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Facial types and morphology: A study among Sisaala and Dagaaba adult population in the Upper West Region, Ghana

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ABSTRACT

Craniofacial measurements can be considered to be one of the important tools for determination of the inter-racial and intra-racial morphological characteristics of the head and face. As such, facial indices 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 facial phenotypes and its prevalence with respect to ethnicity and sex. Therefore, the aim of this study was to classify the facial types among the Dagaabas and Sisaalas in the Upper West Region of Ghana. In the study, a total of 387 healthy individuals (202 females and 185 males), between 18 and 60 years of age were recruited. The study main finding was that, the males had higher facial height and breadth than females. Facial indices were recorded as 98% and 99% for female and male Dagaabas respectively. The Sisaala male and female participants' facial indices recorded 102% and 104% respectively. Thus as high as 83% and 72% of the Sisaalas and Dagaabas respectively had hyperleptoprosopic facial type.

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Introduction

A hallmark of the diversity and individuality of humans is the range of variations in the shape of their faces [1]. Much research has been conducted on the morphological characteristics of the face not only in the recognition of an individual, but also in forensic examination, clinical medicine, plastic and oral surgery, facial reconstruction and victims' identification in mutilated body parts [2–4]. Craniofacial characteristics are also highly informative when diagnosing genetic diseases by clinical geneticists [5]. The introduction of anthropometric methods into clinical practice to quantify changes in the craniofacial framework led to the discovery of features distinguishing various ethnic groups and races [6]. Although several new technologies have been designed currently to computerize anthropometric measurements [7], direct anthropometry performed during a patient examination has been shown to still be the standard technique for quantifying craniofacial dysmorphology [8]. However, there are no significant differences between anthropometric measurements obtained by direct anthropometry

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and the different digital 2D and 3D photogrammetric systems [8,9]. The standard direct anthropometry is inexpensive, reliable [8], less sophisticated [10], non-invasive process and has been widely used for sex and racial determination [4,11,12]. In 2004, Basciftel and his colleagues documented that it is very necessary for the establishment of anthropometric standards for the evaluation of deviations in craniofacial morphology, for a particular population [13]. Population-specific craniofacial standards identified could also be used in the design of equipment, clothing and work spaces for both men and women [14].

Facial (prosopic) index (FI) has been used to describe the various facial types in anthropometry. It is the ratio of the morphological facial height to the bizygomatic width (facial breadth) multiplied by 100 [15]. According to Martin-Saller's scale, facial phenotypes are classified into 5; hyperleptoprosopic, leptoprosopic, mesoprosopic, euryprosopic and hyper-euryprosopic [11,15,16]. The facial type of an individual has been reported to be influenced by sex, ethnicity and race, genetic, socio-economic and nutritional factors [4].

These prosopic indicis have been reported by several investigators to vary between males and females in different populations. Jeremić et al. [4] found significantly ($p < 0.001$) lower values in facial height, breadth and index in females than males. The dominant facial type among the Serbian population was leptoprosopic with an incidence of 81.71% (76.66% males and 87.05% females). Few of the populace were of the mesoprosopic and hyperleptoprosopic facial types [15]. However, in Torres-Restrepo [5] study, mesoprosopic and leptoprosopic facial types were the most predominant facial type, with a percentage of 47.9% each. Leptoprosopic have been shown to be the most predominant facial type identified among Africans [17].

Craniofacial measurements have been identified to be one of the important tools for determination of the morphological characteristics of the face for studying different racial groups [13,14]. In the developed countries, facial recognition systems based on facial parameters are designed and used extensively in various fields. However, there is paucity of information on facial types in Ghana as a whole and particularly in the population under study. The people living in Ghana belonged to different ethnic groups who migrated from different part of Africa to the present day Ghana. History has it that the Sissalas and Dagaabas are among the first settlers in the Upper West Region which makes the duo indisputably the dominant tribes in the region [15,16]. These two tribes even though they have some tribal differences, they share some similarities in their way of life. This study therefore aim at classifying the facial types among the Dagaabas and Sisaalas in the Upper West Region of Ghana.

Materials and methods

Study design and participants

The study was a cross-sectional study involving a total of 387 participants, out of which 202 and 185 were Dagaabas and Sisaalas respectively. It included 208 females and 179 males aged between 18 and 60 years, who were randomly recruited from a healthy adult population of Dagaabas and Sisaalas in Nandom and Lambussie-Kani Districts respectively of the Upper West Region, Ghana. The study as well as the procedures were explained to the participants for them to willingly participate or decline. Informed participant's consent was then obtained from each volunteer before the study. The study adhered to the Helsinki declaration and was approved by the Committee on Human Research and Publication Ethics at KNUST, Kumasi with approval number: CHRPE/AP/426/17.

Measurements of the facial parameters

The direct method of measurement was employed to obtain the facial parameters from each of the participants using a measuring tape (The Perfect Measuring Tape Company, USA). Two facial parameters were measured (to the nearest 0.1 cm) from each participant. To ensure accuracy and uniformity, all the facial measurements were performed with participants in a sitting position: body erect, head up in the Frankfort plane and arms at the sides. The measurements included the following:

(i) Morphological face height (n-gn): the measurement between the nasal root (n; nasion) and the lowest point of the lower border of mandible in the mid-sagittal plane (gn; gnathion).
(ii) Bizygomatic width (zy–zy): the measurement from the left zygion to the right zygion.

Participants whose parents and grandparents (both maternal and paternal) did not have inter-tribal marriages were included in the study. Also, individuals with no physical impairment, craniofacial trauma, facial scars, visible tumours, oedema and non-pregnant women were recruited for the study. Participants who showed physical signs of endocrine disorders such as dwarfism and gigantism were excluded from the study. Data collected in the study included age, tribe and the two facial parameters.

The accuracy and precision of the measurement technique was assessed using Lin's concordance correlation coefficient of reproducibility [7,18]. Twenty facial measurements were initially selected for this purpose and analyzed using the test-retest procedure, where measurements were taken by two investigators. The twenty facial dimensions were analyzed and the Lin's correlation between the two set of measurements were calculated. The results of the analysis (not shown) showed that all the measurements were reproducible with no significant intra- and inter-observer discrepancies.

Table 1
Participants characteristics stratified by sex within tribes.

Parameters	SISAALA ($n = 185$)		DAGAABA ($n = 202$)		p-value
	Female ($n = 97$) Mean ± SD	Male ($n = 88$) Mean ± SD	Female ($n = 111$) Mean ± SD	Male ($n = 91$) Mean ± SD	
Age (years)	39.18 ± 12.80	33.99 ± 13.49	39.08 ± 12.86	37.34 ± 12.02	0.0194 [a, d]
Height (cm)	160.7 ± 5.68	170.1 ± 6.65	160.5 ± 6.30	171.9 ± 7.17	< 0.0001 [a,c, d, f]
Weight (kg)	58.39 ± 9.75	64.50 ± 9.04	58.26 ± 8.73	65.30 ± 8.84	< 0.0001 [a, c, d, f]

Data recorded in mean ± Standard Deviation and range. BMI = Body Mass Index; **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. *Statistically Significant Difference ($p < 0.05$).*

Table 2
Descriptive statistics of facial parameters based on tribe and sex.

Parameters	SISAALA		DAGAABA		ANOVA p-value
	Female ($n = 97$)	Male ($n = 88$)	Female ($n = 111$)	Male ($n = 91$)	
n – gn (Mean ± SD)	12.60 ± 0.90	13.60 ± 0.93	12.25 ± 0.93	13.24 ± 0.76	< 0.0001 [a, c, d, f]
zy – zy (Mean ± SD)	12.39 ± 0.67	13.09 ± 0.69	12.50 ± 0.69	13.35 ± 0.98	< 0.0001 [a, c, d, f]
FI (%)	102.11	104.25	98.29	99.70	< 0.0001 [d, e]

Data recorded in mean ± standard deviation; **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. **n- gn** = nasion to gnathion (Morphological facial height); **zy–zy** = zygion to zygion (bizygomatic width); FI = Facial (Prosopic) index; *Statistically Significant Difference ($p < 0.05$).*

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20 for Windows (IBM Company, Chicago, IL). Data normality was checked using Shapiro–Wilk test. One way analysis of variance (ANOVA) followed by Tukey's multiple comparison test was used to assess sex differences (or sexual dimorphism) as well as intertribal differences of the measured variables. The level of statistical significance was determined at $p < 0.05$ or 95% confidence interval.

The facial index was estimated from the formula:

$$\mathrm{FI} = \frac{\text{Morphological facial hieght } (n - Gn)}{\text{Bizygomatic width } (Zy - Zy)} \times 100$$

Based on the facial index (%), the facial types were classified into the following according to Martin-Saller's scale [4].

1. Hyperleptoprosopic (very long face): facial index above 93.0%.
2. Leptoprosopic (long face): facial index between 88 and 92.9%.
3. Mesoprosopic (round face): facial index between 84 and 87.9%.
4. Euriprosopic (broad face): facial index between 79 and 83.9%.
5. Hypereuriprosopic (very broad face): facial index below 78.9%.

Results

Descriptive characteristics of the participants

Table 1 shows the comparison of the Sisaalas and Dagaabas with regards to age, height and weight. The average ages for the Dagaabas and Sisaalas were 38.30 ± 12.49 years and 36.71 ± 13.31 years respectively. For both tribes, the mean weight and height of the males were numerically higher and statistically significant ($p < 0.0001$) than that of the female participants as shown in Table 1 below.

The Dagaabas were slightly taller than the Sisaalas who were rather heavier. These differences in height and weight were however not statistically different between the two tribes. The mean weight for the Dagaabas and Sisaalas were 61.43 ± 9.43 kg (37 – 94 kg) and 61.51 ± 9.95 kg (42 – 93 kg) respectively with no statistically significant difference between the two groups. The height of Dagaaba participants ranged from 147.00 cm to 198.00 cm (mean: 165.80 ± 8.786 cm) whereas the height of the Sisaala participants was from 133.50 cm to 186.00 cm (mean: 165.20 ± 7.739 cm). The height of the male participants was numerically higher than that of the female participants and this was statistically significant ($p < 0.0001$).

Descriptive statistics of the facial parameters

Table 2 shows the descriptive statistics, including the means, standard deviations and one way analysis of variance (ANOVA) followed by Tukey's Multiple Comparison Test for intertribal and sex differences of the facial dimensions. The

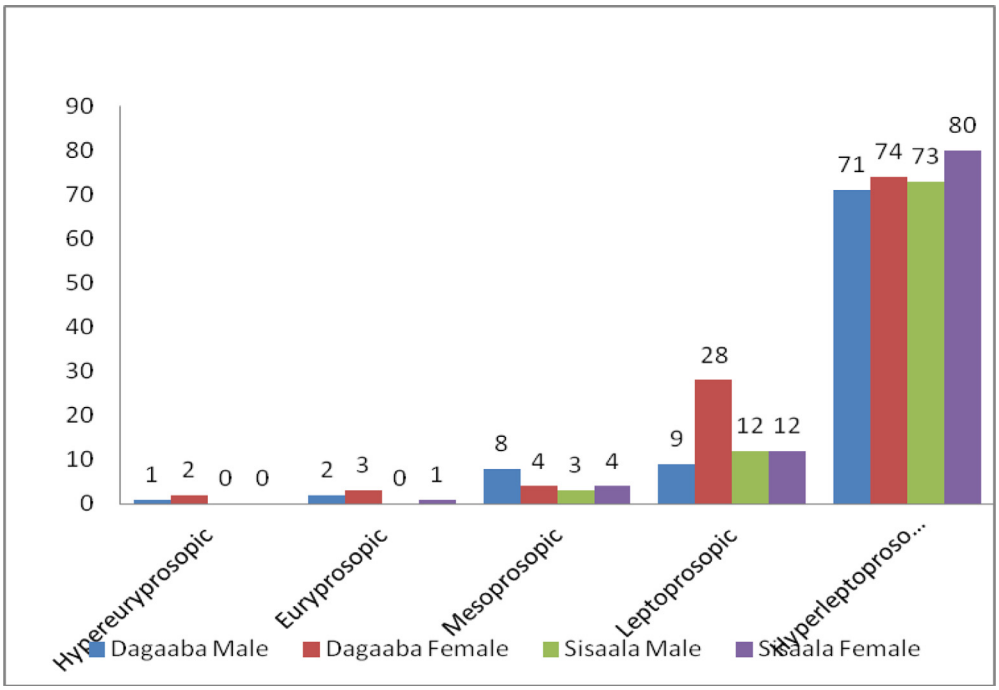

Fig. 1. A bar chat showing the frequencies of the facial types stratified by sex and tribe.

mean value of each of the parameters was significantly higher for males than females. There was significant intertribal differences of the facial parameters of the opposite sex. The male Sisaala participants exhibited significantly higher facial index than the male and female Dagaaba participants.

Facial types among Dagaaba and Sisaala participants

Fig. 1 shows the distributions of the facial types among the two tribes. The dominant facial type among the study participants was hyperleptoprosopic. As high as 153 out of the 185 Sisaala participants (73 males and 80 females) representing 83% and 145 out of the 202 Dagaaba participants (71 males and 74 females) representing 72% of the Dagaaba participants were found to have hyperleptoprosic.

Discussion

The human body dimensions are affected by ecological, biological, geographical, racial, sex, and age factors [13]. In this study, there was statistically significant difference in the facial height between the male and female participants. Equally the facial breadth in the male participants was significantly higher than the female participants. A previous study recorded lower mean of facial height among Igbos of Nigeria [19]. The sex differences are significant in terms of the design of face masks for industrial workers as well as maxillofacial surgery and facial identification in forensic science.

The predominant facial indices were 104.25% and 102.11% for the Sisaala male and female participants respectively. In the Dagaaba male and female participants, 99.70% and 98.29% respectively were recorded which were lower than those recorded for the Sisaala participants. The prosopic (facial) index varied between the males and females. Previous study by Jeremić et al. [4] showed that females in Serbia have significantly ($p < 0.001$) lower values of morphological facial height, facial breadth and facial index than males [15]. In several studies these variations are realised, thus, facial index values among Indian Onges: 77.98% males, 75.29% females [20]; the population of India: 87.19% males, 86.75% females; the population of Malaysia: 85.72% males, 87.71% females [21]; Japanese adult females 82.66% [22], Iranian Fars: 88.22% males, 84.48% females; Iranian Turkman: 87.25% males, 81.48% females [23]. Similar study by Bhasin [24] found facial index in West India to be 84.52%, in North India 82.33%, in East India 86.27%, in Central India 87.45% and in South India 86.61% [24]. All these previous studies presented lower facial indices than that of the present study.

Based on the facial types, the predominant face shape was hyperleptoprosopic, followed by leptoprosopic facial type. The present finding among Sisaala and Dagaaba participants demonstrated a relatively longer and broader faces in comparison with the other tribes in Sub-Saharan Africa. A previous study demonstrated that the Igbo people in Abakaliki had a leptoprosopic facial type and in the Sindhi individuals, 45% were hyperleptoprosopic whiles 46% were leptoprosopic [25]. Similarly, the most predominant facial type among the three dominant ethnic groups of Gombe State, Nigeria was the lep-

toprosopic [6]. Torres-Restrepo [5] found mesoprosopic and leptoprosopic types as the most predominant facial type, with a percentage of 47.9% each. The most predominant facial type among Africans was the leptoprosopic [17]. These differences could be due to genetic and nutritional influences on the participants of the present study and the previous studies.

Conclusion

The study has established that males have higher mean morphological facial height and breadth than females which is very important in the design of face mask and forensic investigations. In addition, the facial index was determined to be 98% and 99% for female and male Dagaabas respectively, whereas the male and female Sisaala participants recorded 102% and 104% respectively. Thus the dominant face type determined in each tribe was hyperleptoprosopic (very long face). The significance of the study is that it has provided preliminary baseline data for facial phenotype among the Dagaabas and Sisaalas of Ghana.

Conflict of interest

None.

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Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sciaf.2019.e00071.

References

[1] D. DeCarlo, D. Metaxas, M. Stone, An anthropometric face model using variational techniques, in: SIGGRAPH, Vol. 98, 1998, pp. 67–74.
[2] C. Vlassoff, Gender differences in determinants and consequences of health and illness, J. Health Popul. Nutr. BioMed. Central; 25 (1) (2007) 47.
[3] K. Krishan, R. Kumar, Determination of stature from cephalo-facial dimensions in a North Indian population, Leg Med. Elsevier; 9 (3) (2007) 128–133.
[4] D.R. Omotoso, O.O. Oludiran, C.L. Sakpa, Nasofacial anthropometry of adult Bini tribe in Nigeria, Afr. J. Biomed. Res. Bioline for the Ibadan Biomedical Communications Group; 14 (3) (2011) 219–221.
[5] Y. Gurovich, Y. Hanani, O. Bar, N. Fleischer, D. Gelbman, L. Basel-Salmon, et al., DeepGestalt-Identifying Rare Genetic Syndromes Using Deep Learning, 2018 arXiv:180107637.
[6] A.A. Akinlolu, B.O. Akinola, R.L. Nurudeen, R.E. Kadiri, M.S. Ajao, Cephalometric study of mouth morphology among major Nigerian Tribes, Anat. J. Africa 4 (1) (2015) 496–504.
[7] P.F. Watson, A. Petrie, Method agreement analysis: a review of correct methodology, Theriogenology. Elsevier; 73 (9) (2010) 1167–1179.
[8] J.Y. Wong, A.K. Oh, E. Ohta, A.T. Hunt, G.F. Rogers, J.B. Mulliken, et al., Validity and reliability of craniofacial anthropometric measurement of 3D digital photogrammetric images, Cleft Palate-Craniofacial J. SAGE Publications Sage CA: Los Angeles, CA 45 (3) (2008) 232–239.
[9] R. Inaba, K. Aizawa, K. Kodate, Proposal of meta-data in a database for identification using face images, Syst. Comput. Japan. Wiley Online Library; 36 (3) (2005) 53–64.
[10] L.G. Farkas, C.K. Deutsch, Anthropometric determination of craniofacial morphology, Am. J. Med. Genet. Wiley Online Library; 65 (1) (1996) 1–4.
[11] L.G. Farkas, M.J. Katic, C.R. Forrest, International anthropometric study of facial morphology in various ethnic groups/races, J. Craniofac. Surg. LWW; 16 (4) (2005) 615–646.
[12] C.N. Stephan, R.M. Norris, M. Henneberg, Does sexual dimorphism in facial soft tissue depths justify sex distinction in craniofacial identification? J. Forensic Sci. ASTM International; 50 (3) (2005) 1–6.
[13] F.A. Basciftci, T. Uysal, A. Buyukerkmen, Craniofacial structure of Anatolian Turkish adults with normal occlusions and well-balanced faces, Am. J. Orthod. Dentofac. Orthop. Elsevier; 125 (3) (2004) 366–372.
[14] F. Pouya, S.H. Eftekhar-Vaghefi, P. Salehinejad, Anthropometric analysis of cephalofacial dimensions in Kerman, Iran, Acta Med. Iran (2017) 241–248.
[15] D. Jeremić, S. Kocić, M. Vulović, M. Sazdanović, P. Sazdanović, B. Jovanović, et al., Anthropometric study of the facial index in the population of central Serbia, Arch. Biol. Sci. 65 (3) (2013) 1163–1168.
[16] M.B. Maina, O. Mahdi, G.G. Kalayi, Craniofacial forms among three dominant ethnic groups of Gombe State, Nigeria, Int. J. Morphol. Citeseer; 30 (1) (2012) 211–216.
[17] A.M. Torres-Restrepo, A.M. Quintero-Monsalve, J.F. Giraldo-Mira, Z.V. Rueda, N. Vélez-Trujillo, P. Botero-Mariaca, Agreement between cranial and facial classification through clinical observation and anthropometric measurement among envigado school children, BMC Oral Health. BioMed. Central; 14 (1) (2014) 50.
[18] N. Chirico, P. Gramatica, Real external predictivity of QSAR models: how to evaluate it? Comparison of different validation criteria and proposal of using the concordance correlation coefficient, J. Chem. Inf. Model. ACS Publications; 51 (9) (2011) 2320–2335.
[19] O. Joy, E. Ahmed, O. Gabriel, E. Ezon-Ebidor, Anthropometric study of the facial and nasal length of adult Igbo ethnic group in Nigeria, Internet J. Biol. Anthropol. 2 (2) (2009).
[20] A.K. Pandey, Cephalo-facial variation among Onges, Anthropology. Taylor & Francis; 8 (4) (2006) 245–249.
[21] V.R. Shetti, S.R. Pai, G.K. Sneha, C. Gupta, P. Chethan, Study of prosopic (facial) index of Indian and Malaysian students, Int. J. Morphol. 29 (3) (2011) 1018–1021.
[22] M.G. Hossain, A. Saw, F. Ohtsuki, P.E. Lestrel, T. Kamarul, Change in facial shape in two cohorts of Japanese adult female students twenty years apart, Singapore Med. J. 52 (11) (2011) 818–823.
[23] M. Jahanshahi, M.J. Golalipour, K. Heidari, The effect of ethnicity on facial anthropometry in Northern Iran, Singapore Med. J. 49 (11) (2008) 940–943.
[24] M.K. Bhasin, Morphology to molecular anthropology: castes and tribes of India, Int. J. Hum. Genet. Taylor & Francis; 9 (3–4) (2009) 145–230.
[25] G.S. Oladipo, E.E. Isong, P.D. Okoh, Facial, nasal, maxillary, mandibular and oro-facial heights of adult Ibibios of Nigeria, Aust. J. Basic Appl. Sci. 4 (12) (2010) 6306–6311.