis provides best estimates for stature reconstruction (Ilayperuma, 2010).

Many studies have been conducted on the estimation of stature from various body parts such as hands, trunk, intact vertebral column, upper and lower limbs, individual long and short bones, foot, and footprints (Krishan, 2008; Modibbo *et al.*, 2012). Although some of these parts of the body and bones may not always be available for forensic examination, it may be helpful to make use of other parts of the body like the head and the facial region. But only a few studies have been conducted on cephalo-facial region with respect to estimation of stature in our locality. Therefore, this study is aimed at estimating stature from the facial dimensions of the photos of Hausa population in Nigeria.

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MATERIALS AND METHODS

The instruments used in this study include stadiometer, Sony digital camera DSC w380, tripod stand, weighing balance, tape role, marker, papers, Chair, and a pair of scissors. The subjects of the study were pre-clinical medical, Anatomy, Physiology, as well as harmonised (Medical Laboratory, Radiology, Optometry, Nursing & Physiotherapy) students belonging to Hausa ethnicity all from the Faculty of Basic Medical Sciences Bayero University Kano (BUK), Kano State, Nigeria. The students were four hundred (400) and were randomly selected comprising of two hundred (200) males and two hundred (200) females, with age range between 18 and 30 years.

A brief questionnaire was completed by all individuals which include information such as age, sex, tribe, birth order, identification number, height, and weight. Participants with stature, vertebral, limb or facial anomalies were excluded from the study.

Photographic Set Up

The photographic set up consisted of a tripod stand (Manfrototripod, model FB 10) that held a 24 mm wide-angle lens camera (Sony, model DSC-W380 made in China) and a primary flashlight. The tripod stand controlled the stability and corrected the height of the camera according to the subject's body height. This ensured the correct horizontal position of the optical axis of the lens of the camera. A 100 mm focal lens and a zooming power of 3.6 was selected in order to maintain the natural proportions (Ozkul *et al*., 2009; Adamu *et al*., 2016).

Photographs Snapping

The camera was used in its manual position; the shutter speed was 1/125 per second. The participant was positioned on a line marked on the floor and framed alongside a vertical scale divided in 5cm segments. From the scale hung a plumbline held by a thick black thread that indicated the True Vertical (TV). The scale allowed measurements at life size (1:1) on the opposite side of the scale and outside the frame (Ozkul *et al*., 2009; Adamu *et al*., 2016).

A distance of approximately 120 cm from the participant was kept constant and each of the participants was asked to seat at ease on a chair facing the camera and near the scale. The participants were also told to keep lips relaxed, adopting the normal position during the day. An identification number was placed behind the participant so as to merge each subject with his/her questionnaire. The operator ensured that the participant's forehead, neck, and ears were clearly visible during the recording.

Anthropometric Measurement

Stature, which is the vertical distance between vertex of the skull to the heel, was measured with the person standing erect and head in a Frankfort plane. The **height** was measured using a stadiometer (Lukpata *et al.*, 2016).

Weight was measured using a weighing balance with the subject standing erect without shoes, also wearing light clothing with the head in a Frankfort plane.

BMI (Body Mass Index) was calculated using a calculator by dividing the weight in kilograms by the square of the height (meters) (Lukpata *et al.*, 2016).

Facial Dimension Measurement

Facial art software with a magnification factor of 0.5 was utilised for this process. The software calculated all the measurements once they were identified on each landmark record. It also processed all the information and record inputted which had previously been digitalized and scaled to life size, which was later transferred to Microsoft excel. The same person measured all the participants.

Plate 1: Measurements of Weight and Stature

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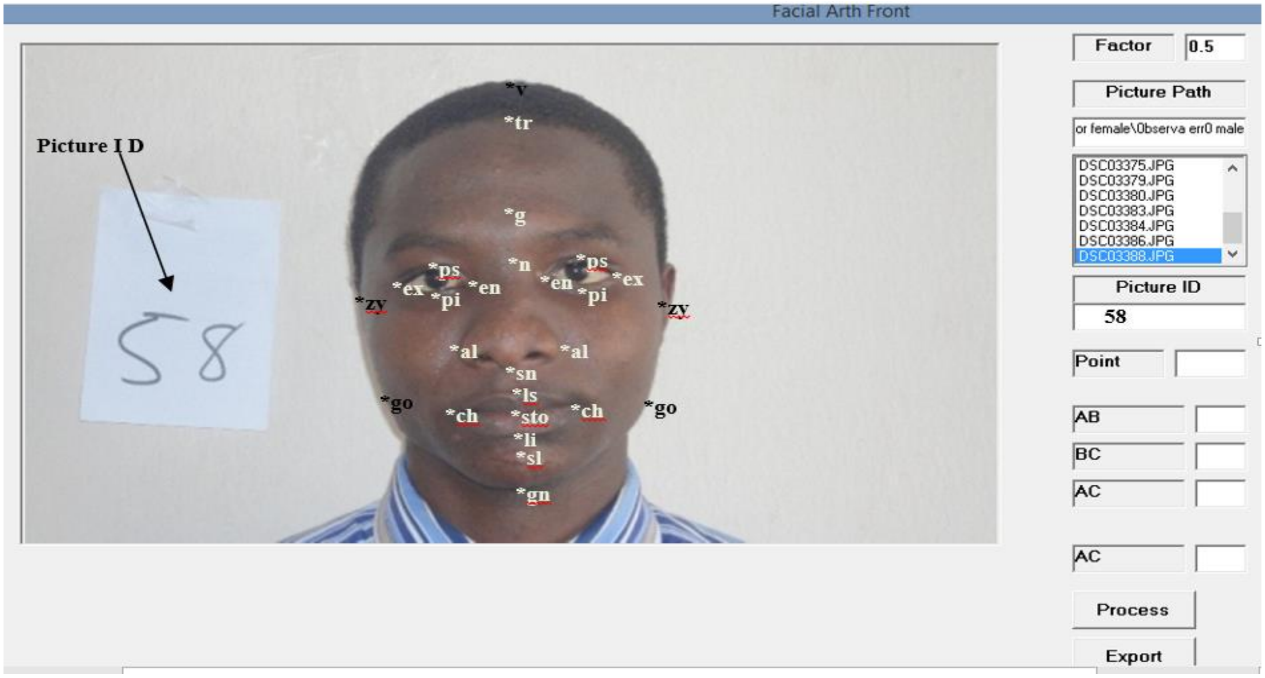

Plate 2: Facial Landmarks shown in Facial art software during analysis.

Facial dimensions were measured to the nearest millimetres (mm) from a 2D image using the face art software installed on a computer. The facial dimensions were:

Biocular Width (exocanthion-exocanthion: ex-ex), Intercanthal Distance (endocanthion -endocanthion: en-en), Eye Fissure Height (palpebral esuperius-palpebrale inferius: ps-pi), Upper Face Width (zygion-zygion: zy-zy), Nose Width (alare-alare: al-al), Mouth Width (cheilion-cheilion: ch-ch), Vermillion Height (labiale süperius-labial einferius: ls-li), Lower Face Width (gonion-gonion: go-go), Forehead Height (trichion-nasion: tr-n), Face Height (glabella-gnathion: g-gn), Lower Face Height (subasale-gnathion: sn-gn), Upper Lip Height (subnasale-labrum superius : sn-ls), Vartex-endocanthion (v-en), Zygion-gnathion (zy-gn), Zygion-vatex (zy-v), Labrum superius-stomium (ls-sto), Nasion-subnasale (n-sn), Vatex-trachion (v-tr), Sub nasale-stomium (sn-sto), Glabella-sub nasale (g-sn), Stomium-labrum inferius (sto-li), Stomium-gnathion (sto-gn), Endocathion-gnathion (en-gn), Aperture Modified Angle (Nasion Angle), ans Trachion-glabella (tr-g).

Statistical Analysis

The data was analysed using SPSS statistical package (IBM 20 software). Multivariate analyses were applied to test the relationship between stature and 2D facial dimensions, and P value of ≤ 0.05 was considered significant.

The data were expressed as Mean ± Standard Deviation (S.D). Pearson's correlation analysis was used in relating the variables with one another. Multivariate analysis, with age, weight and facial dimensions as independent variables and height as the dependent variable, was conducted using R statistics software version 3.1.2 (R core Team, 2014).

RESULTS

The male participants' mean age was observed to be 21.47 years ± 2.66 years, while it was 19.69 years ± 2.18 years for the females. Therefore, males were on average older than the females. But all of them were within the age limit of the study. The mean height for the males was 1.68 m ± 0.61 m and for the female, it was 1.59 m ± 0.06 m. This indicates that the males were on average taller than the females. The mean weight for males was 56.88 kg ± 7.90 kg, whereas for the females, it was 51.97 kg ± 9.16 kg. This indicates that the males were on average heavier than the females. The mean value for BMI in males was 20.07 kgm^2 ± 2.7kgm^2 and in female, it was 20.25kgm^2 ± 3.91kgm^2 (Table 1).

Table 1: Descriptive tatistics of SAge, Height, Weight and Body Mass Index (BMI), (n = 400)

Group Statistics				
	MALE		**FEMALE**	
Variable	Mean	SD	Mean	SD
Age	21.47	2.664	19.69	2.179
Height	1.6836	0.06119	1.59455	0.05952
Weight	56.88	7.904	51.97	9.161
BMI	20.0736	2.63953	20.2224	3.9084

BMI= Body Mass Index

Male respondents were found to have larger values in most of the vertical dimensions than female. The variable with the highest variation was g-sn which was found to be 80.46 ± 5.83 in males than in females (74.00 ± 6.04). The variable with least variation was sn-gn which was found to be 54.70 ± 9.20 in males, whereas in females, it was 53.83 ± 5.17 (Table 2).

Table 2: Descriptive Statistics of the Vertical Facial Dimensions in Both Male and Female Participants, (n = 400)

	MALE		**FEMALE**	
Variable	Mean	SD	Mean	SD
tr-n	38.1202	4.7772	40.9683	3.78499
n-sn	42.1515	4.56365	40.8141	3.73679
sn-gn	54.6943	9.20686	53.8388	5.17419
v-tr	23.3603	3.87618	21.6586	3.23616
tr-g	18.9257	3.45426	21.5403	2.67229
g-sn	80.4567	5.82786	73.9941	6.04022
sn-ls	11.0198	2.43092	9.6754	1.87651
sn-sto	22.2234	2.65152	19.5772	2.24963
sto-gn	32.5302	8.91212	34.3061	4.04491
ls-li	23.4266	3.58189	19.862	2.44969
ls-sto	11.2616	1.94451	9.9436	1.38379
sto-li	12.2092	2.2748	9.94815	1.5559
average	12.364	1.28944	12.9086	1.19561

The male respondents were found to have larger values in most of the vertical dimensions than the females. The variable with the highest variation was zy-zy (113 ± 8.82) for males and 106. ± 7.77 for females. The variable with almost no variation was ex-avrg (males = 29.88 ± 2.49 and 29.38 ± 2.05 = females) (Table 3).

Table 3: Descriptive Statistics of the Horizontal Facial Dimensions of Both Male and Female Participants

	MALE		**FEMALE**	
Variable	Mean	SD	Mean	SD
en-en	28.1638	3.23438	26.4543	2.9417
al-al	42.1095	3.72807	38.2329	2.97815
zy-zy	113.92	8.82048	106.972	7.07346
go-go	102.669	7.76758	93.3756	6.91832
ch-ch	48.2753	4.31743	42.3804	3.48326
ex avrg	29.883	2.48767	29.3808	2.04835

The males generally have higher values in all the dimensions. The variable with the highest variation was zy-v average which was found to be 102.55 ± 7.97 in males and 99.08± 6.43 in females. The variable with almost no variation was v-en and was 69.70 ± 6.85 for males and 69.91 ± 5.30 for females (Table 4).

Table 4: Descriptive Statistics of the Oblique Facial Dimensions of Both Male and Female Participants, (n = 400)

	MALE		**FEMALE**	
Variable	Mean	SD	Mean	SD
en-gn	90.8323	10.6827	89.263	5.9917
v-en	69.7062	6.85574	69.9159	5.30641
Zyvavrg	102.556	7.96654	99.0841	6.43026
Zygavg	92.8417	10.4968	91.1696	5.78089

Table 5: Multivariate Analysis Between Height and Facial Dimensions (n = 400)

Call FORMULA	RVALUE	FSTAT	S E E	P value
lm(formula = HT ~ chch, data = FHD) female horizontal dimension	0.046	10.49	ch-ch 0.001183	0.001***
lm(formula = HT ~ enen + al al, data = MHD) male horizontal dimension	0.0537	6.642	en-en 0.001453 al-al 0.001260	0.001***
lm(formula = HT ~ engn + ven, data = FOD) female horizontal dimension	0.0469	5.901	En-gn 0.000715 v-en 0.0008071	0.003***
lm(formula = HT ~ trn + sngn, data = FVD) female vertical dimension	0.054	6.68	tr-n 0.0010843 sn-gn 0.0007932	0.001***
lm(formula = HT ~ nsn + lsli, data = MVD) male vertical dimension	0.053	6.553	n-sn 0.0009429 ls-ls 0.0012014	0.001***

Stature was found to be correlated with the measured parameters, and has been observed to correlate significantly with en-en, al-al for horizontal dimension g-sn, ls-li for vertical dimension and zy-v. The coefficients of correlation are also statistically significant ($p < 0.01$) (Table 6)

Tables 6: Correlation between Stature and the facial dimensions for Male participants

Horizontal dimension		Vertical dimension		Oblique dimension	
Variable	Pearson cor	Variable	Pearson cor	Variable	Pearson cor
en-en	0.202**	g-sn	0.187**	v-en	0.130
al-al	0.223**	sto-gn	-0.012	en-gn	0.108
zy-zy	0.166	ls-li	0.188**	Zy-v	0.201**
ch-ch	0.192*	Sto-li	0.105		
Ex avrg	0.106**	Tr-n	0.126		
		Sn-ls	-00.030		
		P avg	.105		

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Stature was found to be correlated with the measured parameters, and has been observed to have correlated significantly with en-en, al-al for horizontal dimension, g-sn, ls-li for vertical dimension and zy-v. The coefficients of correlation are also statistically significant ($p < 0.01$) (Table 7).

Tables 7: Correlation Between Stature and the Facial Dimensions for Female Participants

Horizontal dimension		Vertical dimension		Oblique dimension	
Variable	Pearson cor	variable	Pearson cor	variable	Pearson cor
en-en	0.015	g-sn.	0.039	v-en	0.075
al-al	0.106	Sto-gn	0.024	en-gn	0.026
zy-zy	0.003	Ls-li	0.116	Zyg avg	0.017
ch-ch	-0.001	Sto-li	0.068	Zyv avg	0.057
E avg	-0.004	Tr-g	0.041		
		Sn-ls	-0.075		
		P avg	0.027		

DISCUSSION

Establishing stature from craniofacial variables has been of high interest among scholars (Obaje *et al*., 2017) and can be estimated through anatomical or mathematical methods depending on the condition and completeness of the remnants (Ahmed & Taha, 2016). Occasionally, only the head or facial remains are available for medico-legal investigation, and it poses a challenge in identification. Under such conditions, it is vital to ascertain the identity of the deceased. For determining the individuality at a crime or disaster scene, sex and stature are essential parameters (Jasuja & Singh, 2004; Zeybek *et al*., 2008 and Ruff *et al*., 2012). The results of this study indicate that the measurements are reproducible without a significant error, because for both inter and intra observer error, there was more than 70% correlation in most of the variable for both male and female, and the obtained values of the measurements have fallen within the prescribed limits (Ulijaszek & Kerr, 1999).

The present study provides valuable data pertaining to the principal anatomical dimensions of the face and its correlation with stature in adult Hausa population. Males generally have higher value in all the vertical dimensions than females. The variable with the highest variation was g-sn in both males and in females, and the variable with least was sn-gn, which is similar to the findings of Patil and Mody (2005) and Agnihotri *et al*., (2011). The same result was obtained with the horizontal facial dimensions, as males generally have higher value in all the dimensions than females. The variable with the highest variation was zy-zy (113 ±

8.82) for males and for females was 106. ± 7.77, and the variable with almost no variation was ex-avrg for the males was 29.88 ± 2.49 and 29.38 ± 2.05 for females. Regarding the oblique facial dimensions, male generally have higher values in all the dimension than female. The variable with the highest variation was zy-v average which was found to be (102.55 ± 7.97) in males and (99.08± 6.43) in females. The variable with almost no variation was ven which was (69.70 ± 6.85) for male and (69.91 ± 5.30) for female. Kulkarni *et al.*, (2020) reported similar findings with negative correlation between stature and zy-zy in both sexes. Gender difference is an important factor in the morphological variation of human populations (Ukoha *et al*., 2016). This is because the rate of skeletal maturity in males and females vary during the course of growth and development (Williams *et al*., 2000) and because of the influence of steroid sex hormone (Mank *et al*., 2007).

Pearson's correlation test (Table 6) showed a significant correlation between stature and facial dimensions (g-sn, ls-li, en-en, al-al, ch-ch and zy-v) in males. The highest correlation was in al-al in males ($r=0.223$, $p<0.001$). There was no correlation established in the facial dimensions of females in relation to their stature. This finding is contrary to numerous studies conducted on estimation of stature from facial dimensions (Yadav *et al*., 2019, Zaghloul *et al*., 2019; Kulkarni *et al*., 2020). This may be due to racial and environmental differences with the current study population. Jaiswal and Selvan, (2016) also reported the least possibility of correlation from female facial dimensions among other measurements considered in their study among Tamil Nadu population. The similarity with the finding of the present study may be due to commonality in occupation of the females in the different populations despite the racial differences.

CONCLUSION

The relationship between stature and facial dimensions was established in the Hausa ethnic group students of Kano State, Nigeria. The possible application of facial dimensions for use in forensic science, human biology, and paleodemography were demonstrated. Conclusively, males were found to be taller than the females.

Acknowledgements

Our sincere thanks go to all the staff of the Department of Anatomy, Faculty of Basic Medical Science, Bayero University Kano for their understanding and support given to us during the data collection. We will also like to acknowledge the cooperation given to me by the participants.

Conflict of Interest: None declared

Funding: None

Authors' Contributions:
IA; Conceptualization, data collection, drafting of manuscript. SN; Critical appraisal of the manuscripts, AG; Critical appraisal of the manuscripts, IYA; Data analyses and interpretation

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