Anthropometric Analysis of Cephalofacial Dimensions in Kerman, Iran

Fatemeh Pouya[1,2], Seyed Hassan Eftekhar-Vaghefi[1], and Parvin Salehinejad[1,2]

[1] *Department of Anatomy, Medicine Faculty, Kerman University of Medical Sciences, Kerman, Iran*

[2] *Kerman Neuroscience Research Center, Kerman University of Medical Sciences, Kerman, Iran*

Received: 09 Feb. 2016; Revised: 04 Jan. 2017; Accepted: 30 Jan. 2017

Abstract- The human body dimensions are affected by ecological, biological, geographical, racial, sex, and age factors. Craniofacial measurements can be considered to be one of the important tools for determination of the morphological characteristics of the head and face. In this study, which was conducted on Persian adolescents living in Kerman/Iran, different forms of head and face were determined for using in various aspects of medicine. The study was conducted on 732 participants including 366 males and 366 females in the age of 18-20-year-old. In addition to the height and weight of the participants, cephalofacial sizes of them were measured and then cephalic, facial, and brain indices were calculated. Among the cephalofacial sizes, cranial length and breadth, cranial circumference, prosopic length and prosopic breadth were significantly greater in males compared to females (P<0.005). Also, volume and weight of brain were significantly greater in male comparing to female participants (P<0.005). The predominant type of head was meso-cephal, and the predominant type of face was meso-prosopic in both sexes.

Acta Med Iran 2017;55(4):241-248.

Keywords: Anthropometric analysis; Cephalofacial; Chephalometric

Introduction

The human skull is consisting of two parts of different embryological origins: neurocranium and viscerocranium. The neurocranium is a defensive arch surrounding the brain and brain stem. The viscerocranium is shaped by the bones supporting the face (1). The geometry of the cranial base and its fossas: anterior, middle and posterior changes rapidly, particularly during the first trimester of pregnancy (2). At birth, the human skull is made up of 44 distinct bony components. As development happens, several of these bony components slowly fuse together into solid bone such as frontal bone (3,4). So, cephalofacial characteristics can be useful tools in evaluating intrauterine growth and development and detecting health status (5).

Cephalometry is an important branch of anthropometry which involves measurements of the head and face. Cephalometry is helpful in forensic medicine, plastic and reconstructive surgery, orthodontics and clinical diagnosis (6). Also, craniofacial measurements are important for determining various head and face shapes (7). By knowledge of cranial and facial measurements and their indices, we can recognize apparent deviation from normal patterns. A craniofacial condition may include disfigurement brought by birth defect, disease or trauma. In addition, they can be used to determine different shapes of head and face as well as to estimate the sex (8). In this direction, several studies have used cephalometrics to examine anatomic differences in snoring and apneic subjects. One of the most relevant findings of the physical examination in adult patients with snoring is alterations in the craniofacial skeleton (9). Also, abnormalities of the facial skeleton, in association with the narrowing of the upper respiratory airway, often lead to the onset of obstructive apnea (10).

The direct or traditional anthropology concerns to describe the features of bones whereas new physical anthropology concern to explain the functional significance of bones and the normal features of bone (8). Measurement of craniofacial dimensions by direct anthropometry is the standard technique for quantifying of craniofacial morphology (11). In direct anthropometry, four international anatomic shapes for the head; hyperbrachycephalic, brachycephalic, mesocephalic and dolichocephalic and five international anatomic shapes of the face; hypereuryprosopic, hyperleotoprosopic, leptoprosopic, mesoprosopic and

Corresponding Author: P. Salehinejad
Department of Anatomy, Afzalipour School of Medicine, Kerman, Iran
Tel: +98 34 33221666, Fax: +98 34 33221666, E-mail address: p-salehinejad@kmu.ac.ir

euryprosopic are usually used for grouping of head and face in different studies (12). These classifications can be also used to process images by computer algorithms for recognition of individuals of any ethnic group or tribe and to produce a facial database for forensic medicine (13). Forensic anthropologists can measure the dimensions of available dry bone, and put these measurements into a mathematical formula per gender and ancestry group. The formula produces a height range, which can exclude the individuals that fall outside those limits. Albeit, it is still a very challenging task for forensic experts because equations formulated in a particular population do not always fit worldwide; not only because of sex differences but also because of ethnic, dietary, climatic variations amongst not only because of sex differences but also because of ethnic, dietary, climatic variations amongst individuals (14). However, a database of landmark sizes joined to age, gender, ethnic origin, and head shape would improve the accuracy of complex models for using in forensic anthropometry and reconstructive surgery (15). Even, a novel integration of anthropometric and craniofacial data, future head models should incorporate race, gender, and age to improve approximate personalized medicine on a widespread approach (15).

The objectives of the present study are; determination of development aspects including height

And weight as well as cephalometry and determination of anatomical types of head and facial indexes in Kermanian adolescents for using in various aspects of medicine.

Materials and Methods

A cross-sectional study was conducted in the department of anatomy, medical school, Kerman/Iran. The total sample volume determined for the present study was 732 (366 male and 366 female) with age varying between 18-20-year-old. The samples were assessed from Kerman by special questionnaires which mean that their parents were also Kermanian. Samples were selected through random number table and among the pre-college high schools and adult schools of the district of 1 and 2 of education. All of the participants' height and weight were measured, and then measurement of cephalometry including cranial length (head length), cranial breadth (head width), auricular height (ear height) and cranial circumference, prosopic length (facial length) and prosopic breadth (bizygomatic width or facial width) were taken in a specific time. Cranial, facial, and brain indices and volume and weight of brain were also calculated. Data related to height was obtained based on cm and rest of measurements was obtained based on mm. The weight of the body was calculated based on kg, and the weight of brain was calculated based on g. Measurements were made with goniometer, measuring tape, weighing scale, caliper cephalometry. In this study, two anthropometrists including one man and one woman carried out the measurements after receiving appropriate training. Each of these anthropometrists measured cephalofacial dimensions for two times or until two measurements agree within 1 mm (for head and face measurements), 1 cm (for height measurement) and 0.1 kg (for weight measurement) (16). In order to ensure the compatibility of the performance of these anthropometrists with the anthropometric standards, they were allowed to consult with one another.

The following measurements were analyzed in this study:

- Height was measured by goniometer when respondents stand and hands hanging
- Weight was measured using a weighing scale when respondents stand with bare feet (without shoes) and take extra clothes.
- Cranial length was measured using a caliper cephalometry from forehead to inion (17).
- Cranial breadth was measured using a caliper cephalometry maximum distance between parietal bones while the head of the persons under study should be to the front side, eyes, and ears parallel with the ground (12).
- Auricular height has defined the distance between tragus and vertex that be measured by goniometer (18).
- The cranial circumference has measured the distance from above the eyebrows and ears and around the back of the head by measuring tape (19).
- The morphological prosopic length was measured using colis from the nasion to gnathion (18).
- Prosopic breadth was measured as the bizygomatic width between the right and left zygion by spreading and sliding calipers (6).
- Cranial (cephalic) Index (CI) = [Cranial width/Cranial length]×100 (8).
- Proscopic (facial) Index = [Proscopic height/Proscopic width]×100 (8).
- Brain Volume (male)=0.000337(L-11) (B-11) (H-11)+406.01CC
- Brain Volume (female)=0.000400 (L-11) (B-

11) (H-11) + 206.60 CC

- H=Auricular Height, B=Cranial Breadth, L=Cranial Length. In above formula all dimensions are given millimeters. After calculating, brain volume is achieved based on cubic centimeter (20).
- Brain Weight was obtained by multiplying the specific weight of brain (1.03 g/cm^3) in brain volume.
- Brain Index was calculated by dividing of brain weight on total weight of the body (20).

Statistical analysis

Data are presented as mean and standard deviation for numerical variables. Independent t-test was used to compare cephalofacial dimensions between males and females. A *P* less than 0.005 were considered statistically significant.

Results

The mean height and weight of males were 177.02±6.84 cm and 65.72±12.42 kg, respectively. While in females the mean of height and weight was 158.1±4.42 cm and 59.67±3.57 kg, respectively (Table 1). Analysis of cranial length and cranial breath was shown in Figure 1. There was a significant difference in cranial length and breadth between male and female. This means that mean of cranial length was higher in male compared to female.

Table 1. Analysis of height (cm) and weight (kg) between male and female. Mean±SD. A significant difference is seen in height and weight between males and females (*P*<0.005)

Age	Gender	Height	Weight	*P*
18 years	Male	175.8 ± 6.9	63.1± 11.6	0.000
	Female	157.8± 4.3	58.5 ± 3.3	
19 years	Male	176.2± 6.2	65.1± 12.1	0.000
	Female	158.5± 4.5	59.2± 3.5	
20 years	Male	179± 7.3	68.8± 13.4	0.000
	Female	157.9± 3.8	61.3± 3.8	

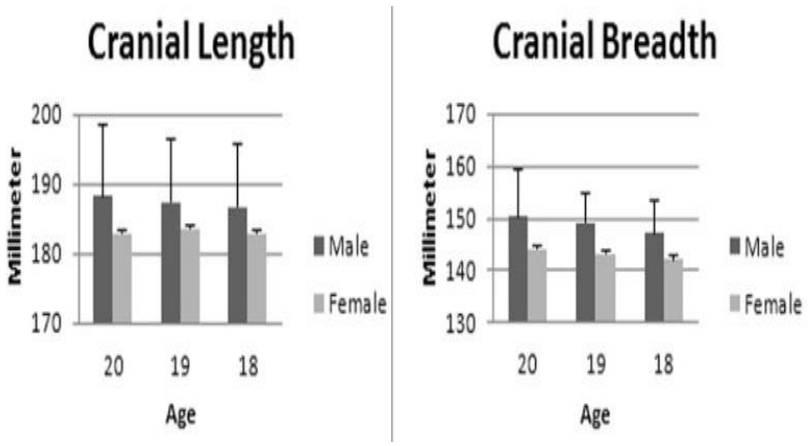

Figure 1. Analysis of cranial length and breadth between male and female. A significant difference is seen in cranial length and breadth between males and females (*P*<0.005)

As it is shown in Table 2, there was not a significant difference in auricular height between male and female. This means that mean of auricular height was approximately equal in male and female. According to two parameters means cranial length and cranial breadth in male, cranial circumference parameter in males was significantly greater compared to females. Also, the cranial index is listed in Table 2. The results of the present study indicate that meso-cephal form was a prominent form of cranial in two genders (Figure 2).

Table 2. Analysis of auricular height (mm), cranial circumference (mm), cranial index between male and female. Mean± SD. A significant difference is seen in cranial circumference between males and females (*P*<0.005)

Age	Gender	Auricular height	*P*	Cranial circumference	*P*	Cranial index
18 years	Male	122.7± 7.456	0.556	56.9±1.69	0.000	78.7
	Female	123.1±0.575		537.9±1.201		77.7
19 years	Male	122.8± 8.063	0.785	57± 1.42	0.000	79.6
	Female	123±0.615		536.6± 1.310		78.09
20 years	Male	124.1± 7.323	0.232	57.4± 1.43	0.000	79.8
	Female	123.3± 0.680		537.4± 1.420		78.7

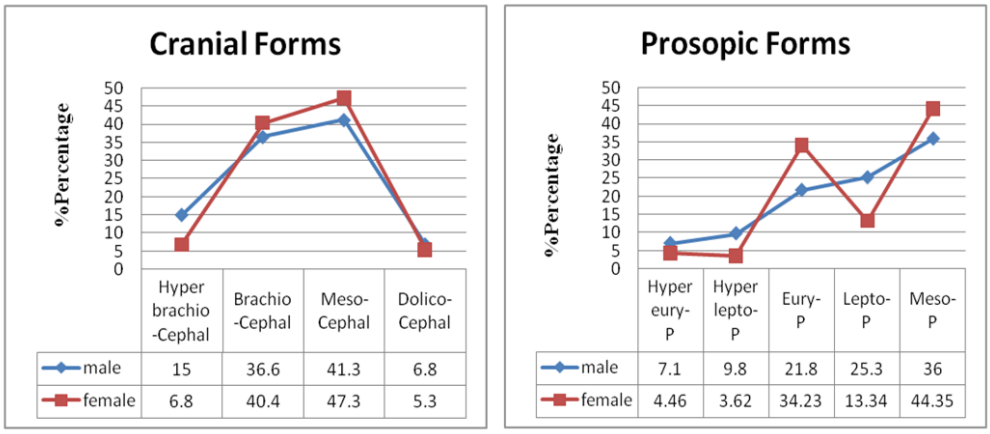

Figure 2. Frequency distribution of cranial forms in male and female participants. Dolico-cephalic has cranial index less than 74.9, mesocephalic has cranial index 75-79.9, brachycephalic has cranial index 80-84.9, and hyperbrachycephalic has cranial index 85-89.9. Frequency distribution of prosopic forms in male and female participants. Meso-Prosopic has facial index 85-89/9, and facial form is round. Lepto-Prosopic has facial index 90-94/9. In this form of facial, nose is outstanding and the forehead is steep. Eury-Prosopic has facial index 80-84/9. In this facial form, the forehead is broad, the facial form is vertical, and frontal sinus is narrow. Hyper Lepto-Prosopic has facial index 95. And hyper eury-prosopic has facial index 79/9 and less.

As shown in Table 3, there is a significant difference in prosopic length and prosopic breadth between males and females. This means that mean of prosopic length and prosopic breadth in males is higher compared to females. The percentages of prosopic forms male and female participants are shown in Figure 2. The most frequent form in both sexes is meso-prosopic form.

Differences in volume, weight, and index of the brain are shown in table 4. There was a significant difference between volume and weight of brain between males and females.

Table 3. Analysis of prosopic length (mm), prosopic breadth (mm) and prosopic index of respondents. Mean±SD. A significant difference is seen in prosopic length and prosopic breadth between males and females (*P*<0.005)

Age	Gender	Prosopic length	Prosopic breadth	Prosopic Index
18 years	Male	113.6± 9.012	127.5±8.39	89.7
	Female	107.6± 0.679	125.1±2.81	86.01
19 years	Male	115.4± 5.145	130.4±6.92	88.5
	Female	108.3± 0.779	125.4±2.57	86.36
20 years	Male	117.2± 6.731	133.3±4.86	87.9
	Female	108.5± 0.772	127.1±2.78	85.36

Table 4. Analysis of brain volume (cm^3), brain weight (g), and brain index of respondents. Mean±SD. A significant difference is seen in brain volume and brain weight between males and females ($P<0.005$)

Age	Gender	Brain volume	Brain weight	Brain Index
18 years	Male	1306.18± 101.45	1351.9±105.03	2.14
	Female	1216.15± 100.99	1259.1±104.42	2.15
19 years	Male	1323.97± 98.65	1370.3±102.13	2.10
	Female	1229.01± 95.244	1272.0±98.53	2.13
20 years	Male	1347.33± 132.58	1394.4±137.06	2.02
	Female	1234.36± 94.63	1277.5±97.89	2.08

Discussion

Craniofacial measurements are very useful tools for studying different racial groups (20). People living in Iran belonged to different races. According to historical references, our samples that were obtained in Kerman city in the south east of Iran are a part of Persian people who have been living in central part of Iran. These people were compared with cephalofacial dimensions in the present study.

For measurement of cephalofacial dimensions, recently, digital anthropometry had been used instead of using traditional instruments; e.g., sliding and spreading calipers (11). But comparing anthropometric measurements obtained by different digital 3D photogrammetry systems and direct anthropometry showed that overall mean differences across digital and direct methods were small enough to be of little practical importance (21). Due to these direct measurements are reliable and inexpensive to make also to provide an extensive normative database for researchers. So, we used direct measurements for cephalofacial dimensions.

One of the most obvious signs of development in a person is height increase. Height growth rate is related to heredity, environment, and gender. Body weight is another indicator of development (22). Most of the times mean of height and weight is higher in male than compared to female. It seems this difference to be a natural growth due to the age of puberty in boys. In the present study, because of the puberty is finished in a female about 18-year-old while, it will continue in male after 18 years. So, mean of height in males was greater than females. Comparing these results to other studies show that Kermanian adolescents are shorter than American adolescents. Also, American adolescents male are heavier compared to Kermanian male adolescents. While Kermanian female adolescents are heavier compared to American female adolescents (23).

In our study, there was a significant difference between cranial length and breadth in male and female. This means that the skull was greater in male compared to female. It is demonstrated by head circumference that was greater in male on average of 1.38 Cm than female individuals.

Cranial dimensions are some interesting factors that are having diversity among populations in different geographical zones. Cranial dimensions can differ with the age of individuals, it reaching a peak around 16-23 years of life, and genetic expression of them that influenced by age factor (8).

In addition, cranial and facial growths are related to overall body growth. This relationship is examined through comparison of cephalometric measurement (20). In our study, when the height and weight sizes were greater the cranial and facial sizes were also greater. Also, It is shown that increased cranial circumference in the first year of life is due to the faster growth of brain (22), while later, head circumference increased when height become taller (24). Our results also were confirmed this issue.

Cephalic index plays a crucial role in comparison of cephalic morphometry between parents, offspring's and siblings and provides information on inheritance pattern. The cephalic index shows the anatomic type of head, the amount of this index is varied from 65-95 and usually is changeable from 70-90. Human populations were characterized as either dolicocephalic (long)

headed with a cranial index of 74.9 or less), mesocephalic (moderate headed with a cranial index of 75-79/9), brachycephalic (short-headed with a cephalic index 80-84/9) (8) or hyper brachycephalic (very short headed with a cephalic index above 85) (25). The same as our study mesocephalic head was predominantly observed (8). While, in adolescents of 14-18 years in Shiraz (neighboring of Kerman) dominant type of head in girls was brachycephalic and in boys was hyperbrachycephalic (26) the cephalic indices in individuals between 18-23 years of age belonging to different parts of India were 80.42,81.34, and 79.14 while in Doni study it was 76.48 in male volunteers (8).

There has been much debate about why humans throughout the world differ in facial form. Previous

studies of human skull morphology found levels of differentiation among populations that were comparable to those of neutral genetic markers. It is suggested that genetic drift (neutral process) plays an important role in facial differentiation (27). In our study, face length ranges were from 113.6±9 to 117.2±6 in different age groups of the males and from 107.6±0.6 to 108.5± 0.7 in different age groups of the females. Also, face breadths were from 127.5±8 to 133.3±4 in different age groups of males and from 125.1±2 to 127.1±2 in different age groups of females. While, in Indian population more number of 18-23 year age males have face length ranges from 100.1 to 110.0, and 110.1, to 120.0, and face breadths ranges from 120.1 to 130.0 and 110.1 to 120.0 (8).

Proscopic or facial index that becomes an important anthropological parameter varies from 65 to 105. Comparing of the facial index in different studies is shown in Table 5. Omotoso *et al.*, showed age and gender are as important factors in the description of human physiognomy (6). What is common among all of these studies is that greater facial index in male compared to female. It may be due to the hormone testosterone which causes the changes in the shape of the face in the male (28).

Table 5. Facial index and face shapes in different parts of the world indicate that the geographical factor, similar to ethnical factor, can affect the form of the face.

Area	Facial Index (Total)	Facial Index (Male)	Facial Index (Female)	Dominant face type	Reference
South India	90.95	--	--	Hyperleptoprosopic Mesoprosopic) males) europrosopic (females)	Doni *et al*., (2013)
India (Dangi)	--	108.6	106.9	Hyperleptoprosopic	Singh and Purkait (2006)
India (Ahirwar)	--	81.3	82.1	Europrosopic	Singh and Purkait (2006)
Malaysia	87.19	--	--	Mesoprosopic And Europrosopic	Shetti *et al.*, (2011)
Nigerian	86.93	--	--	--	Omotoso *et al.*, (2011)
China	--	89.02	88.52	Mesoprosopic	Kurnia *et al*., (2012)
Central Serbia	--	--	--	Leptoprosopic	Jeremić *et al*., (2013)
Pakistan	--	90.55	87.87	Leptoprosopic(Male) Mesoprosopic (Female)	Azizi *et al*., (2014)
Sistan (Fars)	82.22	--	--	Europrosopic	Heidari *et al*., (2006)
Baluchistan	84.86	--	--	Europrosopic	Heidari *et al*., (2006)
Torkaman	--	87.25	81.48	Euryprosopic (Female) Mesoprosopic (Male)	Jahanshahi *et al*., (2008)
Fars	--	88.22	84.48	Euryprosopic (Female) Mesoprosopic (Male)	Jahanshahi *et al*., (2008)
Qazvin	--	102.88	96.69	Hyperleptoprosopic	Azizi *et al*., (2014)

In our study, the least type of face was hyper eury prosopic in male participants (7.1%) and hyper lepto prosopic in female participants (3.62%). Our results showed that the most frequent type of face in male participants was meso prosopic followed by lepto prosopic. In female, although the dominant type was mesoprosopic but the second frequent type was euryprosopic. The present study showed frequency distributions of different types of facial form are different in females although the dominant form in both sexes was the same. It seems that integrated investigation including more participants from different parts of Iran may provide a better image of anatomical aspects of people living in Iran.

The cephalometric data exhibit both craniofacial and soft tissue arrangements (29). In Doni study, the statistical correlation between the cephalic index and the facial index is significant. While the correlation of age and height with cephalic and facial indexes was not significant statistically (8). Esmaeilzadeh *et al*., on 137 four to eleven year old Shirazian people showed that Iranian population has a hypereuryprosopic face and hypercephalic cranium form at birth. While getting older, the midface height increased, and face became

more prominent, and chin became shorter. So the face and cranium changed to eurycephalic and hyperleptoprosopic forms, respectively (30). According to our results, it seems that these changes in 18-20 years lead to meso-cephal and meso-prosopic forms

Brain volume in infancy could predict intellectual function in adulthood (31,32). Although, it could predict cognitive ability in old age (33). As it is shown in table 3, there is a significant difference in brain volume and brain weight between male and female. This means that mean of brain volume and brain weight in the male is higher compared to female. There is not a significant difference in brain index between male and female. Also, the results of Lorenz *et al*. indicated that adolescents with higher age have lower brain index (34). Brain index was reported 12% in newborn and 2% in adult (20).

We concluded that cephalofacial sizes are affected by sex and usable for various aspect of medicine. We also concluded that cranial capacity and brain volume is being affected by sex and race of the population as studied here.

References

1. Carlson MB. Human Embryology & Developmental Biology. In: Establishing the Pattern of the Craniofacial Region. 5th ed. Mosby, Sunders imprint, 2013:166-70 .
2. Derkowski W, Kedzia A, Glonek M. Clinical anatomy of the human anterior cranial fossa during the prenatal period. Folia Morphol (Warsz) 2003;62:271-3
3. Gale CR, O'Callaghan FJ, Bredow M, Martyn CN, Avon Longitudinal Study of Parents and Children Study Tea. The influence of head growth in fetal life, infancy, and childhood on intelligence at the ages of 4 and 8 years. Pediatrics 2006;118;118:1486-92.
4. Li H, Ruan J, Xie Z, Wang H, Liu W. Investigation of the critical geometric characteristics of living human skulls utilizing medical image analysis techniques. Int J Veh Saf 2007;2:345-67.
5. Ukoha UU, Dimkpa U, Ofoego UC, Eteudo AN, Asmugha LA, Okafor JI, et al. Cephalofacial characteristics of children under 6 years of age in east of Nigeria. Natl J Integr Med 2013;4:21-5.
6. Omotoso DR, Oludiran OO, Sakpa CL. Nasofacial Anthropometry of Adult Bini Tribe in Nigeria. Afr J Biomed Res 2011;14:219-21.
7. Yagain VK, Pai SR, Kalthur SG, Chethan P, Hemalatha I. Study of cephalic index in Indian students. Int J Morphol 2012;30:125-9.
8. Praveen Kumar Doni R, Janaki CS, Vijayaraghavan V, Delhiraj U. A study on measurement and correlation of cephalic and facial indices in males of south Indian population. IJMRHS 2013;2:439-46.
9. Zancanella E, Haddad FM, Oliveira LA, et al. Obstructive sleep apnea and primary snoring: diagnosis. Braz J Otorhinolaryngol 2014;80:S1-16.
10. Cuccia AM, Campisi G, Cannavale R, Colella G. Obesity and craniofacial variables in subjects with obstructive sleep apnea syndrome: comparisons of cephalometric values. Head Face Med 2007;3:41.
11. Wong JY, Oh AK, Ohta E, Hunt AT, Rogers GF, Mulliken JB, et al. Validity and reliability of craniofacial anthropometric measurement of 3D digital photogrammetric images Cleft Palate Craniofac J 2008;45:232-9.
12. Safikhani Z, Afzali N, Bordbar H. Determination of anatomical type of head and face in children under 6 years in Ahwaz. Acta Med Iran 2007;45:43-5.
13. Akinlolu AA. Facial biometrics using Akinlolu-Raji image-processing algorithm and anthropological facts which prove that Kebbi and Zamfara Hausas are Hausa Bakwai. Sub-Saharan Afr J Med 2016;3:45-52.
14. Kumar A, Soodeen-Lalloo AK. Estimation of Stature from Fragmented. Anthropol 2013;1:e105.
15. Wendel-Mitoraj KE, Osadebey ME. Applying Craniofacial Metrics to Adapt 3D Generic. Head Models 2012:229-41.
16. Kamal S. Manual for Obtaining Anthropometric Measurements Official Document of the Ngds Pilot Project. (Accessed March 2017, 12, at http://ngds-ku.org 2106).
17. Bayat PD, Ghanbari A, Sohouli P, Amiri S, Sari-Aslani P. Correlation of Skull Size and Brain Volume, with Age, Weight, Height and Body Mass Index of Arak Medical Sciences Students. Int J Morphol 2012;30:157-61.
18. Golalipour MJ, Haidari K, Jahanshahi M, Farahani RM. The Shapes Of Head And Face In Normal Male Newborns In South-East Of Caspian Sea (Iran-Gorgan). J Anat Soc India 2003;52:28-31.
19. Amini F, Mashayekhi Z, Rahimi H, Morad G. Craniofacial morphologic parameters in a Persian population: an anthropometric study. J Craniofac Surg 2014;25:1874-81.
20. Artner J. Atlas of human skeletal anatomy. (Accessed March 2017, 12, at https://fhs.mcmaster.ca/surgery/ documents/atlas_hsa.pdf).
21. Weinberg SM, Naidoo S, Govier DP, Martin RA, Kane AA, Marazita ML. Anthropometric precision and accuracy of digital three-dimensional photogrammetry: comparing the Genex and 3dMD imaging systems with

one another and with direct anthropometry. J Craniofac Surg 2006;17:477-83.
22. Kliegman MR, Stanton FB, Geme ST, Schor FN, Behrman RE. Nelson Textbook of Pediatrics. In: Keane V. Assessment of growth. 19th ed. Philadelphia, PA, Elsevier Saunders, 2011:39 .
23. Parker SE, Mai CT, Canfield MA, Rickard R, Wang Y, Meyer RE, et al. Updated National Birth Prevalence estimates for selected birth defects in the United States, 2004-2006. Birth Defects Res A Clin Mol 2010;88:1008-16.
24. Geraedts EJ, van Dommelen P, Caliebe J, Visser R, Ranke MB, van Buuren S, et al. Association between head circumference and body size Horm Res Paediatr 2011;75:213-9.
25. Rakel ER, Rakel PD. Textbook of Family Medicine. In: Kimmel SR, Ratliff-Schaub K. Growth and development. 7th ed. Philadelphia USA, Elsevier Saunders. 2007:430-57.
26. Vojdani Z, Bahmanpour S, Momeni S, Mokhtar A. Cephalometry in 14-18 years old girls and boys of Shiraz-Iran high school. Int J Morphol 2009;27:101-4.
27. Guo J, Tan J, Yang Y, Zhou H, Hu S, Hashan A, et al. Variation and signatures of selection on the human face J Hum Evol 2014;75:143-52.
28. Yesmin T, Thwin SS, Urmi SA, Wai MM, Zaini PU, Azwan K. A Study of Facial Index among Malay Population. J Anthropol 2014;726974:1-4.
29. Nikakhlagh S, Tahmasebi M, Badri R, Saki N, Rahim F, Badri S. Craniofacial variables in subjects with and without habitual snoring: A cephalometric comparison Indian J Otolaryngol Head Neck Surg 2010;62:304-9.
30. Esmaeilzadeh M, Nejadali A, Kazemzadeh F, Borhani M. An investigation on cephalometric parameters in Iranian population. J Dev Biol Tissue Eng 2012;4:8-11.
31. Raikkonen K, Forsen T, Henriksson M, Kajantie E, Heinonen K, Pesonen AK, et al. Growth trajectories and intellectual abilities in young adulthood: The Helsinki Birth Cohort study. Am J Epidemiol 2009;170:447-55.
32. Heinonen K, Raikkonen K, Pesonen AK, Kajantie E, Andersson S, Eriksson JG, et al. Prenatal and postnatal growth and cognitive abilities at 56 months of age: a longitudinal study of infants born at term Pediatrics 2008;121:e1325-33.
33. Royle NA, Booth T, Hernandez MCV, Penke L, Murray C, Gow AJ, et al. Estimated maximal and current brain volume predict cognitive ability in old age. Neurobiol Aging 2013;34:2726-33.
34. Lorenz JM, Whitaker AH, Feldman JF, Yudkin PL, Shen S, Blond A, et al. Indices of body and brain size at birth and at the age of 2 years: relations to cognitive outcome at the age of 16 years in low birth weight infants. J Dev Behav Pediatr 2009;30:535-43.