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A cross-sectional study of the anthropometry of the face among Bonos and Ewes in the Bono region of Ghana

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Abstract

Background: Growth and development of craniofacial structures are of importance since their anthropometry is useful in maxillofacial surgery, plastic surgery, orthodontics and forensic medicine. Surgeons consider the specific facial structures of such patients to help obtain accurate results. Ghana is however less-endowed with data regarding facial anthropometry for the aforementioned applications. Therefore, the study aimed to bring out the differences between the facial measurements of the male and female participants in order to generate baseline data for Ghanaians, taking into consideration the Bonos and Ewes living in the Bono region of Ghana. Twenty-four anthropometric facial measurements were taken from a total of 291 healthy individuals (152 Bonos and 139 Ewes), aged 18–60 years using Shahe Vernier callipers.

Results: The study revealed Bono males had significantly longer faces than that of the Bono females (upper face height 2 and total face height). For maxillary height, mandibular width and mouth width, the mean values of Bono males were significantly greater than that of the Ewe males. There was a statistically significant difference concerning nasal length and anatomical nose width among the participants ($p < 0.05$). Bono male participants had significantly greater values than Ewe males in both endocanthion-exocanthion and endocanthion-endocanthion measurements.

Conclusions: The results of this study support the assertion regarding the existence of tribal variations and sexual dimorphism associated with facial measurements and have provided additional data for facial morphology for biometric and forensic applications as well as facial reconstruction especially among the study populations in Ghana.

Keywords: Anthropometry, Craniofacial, Maxillofacial, Orthodontics, Tribe, Ghana

Background

The human face is a very useful tool for expression, appearance and identity among others. The features of the face including its bones, muscles, cutaneous and subcutaneous layers all contribute to the unique morphology of a single person (Kumar et al. 2020). The shape of the face is affected by sex, race, ethnicity, climate, socioeconomic, nutritional and genetic factors (Jeremić et al. 2013). Anthropometric studies in various populations have detailed the relationships between the landmarks of the face (Arslan et al. 2008; Choe et al. 2004). Males have greater craniofacial measurements such as mouth width, head circumference and minimum frontal breadth than females. Females, on the other hand, have greater cranial base width than males (Anibor et al. 2011). It has been reported that craniofacial measurements can be used in determining stature (Anibor et al. 2011). It is also hypothesized that differences in nose shape may be due to local adaptation to climate (Zaidi et al. 2017). Shetti et al. (2011) found that facial measurements of

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females show lower mean values compared to males. Males mostly have broader zygomatic regions, supraorbital ridges and prominent mandibles while females may have longer and narrower faces, rounder and broader foreheads and thicker lips (Matthews et al. 2018; Roosenboom et al. 2018).

Pubertal sex hormones also contribute to masculinisation and feminization; the influence of pubertal testosterone causes an increase in lower facial height but a decrease in cheekbone (Hodges-Simeon et al. 2016). It brings about a direct increase in the size and mass of muscles and bones and causes changes in the shape of the face between sexes (Osunwoke et al. 2011). Men usually have less fat tissue; they have stronger and wider bones and more muscle mass compared to women (Marko et al. 2018).

The characteristics of the face can be used as a good identification tool for the dead, missing persons and criminals, using both morphological features and measurements (Ranjana et al. 2016). Growth and development of craniofacial structures are of importance since clinicians depend on them for the process of treatment and diagnosis and in planning for maxillofacial surgeries (Arslan et al. 2008; Tania et al. 2020). Therefore, the knowledge acquired from the study of facial morphology is useful in several areas such as facial aesthetics, forensic medicine and medico-legal disputes as well as reconstructive surgeries (Akinlolu 2016). Surgeons must consider the specific facial structures of such patients to help obtain accurate results (Arslan et al. 2008; Tania et al. 2020). In Ghana, the face is useful in making identity cards and passports among others. Despite the introduction of a biometric system in various identification cards, there is still very little information available on metric facial data and distribution patterns among the tribes. Therefore, the study was designed to bring out the differences between the facial measurements of male and female participants in order to generate baseline data for Ghanaians, taking into consideration the Bonos and Ewes living in the Bono Region of Ghana.

Methods

Study population and location

There are six major ethnic groups in Ghana: the Akans, Ewes, Ga-Adangbes, Mole-Dagbani's, Guans and Gurmas. Akan is the largest ethnic group in Ghana with several subdivisions. Bono is one of the largest tribes in Ghana and they are predominant in the Bono region of Ghana. The largest tribe in the Volta region of Ghana is the Ewes. A significant number of the Ewes are also found in the Bono region. The study took interest in both tribes since they have completely different ancestral origins and physical features that can help make our comparisons between both tribes in the Bono region of Ghana.

This quantitative cross-sectional study employed a non-probability purposive sampling technique to recruit a total of 291 healthy individuals (162 males and 129 females). The study and its protocols were explained to the understanding of the participants. The study adhered to the Helsinki Declaration and was approved by the Committee on Human Research, Publication and Ethics of the University. Informed participant consent was obtained from each participant before facial measurements were taken.

The sample size was determined using the Yamane formula (Adam 2020).

$$n = \frac{N}{1 + N(\propto)^2}$$

where n = sample size
N = study population = 1525
α = margin of error = 0.05; confidence level of 95%
Therefore,

$$n = \frac{N}{1 + N(\propto)^2}$$

$$\frac{1525}{1 + 1525(0.05)^2}$$

$$n = 316$$

However, the sample size of 316 could not be achieved due to factors such as outliers and unwillingness of some individuals to take part in the study.

Inclusion and exclusion criteria

Healthy participants with both parents and grandparents being Bono or Ewe and living in the Bono region were included in the study. Individuals with physical impairment, scarring, craniofacial trauma, amputated limbs, visible tumours, facial oedema and pregnant women were excluded from the study. Participants with physical signs of endocrine disorders such as dwarfism and gigantism were also excluded from the study.

Data collection

The Shahe Vernier calliper was used to take the 24 anthropometric facial measurements (to the nearest 0.1 mm). Manual anthropometry using the digital Shahe Vernier calliper is a gold standard since it is easily accessible. It can access the various bony landmarks directly and it is less costly.

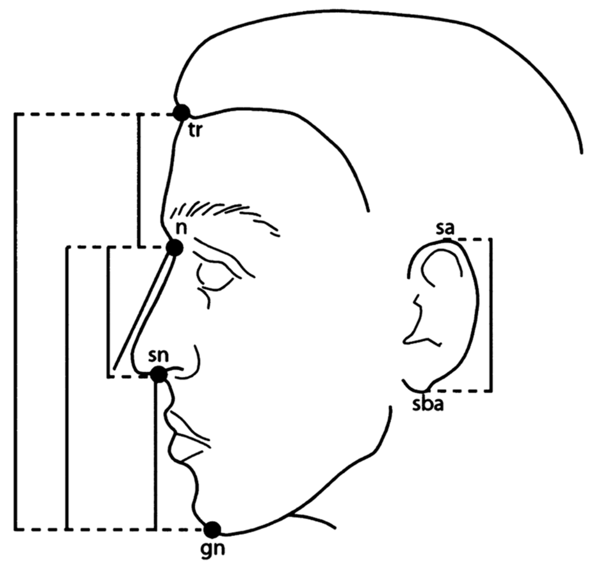

Fig. 1 Measurements of the lateral aspect of the face: upper face height two (tr-n); total face height (tr-gn); morphological face height (n-gn); nasal height (n-sn); ear length: sa-sba (Farkas et al. 2005)

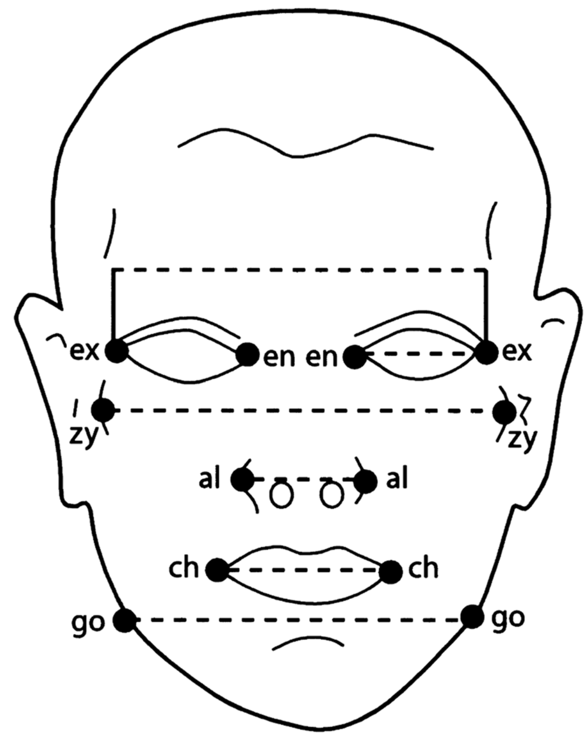

Fig. 2 Measurements on the frontal aspect of the face: intercanthal width (en-en); biocular width (ex-ex); eye fissure width (en-ex); face breadth (zy-zy); mandibular width (go-go); morphological nose width (al-al); mouth width (ch-ch) (Farkas et al. 2005)

The 24 measurements were taken since they are easily identifiable, palpable features on the face of an individual (Figs. 1 and 2). All measurements were duplicated and the averages were taken. To avoid inter-observer error, all the measurements were taken by the same person. All anthropometric measurements of the face were taken with the participants in sitting position with the back perpendicular to the chair, body erect, head up and arms at the sides. A pilot study done prior to the main study showed that eye fissure width, ear width and ear length were bilaterally symmetrical so measurements were taken from one side specifically the left part of the face. The various facial measurements taken from the participants have been explained in Table 1.

Data analysis

Statistical analyses were carried out using International Business machines (IBM), Statistical Package for Social Sciences (SPSS) (version 24.00, incorporated, (Inc.) Chicago, Illinois (IL), United States of America (USA)). The measurements were expressed as means and standard deviations. Differences between tribes were tested using ANOVA, followed by Tukey's Multiple Comparison (TMC) test. The results of the post hoc tests were indicated in the tables by letter indices 'a, b, c, d, e, and f', for pairs of groups with a significant difference. The *p* values are only the results of the ANOVA (overall difference among the four groups) and not the post hoc test.

Results

Analysis of variance of facial anthropometric data stratified by sex within the studied tribes

From the post hoc analysis using Tukey's honest significance difference (HSD), there were no significant differences for upper face height 1 (tr-g) between Bono males, Bono females, Ewe males and Ewe females. Post hoc analysis revealed a significant difference between Bono males and Bono females, with the Bono males having higher values than Bono females in both upper face height 2 (tr-n) ($p = 0.014$) and total face height (tr-gn) ($p = 0.032$) (Table 2).

All morphological facial measurements showed significant variations between sexes among the tribes. In both mid-facial height 1(n–st) and mid-facial height 2 (g-sn), significant differences were observed between Bono males and Bono females ($p = 0.023$) following post hoc test. For morphological face height, maxillary height, face breadth, mandibular width and mouth width, the values of Bono males were significantly greater than those of the Ewe males following post hoc analysis. In the case of mandibular height, post hoc analysis showed that a significant difference was between Bono females and Ewe males (Table 3).

Table 1 Facial measurements taken from the participants and their meanings

Facial measurements	Meaning
Upper face height 1 (tr-g)	Distance from the hair line (trichion) and the midpoint of the supra-orbital margins (glabella)
Upper face height 2 (tr-n)	Distance from the hair line (trichion) to the intersection between frontonasal and internasal (nasion)
Total face height (tr-gn)	Distance from the hair line (trichion) to the lowest point on the lower border of the mandible in the mid-sagittal plane (gnathion)
Midface height 1 (n-st)	Distance from the nasion (n) to the midsagittal of the oral fissure
Midface height 2 (g-sn)	Distance in the median plane from the glabella and the subnasale
Lower face height/mandibular height (st-gn)	Straight distance from the stomion (st) to the gnathion
Maxillary height (sn-st)	Straight distance from the subnasale to stomion in the mid-sagittal plane
Mandibular width (go-go)	Maximum breadth of the lower jaw between two gonion points on the angles of mandibles
Mouth width (ch-ch)	Distance between the cheilion points (ch-ch)
Nasal height (n-sn)	Straight distance from the nasal root (nasion) to the subnasale in the mid-sagittal plane
Nasal length (n-pn)	Straight distance from the nasal root (nasion) to the tip of the nose in the mid-sagittal plane (pronasale)
Nasal tip protrusion (sn-pn)	Straight distance from the subnasale to the tip of the nose in the mid-sagittal plane (pronasale)
Morphological nose width (al-al)	Distance from the lateral-most aspect of one *ala nasi* to the lateral-most aspect of the other *ala nasi*
Anatomical nose width (ac-ac)	Distance from the right to the left alae curvatures (ac)
Intertragal width (t-t)	Anterior distance from the tragus points (t-t)
Tragus-exocanthion (t-ex)	Distance from a tragion (t) point to an exocanthion (ex) of the same laterality
Tragus-subnasale (t-sn)	Distance from a tragion (t) point to the subnasale (sn)
Tragus-cheilion (t-ch)	Distance from a tragion (t) to a cheilion (ch) point of same laterality
Tragus-gnathion (t-gn)	Depth of the lower third of the face from tragion to the lowest point on the lower mandibular border in the mid-sagittal plane (gnathion)
Eye Fissure width (en-ex)	Distance from the left endocanthium to the left exocanthion of the same eye in the horizontal plane
Biocular width (ex-ex)	Distance from the exocanthion of the palpebra to the exocanthium of the opposite eye in the horizontal plane
Intercanthal width (en-en)	Distance from the endocanthium of one palpebra to the endocanthium of the opposite eye in a horizontal plane
Ear length (sba-sa)	Maximum distance from the superior aspect (supra-aurale) to the inferior aspect of the external ear (sub-aurale)
Ear width (pra-pa)	Width of the external ear (pinna) taken from preaurale to post-aurale

Table 2 Analysis of variance of the upper facial measurements of the Bono and the Ewe participants

Measurements	Tribe	*N*	Mean (mm)	SD (mm)	*p*-value
Upper face height 1 (tr-g)	Bono males	87	58.88	7.97	
	Bono females	65	55.19	8.42	
	Ewe males	75	58.78	9.73	0.070
	Ewe females	64	55.25	8.61	
Upper face height 2 (tr-n)	Bono males	87	70.07_a	7.06	
	Bono females	65	66.20_a	8.86	
	Ewe males	75	69.32	9.63	0.014
	Ewe females	64	66.75	8.85	
Total face height (tr-gn)	Bono males	87	185.61_a	25.80	
	Bono females	65	174.82_a	28.05	
	Ewe males	75	176.30	22.51	0.032
	Ewe females	64	177.85	23.34	

N number of participants, *SD* standard deviation, *tr-g* trichion to glabella, *tr-n* trichion to nasion, *tr-gn* trichion to gnathion, *mm* millimetre. a = identical subscript letters have differences existing between the mean values of two tribes by means of a post hoc test (the *p* values are only the result of the ANOVA and not the post hoc test). Statistical significance at $p < 0.05$

Table 3 Analysis of variance of morphological facial measurements of Bono and Ewe participants

Measurements	Tribe	*N*	Mean (mm)	SD (mm)	*p*-value
Mid-facial height 1 (n-st)	Bono males	87	68.94_a	9.79	0.023
	Bono females	65	64.43_a	11.85	
	Ewe males	75	65.37	8.02	
	Ewe females	64	66.00	8.72	
Mid-facial height 2 (g-sn)	Bono males	87	53.81_a	8.66	0.014
	Bono females	65	49.47_a	9.97	
	Ewe males	75	53.10	10.95	
	Ewe females	64	49.92	10.22	
Mandibular height (st-gn)	Bono males	87	37.38	6.77	0.010
	Bono females	65	34.36_c	6.78	
	Ewe males	75	37.70_c	8.81	
	Ewe females	64	34.66	7.72	
Maxillary height (sn-st)	Bono males	87	22.38_e	5.59	0.047
	Bono females	65	21.15	5.68	
	Ewe males	75	20.17_e	4.69	
	Ewe females	64	20.67	4.73	
Mandibular width (go-go)	Bono males	87	94.69_e	13.65	0.044
	Bono females	65	91.16	12.91	
	Ewe males	75	89.26_e	11.02	
	Ewe females	64	90.79	12.21	
Mouth width (ch-ch)	Bono males	87	49.82_e	8.06	0.042
	Bono females	65	48.16	8.36	
	Ewe males	75	46.60_e	6.50	
	Ewe females	64	47.35	6.53	

N number of participants, *SD* standard deviation, *mm* millimetre, *n-st* nasion to stomion, *g-sn* glabella to subnasale, *st-gn* stomion to gnathion, *sn-st* subnasale to stomion, *go-go* gonion to gonion, *ch-ch* cheilion to cheilion. a, c, e = identical subscript letters have differences existing between the mean values of two tribes by means of a post hoc test (the *p* values are only the result of the ANOVA and not the post hoc test). Statistical significance at $p < 0.05$

For the nasal measurements, only anatomical nose width(ac-ac) and nasal length (n-pn) showed some significant differences among the studied populations. Anatomical nose width was significantly different between Bono females and Bono males as well as Bono males and Ewe females. However, for nasal length, it showed a significant difference only between Bono males and Ewe males (Table 4).

The means of the intertragal width (t-t) for the Bono males and Ewe males were significantly higher than those for the Bono females and Ewe female participants. One-way analysis of variance of intertragal width, tragus-exocanthion, tragus-subnasale, tragus-cheilion and tragus-gnathion among Bono males, Bono females, Ewe males and Ewe females showed statistically significant differences. The post hoc analysis revealed that the significant difference was between Bono females and Bono males, Bono males and Ewe females for the tragus to tragus (t-t) ($p = 0.007$) (Table 5).

The mean tragus-exocanthion (t-ex) of the Bono male and female participants was statistically different from Bono female and Ewe male, Bono male and Ewe female, Ewe female and Ewe male participants ($p = 0.004$). The post hoc analysis revealed a significant difference between Bono female and Ewe male participants for tragus-subnasale (p=0.009). There were significantly higher values for Bono male and Ewe male participants. The post hoc analysis revealed significant differences between Bono females and Ewe males, Ewe females and Ewe males for the mean of tragus-cheilion measurements. The mean of tragus to gnathion was statistically significant for Bono female and Bono male participants ($p = 0.017$) (Table 5).

From the post hoc analysis using Tukey honest significant difference, there were no significant differences in biocular width (ex-ex) among tribes and sex. However, for eye fissure width and intercanthal width, there was a statistically significant difference between Bono males and Ewe males. The Bono male participants had significantly higher values than Ewe males in both endocanthion-exocanthion and endocanthion-endocanthion (Table 6).

From Table 7, all the auricular measurements showed significant variation between sex within the same tribe. The post hoc analysis revealed that in both ear length

Table 4 Analysis of variance (ANOVA) of nasal measurements of Bono and Ewe participants

Measurements	Tribe	*N*	Mean (mm)	SD (mm)	*p*-value
Nasal height (n-sn)	Bono males	87	57.66	7.48	0.088
	Bono females	65	55.35	10.04	
	Ewe males	75	55.04	5.36	
	Ewe females	64	55.52	5.38	
Nasal length (n-pn)	Bono males	87	42.96_{e}	7.80	0.031
	Bono females	65	41.03	7.60	
	Ewe males	75	39.74_{e}	6.06	
	Ewe females	64	40.65	6.64	
Nasal tip protrusion (sn-pn)	Bono males	87	15.57	2.95	0.198
	Bono females	65	15.11	3.15	
	Ewe males	75	14.54	3.13	
	Ewe females	64	14.96	3.00	
Morphological nose width (al-al)	Bono males	87	37.17	7.52	0.099
	Bono females	65	35.29	7.38	
	Ewe males	75	34.42	7.12	
	Ewe females	64	35.05	7.49	
Anatomical nose width (ac-ac)	Bono males	87	$28.27_{a,d}$	6.15	0.007
	Bono females	65	25.10_{a}	7.15	
	Ewe males	75	27.74	7.71	
	Ewe females	64	25.21_{d}	7.03	

N number of participants, *SD* standard deviation, *mm* millimetre, *n-sn* nasion to subnasale, *n-pn* nasale to pronasale, *sn-pn* subnasale to pronasale, *al–al* ala to ala, *ac-ac* ala curvature to ala curvature. a, d, e = identical subscript letters have differences existing between the mean values of two tribes by means of a post hoc test (the *p* values are only the result of the ANOVA and not the post hoc test). Statistical significance at $p < 0.05$

Table 5 Analysis of variance of tragal-related measurements by tribes

Measurements	Tribe	*N*	Mean (mm)	SD (mm)	*p*-value
Intertragal width (t-t)	Bono males	87	$201.98_{a,d}$	42.16	0.007
	Bono females	65	180.80_{a}	49.33	
	Ewe males	75	198.08	49.01	
	Ewe females	64	181.16_{d}	47.74	
Tragus-exocanthion (t-ex)	Bono males	87	$78.28_{a, d}$	10.08	0.004
	Bono females	65	$73.53_{a, c}$	10.52	
	Ewe males	75	$78.32_{c, f}$	12.31	
	Ewe females	64	$73.61_{d, f}$	10.17	
Tragus-subnasale (t-sn)	Bono males	87	106.24	10.13	0.009
	Bono females	65	101.56_{c}	10.52	
	Ewe males	75	106.76_{c}	13.45	
	Ewe females	64	102.13	11.85	
Tragus-cheilion (t-ch)	Bono males	87	118.51	30.82	0.008
	Bono females	65	107.54_{c}	22.97	
	Ewe males	75	$121.43_{c, f}$	35.87	
	Ewe females	64	108.28_{f}	26.43	
Tragus-gnathion (t-gn)	Bono males	87	122.42_{a}	12.50	0.017
	Bono females	65	115.82_{a}	16.46	
	Ewe males	75	118.64	10.36	
	Ewe females	64	119.05	10.96	

N number of participants, *SD* standard deviation, *mm* millimetre, *t-t* tragus to tragus, *t-ex* tragus to exocanthion, *t-sn* tragus to subnasale, *t-ch* tragus to cheilion, *t-gn* tragus to gnathion. a, c, d, f = identical subscript letters have differences existing between the mean values of two tribes by means of a post hoc test (the *p* values are only the result of the ANOVA and not the post hoc test). Statistical significance level at $p < 0.05$

Table 6 Analysis of variance of ocular measurements stratified by tribe

Measurements	Tribe	*N*	Mean (mm)	SD (mm)	*p*-value
Left eye fissure width (en-ex)	Bono males	87	42.43_e	5.87	0.050
	Bono females	65	40.85	5.86	
	Ewe males	75	40.02_e	5.29	
	Ewe females	64	40.73	5.56	
Biocular width (ex-ex)	Bono males	87	103.79	11.80	0.151
	Bono females	65	101.44	11.36	
	Ewe males	75	99.74	12.02	
	Ewe females	64	100.35	12.94	
Intercanthal width (en-en)	Bono males	87	32.31_e	8.28	0.035
	Bono females	65	30.49	8.64	
	Ewe males	75	28.96_e	6.31	
	Ewe females	64	29.83	6.51	

N number of participants, *SD* standard deviation, *mm* millimetre, *en-ex* endocanthion to exocanthion, *ex-ex* exocanthion to exocanthion, *en-en* endocanthion to endocanthion. e = identical subscript letters have differences existing between the mean values of two tribes by means of a post hoc test (the *p* values are only the result of the ANOVA and not the post hoc test). Statistical significance at $p < 0.05$

Table 7 Analysis of variance of auricular measurements

Measurements	Tribe	*N*	Mean (mm)	SD (mm)	*p*-value
Left ear length (sba-sa)	Bono males	87	38.65a	10.70	
	Bono females	65	33.34a	12.77	0.012
	Ewe males	75	34.60	8.58	
	Ewe females	64	35.45	9.52	
Left ear width (pra-pa)	Bono males	87	24.80a	5.44	
	Bono females	65	22.06a	7.25	0.022
	Ewe males	75	23.28	4.19	
	Ewe females	64	23.33	4.36	

N number of participants, *SD* standard deviation, *mm* millimetre, *pra-pa* preaurale to postaurale, *sba-sa* subaurale to superaurale. a = identical subscript letters have differences existing between the mean values of two tribes by means of a post hoc test (the *p* values are only the result of the ANOVA and not the post hoc test). Statistical significance at $p < 0.05$

(sba-sa) and ear width (pra-pa), significant differences were observed between Bono females and Bono males at $p = 0.012$ and $p = 0.022$ respectively.

Discussion

Facial anthropometric measurements stratified by sex and tribe

In the present study, although the male participants recorded numerically greater upper facial anthropometric measurements than the females, those that showed significant sexual dimorphism were upper facial height 2 and total facial height. This could be attributed to pubertal testosterone which causes a steep and prolonged increase in lower facial height, size and mass of muscles in males than females resulting in differences in facial measurements (Osunwoke et al. 2011; Marko et al. 2018) as well as bony structures, soft-tissue, subcutaneous fat and fascia of the skin are affected by the ageing process. However, subcutaneous fat muscle and fascia act in dynamic unison to determine the phenotypic presentation of the face throughout life (Zimbler et al. 2001).

The present study demonstrated sexual differences regarding total facial height which agrees with the works of Dayal et al. (2008), Singla et al. (2020) and Maalman et al. (2017). This could be due to the similarity in climate, diet, ethnicity and socio-economic factors. Total facial height is likely to be one of the major variables important for discriminating between males and females (Patil and Mody 2005).

The mandibular width of the present study was significantly different from that of Northwest Indians (Sahni et al. 2010). This difference could be a result of genetic trait of morphological facial measurements. Moreover, the maxillary height of adult Ibibios of Nigeria according to Oladipo et al. (2010) and Didia and Dapper (2005) also in Nigeria exhibited sexual dimorphism which agrees with the present study and could be due to genetic factors and similarity in race since Ghanaians and Nigerians are both Negroes, and this might have brought about the existing differences in shape and configuration of the maxillary height of both sexes.

The present study agrees with the findings of Ewunonu and Anibeze (2013) in the South Eastern Nigerian population where the mean nasal height and width among the male participants were significantly higher than that of the female participants. Shetti et al. (2011) found that nasal measurements of females show lower mean values compared to males. Zaidi et al. (2017) hypothesized that differences in nose shape may be due to local adaptation to climate and reported that the distance between *nasal alare* was significantly higher among West Africans, South Asians and East Asian ancestry compared to the European ancestry. Facial anthropometric measurements show racial variations according to nasal type. African noses appear to be the shortest and widest. Afro-Caucasians have the narrowest, with Afro-Indians having the longest. Ageing causes significant changes in the appearance of the nose and nasal elongation (Porter and Olson 2001).

The nose is an individual's most defining feature because it is at the centre of the face, anthropometric analysis of it can provide data which could contribute to satisfactory results of cosmetic nasal surgery. Nasoplastic surgeons require access to facial databases based on accurate anthropometric measurements to perform optimum correction in both sexes. A successful outcome in rhinoplasty requires a thorough and accurate preoperative planning and awareness of the morphological differences (Ofodile and Bokhari 1995).

All the tragal-related measurements of both tribes such as intertragal width, tragus-exocanthion, tragus-subnasale, tragus-cheilion and tragus-gnathion were sexually dimorphic and males recorded greater values than females since they have stronger and wider bones and more muscle mass compared to females (Anibor et al. 2011; Marko et al. 2018). This indicates that facial equipment such as face masks, helmets and spectacles must be designed considering sex. Lee et al. (2012) recommended that Korean female facial characteristics need to be considered in the design of oxygen masks to fit Korean pilots. In the present study, eye measurements, mean intercanthal width and biocular width were numerically greater in males than in females. This is supported by the findings of Matthews et al. (2018), who reported that males mostly have broader supraorbital ridges than females which might have enhanced the intercanthal and biocular width to be greater in males than the females. However, eye fissure width showed no significant difference between males and females. This could be attributed to minimal changes in facial growth at age range 18–60 years in some of the facial measurements (Didia and Dapper 2005).

Moreover, all the auricular measurements, ear width and ear length showed significant differences between Bono males and Bono females. This could be attributed to auricular expansion which starts earlier in males than females (Taura et al. 2013). In contradiction to this finding, Maalman et al. (2017) reported that Dagaaba and Sisaala female participants in Ghana have greater ear length than the males, attributing the differences to the wearing of heavy earrings by the females and a possible loss of fat as one advances in age. The mean ear length and width of the Bono and Ewe males were numerically lower than those of a South-Eastern Nigerian population (Ewunonu and Anibeze 2013). Also, in a study by Japatti et al. (2018) among Maharashtrian adults in India, there was sexual dimorphism in ear width but their mean values were not statistically significant. Several authors have stated that ear length increases faster and for longer duration compared to ear width (Purkait and Singh 2007; Meijerman et al. 2007; Niemitz et al. 2007; Japatti et al. 2018). This could be attributed to the human external ear which grows continuously even after skeletal maturity is reached. Ageing brings about changes in the microscopic structure of the cartilage and this decreases elastic fibres and density of the cartilage causing an increase in length and reduction in the breadth of the ear (Japatti et al. 2018).

Conclusions

Male facial measurements were numerically higher than those of the female participants. There were no significant differences for upper face height one among males and females of the Bono and Ewe tribes. All the measurements classified under morphological facial and auricular showed significant variations among the tribes stratified by sex. There was a statistically significant difference concerning nasal length and anatomical nose width among the participants ($p < 0.05$). The Bono male participants had significantly higher values than Ewe males in both endocanthion-exocanthion and endocanthion-endocanthion.

The results of this study support the assertion regarding the existence of tribal variations and sexual dimorphism associated with facial measurements and have provided additional data for facial morphology for biometric and forensic applications as well as facial reconstruction especially among the study populations in Ghana.

Abbreviations

ac-ac: Ala curvature-ala curvature; al-al: Ala-ala; ANOVA: Analysis of variance; ch-ch: Cheilion-cheilion; en-en: Endocanthium-endocanthium; en-ex:

Endocanthium-exocanthium; ex-ex: Exocanthium-exocanthium; go-go: Gonion-gonion; g-sn: Glabella-subnasale; HSD: Honest significant difference; IBM: International Business Machines; Inc: Incorporated; mm: Millimetre; n-pn: Nasion-pronasale; n-sn: Nasion-subnasale; n-st: Nasion-stomion; pra-pa: Preaurale-postaurale; SD: Standard deviation; sn-pn: Subnasale-pronasale; sn-st: Subnasale-stomion; SPSS: Statistical Package for Social Sciences; st-gn: Stomion-gnathion; t-ch: Tragus-cheilion; t-ex: Tragus-exocanthium; TMC: Tukey's multiple comparison; tr-g: Trichion-glabella; t-gn: Tragus-gnathion; tr-n: Trichion-nasion; t-sn: Tragus-subnasale; t-t: Tragus-tragus; USA: United States of America.

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Authors' contributions

All authors contributed significantly in the preparation of this manuscript. Conceptualisation of this manuscript was by FKS. The methodology of this manuscript was designed by FKS, CSA, AKA and TKD. Data was collected by FKS, NDD and JN. The original draft of the manuscript was done by FKS, CSA, TKD, AKA and NDD. The work was supervised by CSA, TKD and AKA. The manuscript was reviewed and edited by CSA, TKD, AKA, NDD and JN. The authors read and approved the final manuscript.

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Availability of data and materials

Data and materials would be made available upon request.

Declarations

Ethics approval and consent to participate

The study adhered to the Helsinki Declaration and was approved by the Committee on Human Research, Publications and Ethics, KNUST, with approval number: CHRE/AP/131/20.

Consent for publication

Informed participant consent was obtained from each volunteer before facial measurements as well as other demographics were taken after explaining the protocols to them. Consent was obtained from participants whose images were used as a sample for measurement of facial parameters.

Competing interests

Not applicable.

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