Original Research Article

International Journal of Anatomy and Research, Int J Anat Res 2017, Vol 5(3.1):4129-35. ISSN 2321-4287
***DOI:** https://dx.doi.org/10.16965/ijar.2017.268*

ANTHROPOMETRIC STUDY OF FACIAL MORPHOLOGY IN TWO TRIBES OF THE UPPER WEST REGION OF GHANA

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ABSTRACT

Facial indices are among the most important cephalometric parameters useful in inter-racial and intra-racial morphological classification and categorization. As such, facial parameters serve as prominent identification tools in combination with fingerprint patterns for biometric and forensic purposes in the developed world. However in Ghana, although emphasis is placed on the face in the photographic recognition systems used in the issuance of passports, very little information is available on metric facial data, facial types and their distribution patterns and their association with ethnicity, sex and age. Therefore the aim of this study is to generate baseline data on facial dimensions and their relationship with height, age and sex of the Sisaalas and Dagaabas of the Upper West Region of Ghana. A total of 387 healthy individuals (202 females and 185 males), between 18 – 60 years of age were recruited for the study. The results of the study showed that male facial parameters had significantly higher dimensions than those of the female participants.

KEY WORDS: Cephalometric, Sex, Tribe, Reconstruction, Ghana

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Access this Article online

Quick Response code	Web site: International Journal of Anatomy and Research ISSN 2321-4287 www.ijmhr.org/ijar.htm	
DOI: 10.16965/ijar.2017.268	Received: 24 May 2017 Peer Review: 25 May 2017 Revised: None	Accepted: 10 Jul 2017 Published (O): 31 Jul 2017 Published (P): 31 Jul 2017

INTRODUCTION

The human face is widely recognized as the feature which best distinguishes a person [1]. It is the anterior part of the head that includes the forehead, eyes, nose, mouth and chin and it extends from the chin to the hairline [2]. With knowledge on standard facial traits, an individualized norm can be established to optimize facial attractiveness. In order to treat congenital or post-traumatic facial disfigurements in members of a particular racial or ethnic group successfully, surgeons require access to craniofacial databases based on accurate anthropometric measurements [3]. Previous studies have discovered facial features for distinguishing various races and ethnic groups using anthropometric methods [3-5]. These findings were introduced into clinical practice to quantify changes in the craniofacial framework [3]. It has therefore become very necessary for the establishment of anthropometric standards for the evaluation of deviations in craniofacial morphology, for a particular population [6]. Farkas et al. showed that, normative data of facial measurements are indispensable to precise determination of the degree of deviations from the normal facial features [3].

In several previous studies, it has been established that, facial dimensions are among important cephalometric results that have been used to describe racial and sexual differences [1,3,6,7]. Thus, knowledge of mean facial dimensions is important in the evaluation of age, sex and racial differences, in clinical and forensic applications [1].

The anthropometric analysis of the face is an important step for patients undergoing craniofacial reconstructive surgery [8]. Literature on sexual dimorphism of anthropometric measurements indicates that significant differences exist between the sexes. These differences must be identified and used in the design of equipment, clothing and work spaces for both men and women. However, the impact of these differences in facial type on head and face equipment is not fully documented.

Franklin et al. reported the largest sexual dimorphism in facial width, cranial length and height [9]. Alternatively, bizygomatic breadth, and mandibular ramus height had the most significant difference in total face height [10].

A hallmark of the diversity and individuality of humans is the range of variations in the shape of their faces [11]. Direct facial anthropometry is considered a gold standard method in assessing facial dimensions and has been widely used for sex determination [3,12].

Facial indices are among the most important cephalometric parameters useful in inter- racial and intra-racial morphological classification and categorization. These indices are useful in the description of the facial and nasal morphological characteristics of human populations in different geographical locations [13].

Facial measurements are taken for different reasons: they provide information about health for Physicians; comparative analysis with different body organs for anatomists and improve accuracy in moulding and drawing for artists. Over the last decade, there has been a rise in the occurrence of disasters such as floods, earthquakes, typhoons, fire, road traffic accidents etc. In such situations, it becomes difficult to determine the sex of the dead victims especially bodies that have decomposed. In the developed countries, facial recognition systems based on facial parameters are used in combination with dental records to identify such victims.

Substantial studies have been carried out in the developed world on the sexual dimorphism of the face and hand print patterns [14,15]. Facial morphology serves as a prominent identification tool at the points of entry into most developed countries. There are several reports to show that facial parameters have been used in combination with fingerprint patterns for biometric and forensic purposes in the developed world [16]. However in Ghana, although emphasis is placed on the face in the photographic recognition systems used in the issuance of passports, very little information is available on metric facial data, face types and their distribution patterns and their association with ethnicity, sex and age. Therefore the present study was designed to examine the facial morphology of two tribes (Sisaalas and Dagaabas) in the Upper West Region of Ghana in order to provide some baseline facial data for the study population. Specifically, the study was carried

· To identify the facial dimensions in males and females.

· To establish facial anthropometry as a baseline for the Sisaalas and Dagaabas.

· To compare the facial dimension differences between males and females as well as between the tribes.

MATERIALS AND METHODS

This study was a descriptive cross-sectional study conducted from November, 2015 to January, 2016 in the Upper West region of Ghana. A total of 387 healthy individuals (202 females and 185 males) were recruited for the study. The participants were Dagaabas and Sisaalas between 18 – 60 years of age and residents of Nandom and Lambussie-Kani Districts in the Upper West Region. Ethical approval and informed participant consent were sought.

Participants whose parents and grandparents (both maternal and paternal lines) did not have inter-tribal marriages were considered homogenous and were included in the study. Also individuals with no physical impairment, craniofacial trauma, facial scars, amputated limbs, visible tumours, oedema and non-pregnant women were included in the study. Pregnant women, individuals with craniofacial trauma, facial scars, amputated limbs, any facial tumours, oedema, history of diabetes mellitus and those with physical signs of endocrine disorders such as dwarfism or gigantism were excluded from the study.

Data collection: Data collected in the study included sex, age, tribe, and facial parameters. All measurements were duplicated and the averages were taken. To avoid inter-observer error, all the measurements were taken by the same person. All data taken were recorded in a log book. All anthropometric measurements of the face were performed with participants in the sitting position: body erect, head up, arms at the sides and palms forward. Using Dritz C150 fiberglass measuring tape (Prym consumer USA Inc.), 10 facial anthropometric indices were measured:

Upper face height one (tr-g): the distance between the hair line (trichion) and the midpoint of the supra-orbital margins (glabella).

Upper face height two (tr-n): the distance from the hair line (trichion) to the point on the root of the nose where the mid-saggital plane cuts the nasofrontal sutures (nasion).

Midface height one (n-st): the distance from the nasion (n) to the point mid-sagittal of the oral fissue.

Midface height two (g-sn): The distance in the median plane between the glabella and the subnasale.

Lower face height/ Mandibular height (st-gn): measured as the straight distance between the stomodium (st) and the gnathion (gn).

Total (physiognomic) face height (tr-gn): measured as the straight distance from the hair line (trichion) to the lowest point on the lower border of mandible in the mid-sagittal plane (gnathion).

Morphological face height (n-gn): measured as the straight distance from the nasal root (nasion) to the lowest point on the lower border of mandible in the mid-sagittal plane (gnathion).

Face breadth (zy-zy): measured as the maximum distance between the most lateral points on the zygomatic arches (left zygion to right zygion).

Mandibular width (go-go): measured as the maximum breadth of the lower jaw between two gonion points on the angles of mandibles (gonion is the most posterior, inferior and laterally situated point on the external angles of the mandible).

Mouth width (ch-ch): measured the width of the mouth as the distance between Cheilion points (ch-ch).

Fig. 1: An illustration showing the measurements of the lateral aspect of the face: upper facial height one (tr - n), total facial height (tr - gn); morphological facial height (n - gn); lower face height (sn - gn); nasal height (n - sn); ear length (sa - sba) (Source:[3]).

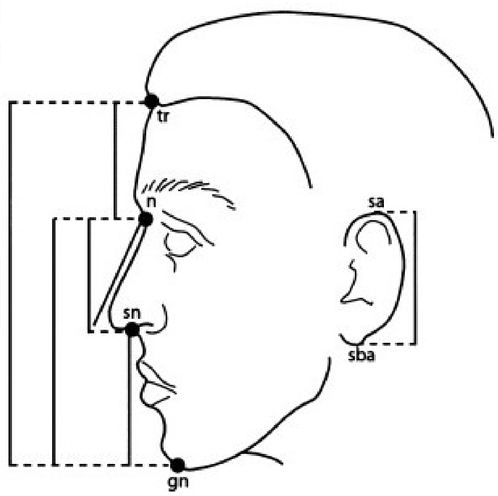
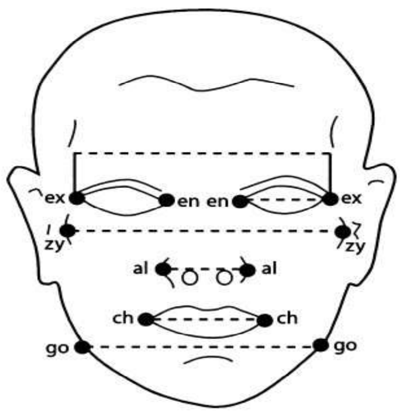


Fig. 2: An illustration showing the measurements of the frontal aspect of the face: intercanthal width (en - en); binocular width (ex - ex); eye fissure length (en - ex); facial breadth (zy - zy); mandibular width (go - go); morphological nose width (al - al); mouth width (ch - ch) (Source: [3]).



Data analysis: Statistical analyses were carried out using the IBM Statistical Package for Social Sciences (SPSS) software (SPSS 20.0 version, Inc., Chicago, IL, USA) and GraphPad Prism 6 (GraphPad Software, Inc., San Diego, CA, USA). The measurements were expressed in means ± standard deviation. Normal distribution was tested with the one-sample Kolmogorov-Smirnov test and Shapiro-Wilk normality test. Differences among age groups were tested with the analysis of variance test (ANOVA), followed by the Tukey's Multiple Comparison (TMC) Test. Differences among sex and tribes mean of facial dimensions were tested with ANOVA and followed by the Tukey's Multiple Comparison (TMC) Test. The association between facial dimensions, age and height was assessed using Pearson's correlation analysis. Linear regression (step-wise) analysis was applied to determine model fit equations of the facial dimensions, age and height. The model of best fit was chosen based on the adjusted determinant of regression coefficients. The level of statistical significance was determined at $P < 0.05$ or 95% confidence interval.

RESULTS

Intra-Tribal facial anthropometric data stratified by sex: The means of upper facial height one (tr-n) for male and female Sisaala participants were recorded as 7.43 ± 1.0 cm and 6.83 ± 0.8 cm respectively. Whiles those of the male and female Dagaaba participants were 7.76 ± 0.9 cm and 7.10 ± 0.8 cm respectively. For the Sisaala participants the mean upper facial height two (tr-g) recorded were 4.81 ± 0.8 cm and 5.28 ± 1.0 cm for the female and male participants respectively. Within the tribe, there was a statistically significant difference ($p = 0.000$) between the male and female participants, but not between the same sex of the two tribes. The mean (5.28 ± 1.0 cm) for total facial height (tr-g) of the male Sisaalas was the same as the mean (5.29 ± 0.7 cm) for total facial height (tr-g) of the female Dagaabas.

However, the mean total facial height (tr-g) of the female Sisaalas (4.81 ± 0.8 cm) was significantly different from the male Sisaalas (5.28 ± 1.0 cm), female Dagaabas (5.29 ± 0.7 cm) and the male Dagaabas (5.78 ± 0.9 cm). There was also a significant difference ($p = 0.0001$) between the male Sisaalas and the male Dagaabas (Table 1).

Table 1: Summarised analysis of variance comparisons of the upper facial parameters stratified by tribe and sex of the study participants.

Parameters	Sisaala		Dagaaba		ANOVA p-Value
	Female (N = 97) Mean (cm) ± SD	Male (N = 88) Mean (cm) ± SD	Female (N = 111) Mean (cm) ± SD	Male (N = 91) Mean (cm) ± SD	
tr-n	6.83 ± 0.8	7.43 ± 1.0	7.10 ± 0.8	7.76 ± 0.9	<0.0001 [a, c, d, f]
tr-g	4.81 ± 0.8	5.28 ± 1.0	5.29 ± 0.7	5.78 ± 0.9	<0.0001 [a, b, c, e, f]
tr-gn	18.8 ± 1.1	20.33 ± 1.2	18.95 ± 1.3	20.58 ± 1.6	<0.0001 [a, c, d, f]

Data recorded in mean ± standard deviation (SD). N = Number of Participants; **cm** = centimetres; **a** = female Sisaala versus male Sisaala; **b** = female Sisaala versus female Dagaaba; **c** = female Sisaala versus male Dagaaba; **d** = male Sisaala versus female Dagaaba; **e** = male Sisaala versus male Dagaaba; **f** = female Dagaaba versus male Dagaaba. Upper facial height one (**tr – n**) = trichion to nasion; Upper facial height two (**tr – g**) = trichion to glabella; Total facial height (**tr – gn)** = trichion to gnathion; **Statistically Significant Difference ($P < 0.05$)**.

Table 2: Analysis of variance of morphological facial dimensions between sexes and tribes of participants.

Parameters	SISAALA		DAGAABA		ANOVA p-Value
	FEMALE (N = 97)	MALE (N = 88)	FEMALE (N = 111)	MALE (N = 91)	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
n-st	7.82 ± 0.6	8.31 ± 0.6	7.47 ± 0.5	8.02 ± 0.9	<0.0001 [a, b, d, e, f]
g-sn	7.65 ± 0.6	8.36 ± 0.7	7.36 ± 0.5	7.96 ± 0.6	<0.0001 [a, b, c, d, e, f]
st-gn	4.09 ± 0.5	4.42 ± 0.6	3.94 ± 0.5	4.41 ± 0.5	<0.0001 [a, c, d, f]
n-gn	12.6 ± 0.9	13.60 ± 0.9	12.36 ± 0.9	13.34 ± 1.	<0.0001 [a, c, d, f]
sn-st	2.61 ± 0.3	2.70 ± 0.3	2.63 ± 0.4	2.77 ± 0.3	<0.0001 [a, c, d, f]
zy-zy	12.39 ± 0.7	13.09 ± 0.7	12.50 ± 0.7	13.35 ± 1.0	<0.0001 [a, c, d, f]
go-go	12.43 ± 0.7	13.27 ± 0.7	12.64 ± 1.0	13.65 ± 1.0	<0.0001 [a, c, d, e, f]
ch-ch	6.71 ± 0.7	7.41 ± 0.6	6.92 ± 0.8	7.43 ± 0.7	<0.0001 [a, c, d, f]

Data recorded in mean ± standard deviation (SD). N = Number of Participants; **a** = female Sisaala versus male Sisaala; **b** = female Sisaala versus female Dagaaba; **c** = female Sisaala versus male Dagaaba; **d** = male Sisaala versus female Dagaaba; **e** = male Sisaala versus male Dagaaba; **f** = female Dagaaba versus male Dagaaba. Midfacial height one (**n-st)** = nasion to stomodium; Midfacial height two (**g – sn)** = glabella to subnasale; Mandibular height (**st – gn)** = stomodium to gnathion; Maxillary height (**sn – st)** = subnasale to stomodium; Facial breadth (**zy-zy) =** zygion to zygion; Mandibular width (**go – go) =** gonion to gonion; Mouth width **(ch – ch)** = cheilion to cheilion; **Statistically Significant Difference ($P < 0.05$).**

All the parameters classified under morphological facial dimensions showed significant variations between sex within tribes and opposite sex of the other tribe. Furthermore, there were significant differences between the means of the midface 1 and 2 (n-st and g-sn) of the same sex of the two tribes with both sexes of the Sisaalas showing higher numerical values than those of the Dagaabas as shown in table 2.

DISCUSSION

Facial anthropometric measurements stratified by sex: The current study revealed that, all the facial anthropometric measurements were significantly different with higher numerical values in the male participants than in the female participants in both the Sisaala and Dagaaba ethnic groups. For instance, the mean upper facial measurement from upper facial height one in the male Sisaala and Dagaaba participants was 7.60 ± 0.89 cm (5.0 - 10.0 cm) while the females recorded 6.97 ± 0.83 cm (5.0 - 9.0 cm). The mean total facial height among the male participants was 20.46 ± 1.40 cm (17.5 - 29.0 cm) while in the female participants, it was 18.90 ± 1.24 cm (12.6 - 22.5 cm). This observation is in line with the finding of Dayal et al. [10] where there was significant difference in total facial height, between males and females. Patil and Mody [17] identified total facial height to be one of the major variables important for discriminating between males and females. Karaca et al. [18] recorded lower values in a Turkish population with a mean upper facial height one of 5.13 cm and upper facial height two of 6.69 cm for females and upper facial height one of 5.27 cm and upper facial height two of 6.88 cm for males. However, there was no significant difference between the upper facial height of the males and females [18]. Ibrahimagiæ-Šeper recorded the total facial length for the population of Zenica in Bosnia Herzegovina to be 17.41 cm in females and 18.54 cm in males [19]. These values were also smaller than the recorded values in the present study. Omotoso et al. reported a significant sexual difference for all the facial measurement except facial width ($P > 0.05$) [12]. Similarly, sexual dimorphism was reported in a study by Pandey[20] among Onges tribe in India. The study by Olotu et al. showed that the mean facial and nasal height of adult Igbo males in Nigeria were significantly higher than the values for adult Igbo females [21].

The results of the present study showed that there is a strong positive correlation between upper facial height two and upper facial height one in both sexes. This implies that in facial injury that demands plastic surgery, a regression equation could be used to predict the dimension of the upper facial height for males and females of the study population. Upper facial height one (tr-n) could be predicted from upper facial height two (tr-g) by the equation; tr-n = 2.197 + 0.94 (tr-g) for females (Adj. R^2 = 80.2%, p = 0.000) and tr-n = 2.756 + 0.875 (tr-g) for males (Adj. R^2 = 74.5%, P = 0.000).

The present study recorded higher values in males than females for all the eight (8) measurements classified under the morphological face (Table 2). Male facial dimensions recorded higher numerical values than the female participants. Similarly, mean facial breadth in the male participants was 13.22 ± 0.86 cm (11.0 - 18.0 cm) while the female participants recorded 12.45 ± 0.69 cm (11.0 - 14.0 cm; p-value 0.000). The mean values of the morphological facial height and facial breadth in males were higher than that of females in a similar study by Jeremiæ et al. [22] however their means were lower than those obtained in this study.

Niswander et al. using a Brazilian Indian population, and Nagle et al. in Lithuania recorded 12.57 cm and 12.08 cm respectively for mean morphological facial height [23,24]. Herskovits recorded a mean morphological facial height of 10.84 cm in West Africans (25). Omotoso et al. documented a mean morphological facial height of 11.24 ± 0.46 cm for males and 11.12 ± 0.58 cm for females in the Bini ethnic group in the South – South region of Nigeria [12]. This shows that morphological facial height is comparably longer among Sisaalas and Dagaabas.

Mean mid-facial height one and mean mid-facial height two recorded 8.16 ± 0.75 cm and 8.15 ± 0.67 cm for the male participants respectively and 7.63 ± 0.58 cm and 7.50 ± 0.58 cm for the female participants respectively. Mid-facial height one and two showed strong positive correlations (p = 0.000, r = 0.615) with each other in both male and female participants. Therefore this relationship may be useful in maxillofacial surgery in which the dimensions could be estimated from each other. Morphological facial height values obtained in this study (13.22 ± 0.86 cm, males and 12.45 ± 0.69 cm, females) were numerically lower but not statistically significant from that of a population in the North-eastern part of Nigeria (14.12 cm ± 0.75 in males and 14.13 cm ± 0.76 in females) [26], Sri Lanka population (14.02 ± 1.03 cm in males and 13.88 ± 1.29 cm in females) [27] and Indian population (13.00 ± 0.72 cm in males and 12.54 ± 0.6 cm in females) [28]. However, the results obtained for this parameter were significantly higher than that of the Bini ethnic group in South-south Nigeria (11.24 ± 0.46 cm, males and 11.12 ± 0.58 cm, females) [12] and Haryanvi adults in India (11.74 ± 0.70 cm in males and 10.21 ± 0.94 cm in females) [29].

In the present study, the facial breadth in the male participants was 13.22 ± 0.86 cm and 12.45 ± 0.69 cm for female participants. In comparison with previous studies, there were no statistically significant differences between the present study and the Bini ethnic group in the South – south region of Nigeria (12.92 ± 0.53 cm for males and 12.86 ± 0.63 cm for females) [12], Turkish adults (12.91 ± 0.71 cm for males and 12.72 ± 0.65 cm for females [18] and the population of Zenica in Bosnia Herzegovina (14.14 cm for males and 13.60 cm for females) [19].

Mean lower facial height/mandibular height and mandibular width (bigonial diameter) recorded higher numerical values in the male participants than in the female participants. These measurements were not significantly different from the values of Northwest Indians (10.64 cm for males, 10.26 cm for females) [30]. However, these findings were significantly higher than those reported in other previous studies. In the Indo-Mauritian population males and females recorded 10.55 cm and 9.9 cm respectively [31] whereas the Haryanvi Banias of India recorded 11.45 cm for males and 10.33 cm for females [32].

Mouth width was found to vary between 5.5 cm and 9.0 cm with the mean of 7.42 ± 0.67 cm in the male participants and 4.5 cm and 9.0 cm with the mean of 6.82 ± 0.76 cm in the female participants. The mean mouth width for the female participants in the present study (6.82 ± 0.76 cm) was higher than that of African American Women (5.16 ± 0.34 cm) and North American Caucasian Women (5.02 ± 0.23 cm) [33].

From the results of the present study, it appears that females have smaller faces as compared to males. This could be as a result of genetic make-up and inheritance which manifests as sexual dimorphism.

CONCLUSION

Male facial parameters were significantly higher than those of the female participants. There were significant variations in all facial anthropometric parameters between the male and female participants. Out of the ten parameters, six; upper facial heights one and two, midfacial heights one and two, maxillary height and mouth width varied significantly between Dagaabas and Sisaalas. The significance of the study is that it has provided preliminary baseline data for facial morphology for biometric and forensic purposes as well as facial reconstruction.

Conflicts of Interests: None

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How to cite this article:

Raymond Saa-Eru Maalman, Chrissie Stansie Abaidoo, JoshuaTetteh, Nancy Darkoa Darko, Obed Ohene-Djan Atuahene, Atta Kusi Appiah, Thomas Diby. ANTHROPOMETRIC STUDY OF FACIAL MORPHOLOGY IN TWO TRIBES OF THE UPPER WEST REGION OF GHANA. Int J Anat Res 2017;5(3.1):4129-4135. **DOI:** 10.16965/ijar.2017.268