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Estimation of Stature from Craniofacial Anthropometric Measurements in Egyptians and Bengalis Samples (A Comparative Study)

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Abstract Many attempts have been made to find out correlation and to derive a regression formula between crainofacial measurements and body stature, since the craniofacial remains may be the only available for postmortem examination. This study is to compare craniofacial anthropometric ratios between Egyptian and Bengali populations and to find out the correlation between craniofacial anthropometric measurements and stature with suggesting regression formulae in both populations for stature reconstruction from these dimensions. This cross-sectional analytical study included 100 subjects; 60 Egyptians and 40 Bengalis aged from 18-60 years with normal face patterns. Stature and four craniofacial parameters as maximum head length & breadth, and maximum face breadth &length were measured. The results showed that, all crainofacial parameters were significantly higher in Egyptian males than females. Maximum facial length was significantly higher in Egyptians than Bengalis of both sexes. However, maximum facial breadth and maximum head length were significantly higher in Bengalis than Egyptians of both sexes. The highest correlation coefficient with stature was exhibited by maximum facial breadth in Bengali males (r=0.60), maximum facial length in Egyptian males (r=0.42). On the other hand, in Egyptian and Bengali females, maximum head length showed highest correlation coefficient with stature (r=0.37& r=0.89 respectively). Therefore, the prediction of stature is more reliable from facial dimensions in Bengali and Egyptian males and from cephalic length in both Egyptian and Bengali females.

Keywords craniofacial; anthropometric measurement; Egyptian and Bengali

Introduction

Anthropometry is the biologic science of human body measurement. Craniofacial anthropometry discusses the characteristic measurements of head and face different soft and hard tissues (Mahdi, 2012). It varies widely with age and sex within and between racial groups. Over centuries, there have been remarkable changes in anthropometric measurement due to geographical, cultural, genetic and environmental factors as well as worldwide mingling of races (Shrestha et al., 2009).

Studying the craniofacial anthropometric ratios is very useful in multi disciplinary science, which can be applied for reconstructive treatment in plastic surgery, orthodontics treatment, growth & development studies, and non-medical branches such as respiratory equipment and eyeglasses industries. Additionally, it can be used in forensic analysis to determine age, gender, and race of an individual (Kurnia et al., 2012). With measurement data, the forensic examiner is able to quantify the degree of difference or similarity and state how much confidence can be placed in this interpretation (Krishan, 2007).

Estimation of stature is an important tool in forensic examination especially in unknown, highly decomposed, fragmentary and mutilated human remains. Since it helps in narrowing down the investigation process and thus provides a useful clue to the investigation agencies (Ilayperuma, 2011).

Stature has a definite and proportional biological relationship with every part of the human body, i.e. head, face, trunk and extremities. This relationship helps a forensic scientist to calculate stature from dismembered and mutilated body parts in forensic examinations. For such a calculation, two methods are used, i.e. regression method and multiplication method. The regression

analysis provides best estimates for stature reconstruction (Iscan, 2005; Krishan, 2008).

Many studies have been conducted on the estimation of stature from various body parts like hands, trunk, intact vertebral column, upper and lower limbs, individual long & short bones, foot and footprints (Abdel-Malek et al, 1990; Jason & Taylor, 1995; De Mendonça, 2000; Hauser et al., 2005; Nagesh and Kumar, 2006; Krishan and Sharma, 2007). However, only a few studies have been conducted on craniofacial region with respect to estimation of stature.

This study aimed to compare craniofacial anthropometric ratios between Egyptian and Bengali populations. Additionally, the present study provided craniofacial anthropometric correlation with stature and suggested regression formulae for prediction of stature from these dimensions in both populations.

Subjects and methods

I. Place of the study and choice of the patients

This cross-sectional study was conducted on 100 subjects 60 Egyptian people; 30 males and 30 females ages ranged from (19 to 48 years old) and 40 Bengali people: 20 males and 20 females ages ranged from (18 to 40 years old). Egyptian measurements were performed at the Department of Forensic Medicine and Clinical Toxicology, Tanta University while Bengali measurements were performed at Forensic Medicine Center in Hail, Ministry of Health, Saudi Arabia. The participants were randomly selected with normal face patterns and without any obvious craniofacial abnormalities like developmental disability, oculo-facial trauma, craniofacial congenital anomaly, malnutrition diseases and had no history of plastic or reconstructive surgery.

A signed written informed consent from all participants was taken before starting the research after complete and extensive description of the study. The confidentiality of records of the patients was maintained by giving a code number for everyone. The Research Ethics Committee of Tanta Faculty of Medicine approved the design of the study.

II. Materials

Instruments used included weighing machine, measuring tape and sliding and manual spreading calipers **(Fig 1)**. Calipers were manufactured in India by UNA and CO, scale reading up to 60 cm.

III. Methods

The following measurements were recorded:

Stature: Each subject stood without shoes on a horizontal platform with weight distributed evenly on both feet, heels together, and the head positioned, with head in Frankfurt horizontal plane. The subject's back should be as straight as possible against the vertical broad and measurement for total stature was taken as the vertical distance between highest point on the head (vertex) and the floor. To obtain a consistent measure, each subject was asked to inhale deeply and stretch to his or her fullest stature. The measurement of stature required a vertical metric ruler, and a non-compressible flat even surface on which the subjects stood. The graduations on the metric ruler were at 0.1 cm intervals, and the metric ruler had the capacity to measure up to 210 cm.

Subjects were asked to sit comfortably in a stool with arm hanging by side and head positioned in Frankfurt plane to take the four craniofacial measurements by using sliding caliper according to the landmarks and procedures recommended by Weiner and Lourie (1981); Lohman et al. (1988); Krishan and Kumar (2007).

The anthropometric measurements defined as:

Maximum head length (MHL): It measures straight distance between glabella (the most prominent point on the fontal bone above the root of the nose, between the eyebrows) and the opisthocranion (the most prominent portion of the occiput, close to the midline on the posterior rim of the foramen magnum) (Fig 2).

Maximum head breadth (MHB): It is the maximum biparietal diameter and is the distance between the most lateral points of the parietal bones (Fig 3).

Maximum facial length (MFL): It is the straight distance from the nasal root (nasion) to the lowest point on the lower border of mandible in the mid sagittal plane (gnathion) (Fig 3).

Maximum facial breadth (MFB): it is measured as bizygomatic breadth (farthest points on zygomatic arches) (Fig 3).

The collected data were subjected to statistics as mean, S.D. Student t- test, Karl Pearson's correlation coefficient, regression analysis using Statistical Package for Social Sciences (SPSS) software.

Results

This study was conducted on 60 Egyptians and 40 Bengalis. Mean age of Egyptian males was 26.23 years and Egyptian females was 24.20 years, while the mean age of Bengali males was 27.70 years and Bengali females was 24.70 years.

Table (1) showed that, all parameters were significantly higher in Egyptian males than female's i.e stature, weight, maximum facial breadth & length and maximum head & breadth. Stature and maximum facial breadth were significantly higher in Bengali males than females. However, maximum facial length was significantly higher in Bengali females than males.

When different parameters were compared among Egyptian and Bengali subjects of same sex, the present study observed that, weight, maximum facial lengths were significantly higher in both Egyptian males and females than Bengali males and females. Stature was greater in Egyptian males than Bengali males significantly. However, maximum facial breadth and maximum head length were significantly higher in Bengalis than Egyptians of both sexes (Table 2).

Table (3) demonstrated that maximum facial length and breadth in Bengali males and maximum facial breadth, maximum head length and breadth in Bengali females showed significant positive correlation with stature.

However, only maximum facial length in Egyptian males and maximum head length in Egyptian females had significant positive correlation with stature. The highest correlation coefficient is exhibited by maximum head length in Bengali females (r=0.89), maximum facial breadth in Bengali males (r=0.60), maximum facial length in Egyptian males (r=0.42) and maximum head length in Egyptian females (r=0.37).

Tables (4&5) showed regression equations for estimation of stature from craniofacial measurements in Bengalis and Egyptians of both sex respectively. There are separate equations for each craniofacial dimension that can help in estimation of stature from individual part of head and face. The regression equations have been calculated by regression analysis of the data and the values of constants 'a' and 'b' are calculated; where 'a' is the regression coefficient of the dependant variable, i.e. stature, and 'b' is the regression coefficient of the independent variable, i.e. any measurement of the craniofacial measurements (in cm). Hence, stature = a + bx, where, 'x' is any craniofacial measurement. The regression formulae have been calculated separately from various craniofacial measurements with stature by substituting the appropriate values of constants 'a' and 'b' in the standard equation of regression line.

These tables demonstrated the coefficient of determination (R^2) and the standard error of estimate (SEE) which calculated separately for each regression formula for estimation of stature. R^2 determines the strength of association between the parameters and the standard error of estimate (SEE) tends to predict the deviation of estimated stature from the actual stature.

The maximum facial breadth exhibited highest R^2 (36.17%) and lowest value of SEE (2.29) in Bengali males. In Egyptian males, maximum facial length showed highest R^2 (17.72%) and lowest value of SEE (6.13). On the other hand, in both Bengali and Egyptian females, maximum head length showed highest R^2 (80.55% and 13.89% respectively) and lowest value of SEE (3.37 and 6.25) respectively. Suggesting that, the prediction of stature from facial dimensions was more reliable in Bengali and Egyptian males than cephalic dimensions. However, in Bengali and Egyptian females, the cephalic length was more reliable than facial dimensions in prediction of the stature (Tables 4& 5).

Table (1): Student -t- test comparison between males and females different parameters in Egyptian and Bengali population samples

Races	Parameters	Males	Females	P-value
		Mean± SD	Mean± SD	
Egyptian population	Stature (cm)	175.20±6.64	159.73±6.62	0.000***
	Maximum facial breadth (cm)	11.80±0.58	10.60±0.78	0.000***
	Maximum facial length (cm)	13.45±0.90	12.40±0.81	0.000***
	Maximum head length (cm)	16.93±0.95	16.18±0.95	0.003**
	Maximum head breadth (cm)	12.83±0.89	11.70±0.86	0.00***
Bengali Population	Stature (cm)	162.25±3.56	157.55±7.44	0.015*
	Maximum facial breadth(cm)	13.22±1.09	11.76±1.67	0.002**
	Maximum facial length(cm)	11.40±0.76	11.91±0.16	0.006**
	Maximum head length(cm)	17.80±0.682	17.48±1.29	0.34
	Maximum head breadth(cm)	12.76±0.87	12.63±2.52	0.83

** p value ≤ 0.05, ** p value ≤ 0.01, *** p value ≤ 0.001*

Table (2): Student t test comparison between comparison of between Egyptians and Bengalis different parameters of the same sex

Gender	Parameters	Egyptian population	Bengali population	P-value
		Mean± SD	Mean± SD	
Males	Stature (cm)	175.20±6.64	162.25±3.56	0.000***
	Maximum facial breadth(cm)	11.80±0.58	13.22±1.09	0.000***
	Maximum facial length(cm)	13.45±0.90	11.40±0.76	0.000***
	Maximum head length(cm)	16.93±0.95	17.80±0.68	0.001***
	Maximum head breadth(cm)	12.83±0.89	12.76±0.87	0.791
Females	Stature (cm)	159.73±6.62	157.55±7.44	0.282
	Maximum facial breadth(cm)	10.60±0.78	11.76±1.67	0.002**
	Maximum facial length(cm)	12.40±0.81	11.91±0.16	0.011*
	Maximum head length(cm)	16.18±0.95	17.48±1.29	0.000***
	Maximum head breadth(cm)	11.70±0.86	12.63±2.52	0.066

* p value ≤ 0.05, ** p value ≤ 0.01, *** p value ≤ 0.001

Table (3): Pearson Correlation Coefficients between Stature and craino-facial measurements in both Egyptian and Bengali population samples

Races	Parameters (cm)	Stature in (cm)			
		Males		Females	
		r	P-value	r	P-value
Egyptian population	Maximum facial breadth	0.28	0.13	0.09	0.62
	Maximum facial length	0.42	0.02*	0.32	0.08
	Maximum head length	0.21	0.24	0.37	0.04*
	Maximum head breadth	0.08	0.64	0.16	0.37
Bengali population	Maximum facial breadth	0.60	0.00**	0.58	0.00**
	Maximum facial length	0.55	0.01*	-0.07	0.75
	Maximum head length	0.00	0.99	0.89	0.00***
	Maximum head breadth	0.41	0.06	0.75	0.00***

** p value ≤ 0.05, ** p value ≤ 0.01, *** p value ≤ 0.001*

Table (4): ***Regression Equations for Estimation of Stature (cm) from craniofacial measurements in Bengali population samples***

Gender	Parameter (cm)	Regression equation	R2	SEE
Bengali Male	Maximum facial breadth	Stature=135.28+ 1.96 (MFB)	36.17%	±2.92
	Maximum facial length	Stature=131.44+ 2.61 (MFL)	31.13%	±3.041
	Maximum head length	Stature=161.27- 0.001 (MHL)	0.00%	±3.66
	Maximum head breadth	Stature=139.80+1.68 (MHB)	17.15%	±3.33
Bengali Female	Maximum facial breadth	Stature=126.98+ 2.59(MFB)	34.04%	±6.21
	Maximum facial length	Stature=197.39-3.34 (MFB)	0.57%	±7.62
	Maximum head length	Stature=67.09+ 5.17 (MHL)	80.55%	±3.37
	Maximum head breadth	Stature=129.54+2.21 (MHB)	56.47%	±5.04

(MHL): Maximum head length; *(MHB)*: *Maximum head breadth; (MFL):Maximum facial length*; *(MFB): Maximum facial breadth.*

Table (5): ***Regression Equations for Estimation of Stature (cm) from craniofacial measurements in Egyptian population***

Gender	Parameter (cm)	Regression equation	R2	SEE
Egyptian Males	Maximum facial breadth	Stature=137.03+ 3.23 (MFB)	8.01%	±6.48
	Maximum facial length	Stature=133.55+ 3.09 (MFB)	17.72%	±6.13
	Maximum head length	Stature=149.93+1.51(MHL)	4.77%	±6.60
	Maximum head breadth	Stature=166.89+0.64 (MHB)	0.76%	±6.73
Egyptian Females	Maximum facial breadth	Stature=151.46+ 0.78(MFB)	0.85%	±6.71
	Maximum facial length	Stature=127.31+2.61 (MFL)	10.32%	±6.38
	Maximum head length	Stature=117.81+ 2.59 (MHL)	13.84%	±6.25
	Maximum head breadth	Stature=144.65+1.28 (MHB)	2.85%	±6.64

(MHL): Maximum head length; *(MHB)*: *Maximum head breadth; (MFL):Maximum facial length*; *(MFB): Maximum facial breadth.*

Fig (1): ***Manual spreading caliper***

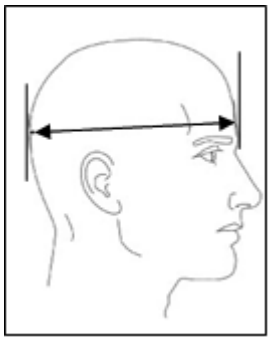

Fig (2): ***Maximum head length (MHL)***

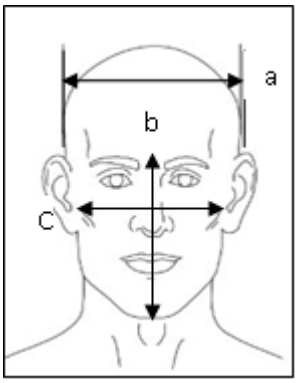

Fig (3):a: ***Maximum head breadth (MHB)*****; b:** ***Maximum facial length (MFL) ;c:Maximum facial breadth (MFB)***

Discussion

Various methods used to identify unknown human remains. The reliability of each method varies. A drawback to these techniques is limited applicability to fragmentary remains. In mutilated body, it is common to have the extremities or head amputated from the trunk. Then, an estimate must be made based on the known relationship of the remains to stature (Kalia et al., 2008).

The results of this study showed that the mean values of all craniofacial parameters were higher in Egyptian males than Egyptian females. Several studies revealed that marked differences exist in cranial shape between males and females, where cranium in males being larger than females (Shrestha et al., 2009; Anibor et al., 2011). It could be explained on hormonal influence on facial morphology (Prasanna et al., 2013).

On the other hand, the mean value of maximum facial breadth in Bengali males was significantly higher than females and maximum facial length in Bengali females was significantly higher than males. It could be due to genetic factors in Bengali population.

The present study demonstrated that, mean of maximum facial length was significantly higher in both Egyptian males and females compared to Bengali males and females. Buretic-Tomljanovic et al. (2007) found that environmental factors such as diet and climate had a significant effect on body stature and craniofacial variability in adults. Therefore, Egyptians lived in colder weather than Bengalis, which may lead to an increase in nose length and as a result an increase in facial length.

However, the mean of maximum facial breadth and maximum head length were significantly higher in Bengalis than Egyptians of both sexes. The variation in facial breadth between different populations could be attributed to food habits, which may have led to an increased size of the maxillary alveolar arch in Bengalis (Prasanna et al., 2013).

Comparing to other studies, the mean of Egyptian maximum facial length (MFL) was significantly higher than Haryana and Chinese, Indian and Malaysian studies (Du et al. 2008; Shetti et al., 2011; Kumar and Gopichand, 2013; Prasanna et al., 2013). On the other hand, the mean of MFL in Bengali males was comparable to Chinese males' measurements in Du et al. (2008) and to south Indian males in Prasanna et al. (2013) and with Malaysian males in Shetti et al. (2011).

In this study, the mean values of maximum facial breadth (MFB) of both genders in Bengalis coincide with Malaysian in the study recorded by Shetti et al. (2011), but were less than Chinese (Du et al., 2008). However, these measurements were higher than those recorded by Prasanna et al. (2013) in North and South Indians males. Moreover, the maximum facial breadth of the Egyptian showed lower values in both genders than Chinese and Malaysian populations (Du et al., 2008; Shetti et al., 2011).

Additionally, the mean values of head length and breadth in both Bengali and Egyptian populations in this study were less than previous studies which conducted by Gupta et al. (2013) in North Indian, Ngeow and Aljunid, (2009) in Malaysian, Ilayperuma, (2011) in Sir Lankan and Kumar and Gopichand, (2013) in Haryanvi adults. These intra–and inter–population variations were affected by genetic, environmental, biological, geographical, racial, gender and age factors (Durtschi , 2009).

Stature measurement helps in determining the levels of nutritional support and monitoring the effect of nutritional intervention (Shahar and Pooy, 2003). When community wise and sex wise comparisons were performed in the current study, it showed statistically significant difference with males being taller than females.

The present study demonstrated that stature was greater in Egyptian males than Bengali males significantly. It could be attributed to both genetic and environmental influences (Pietiläinen et al., 2002; Shrestha et al., 2009).

Estimation of stature for the purpose of identification has a significant forensic importance. This technique based on a principle that bones or human body

parts were correlated positively with the stature. Therefore, there is a need to investigate whether any possible significant correlation exists between stature and craniofacial parameters. Considering this fact, an attempt had been made in the present study to estimate stature from craniofacial parameters in both Bengali and Egyptian populations.

The present study revealed that the highest correlation coefficient with stature was exhibited by maximum facial breadth in Bengali males (r=0.60), maximum facial length in Egyptian males (r=0.42), maximum head length in both Bengali and Egyptian females (r=0.89, 0.37 respectively). These results are in agreement with previous studies recorded by Patil and Mody, (2005); Krishan& Kumar, (2007); Kharyal and Nath, (2008) ; Krishan, (2008); Kumar and Gopichand, (2013) who demonstrated stronger correlation between stature and maximum facial length in males compared to females. Additionally, Ryan and Bidmos, (2007); Ilaypperuna (2011); Chavan et al. (2009); Kumar and Gopichand, (2013) revealed strong positive correlation between stature and maximum head length in females. However, Pelin et al. (2010) demonstrated that craniofacial dimensions were not good predictors for body stature for Turkish population, as the Turkish sample consisted of many ethnic backgrounds.

In the present study, the value of SEE ranged from 2.92 to 7.62 cm in Bengali population and from 6.31 to 6.73 cm in Egyptian population. This coincides with Krishan and Kumar, (2007) who reported that the SEE ranged from (4.41 to 7.21 cm) in estimating stature from sixteen craniofacial measurements in their sample on North Indian male adolescents.

The current study revealed that, the prediction of stature from facial dimensions is more reliable in Bengali and Egyptian males than cephalic dimensions. However, in Bengali and Egyptian females, the cephalic length is more reliable than facial dimensions in prediction of the stature. It was confirmed by the lower SEE and higher R2 of these dimensions in every race and gender. This finding agrees with Kumar and Gopichand, (2013) who concluded that the most reliable craniofacial measurements to estimate stature using regression analysis among males is morphological facial length and among females is maximum head length in Haryanvi subjects. However, Krishan, (2008) demonstrated that cephalic region gave better reliability of stature estimation than facial measurements in North Indian males.

Conclusion

From the present study, it could be concluded that, the craniofacial parameters show both gender and racial variations. Facial dimensions are more reliable in Bengali and Egyptian males while cephalic length is more reliable than facial dimensions in prediction of the stature in both Egyptian and Bengali females.

Recommendations

Further researches are recommended with larger samples in order to verify the accuracy of stature estimation in both populations. Additionally, we recommended studies on cadavers and skulls without soft tissue covering as well as assessment of the effect of multiple factors on the regression coefficient in stature estimation to determine the most dominant factor.

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الملخص العربى

تقدير طول القامة من قياسات الوجه والرأس في عينات من المصريين والبنغال (دراسة مقارنة)

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أجريت العديد من المحاولات لمعرفة مدى الارتباط واشتقاق صيغة الانحدار بين قياسات الوجه والرأس وطول قامة الجسم، حيث انه قد تكون هذه القياسات هى فقط المتاحة متاحة فقط للفحص بعد الوفاة. ولذلك هدفت هذه الدراسة إلى مقارنة نسب الأنثروبومتري للوجه والرأس بين السكان المصريين والبنغاليين. بالإضافة إلى، تقييم مدى ارتباط هذه القياسات بطول القامة مع اقتراح معادلة الانحدار للتنبؤ بحساب طول القامة من هذه القياسات في كلا الجنسين. وقد شملت هذه الدراسة مائه شخص: (ستين من المصريين وأربعين من البنغاليين) الذين تتراوح أعمارهم بين ١٨-٦٠ عاما. تم قياس طول القامة وأخذ أربع قياسات للوجه والرأس (الحد الأقصى لطول الرأس، أقصى اتساع للرأس، الحد الأقصى لطول الوجه و أقصى اتساع للوجه). وأشارت النتائج إلى أن جميع قياسات الوجه والرأس كانت أكبر في الذكور عن الإناث المصريين.وكان الحد الأقصى لطول الوجه أكبر في المصريين من البنغاليين فى كلا الجنسين. ولكن وجد أن أقصى اتساع للوجه وأقصى طول للرأس أكبر في البنغاليين عن المصريين فى كلا الجنسين. وقد اظهرت هذه القياسات أن أعلى معامل ارتباط مع طول القامه كان مع أقصى اتساع للوجه عند الذكور البنغالين (ص = ٠,٦٠)، ومع الحد الأقصى لطول الوجه عند الذكور المصريين (ص = ٠,٤٢)، من ناحية أخرى فإن أقصى طول للرأس في الإناث المصريات والبنغاليات أظهر أعلى معامل ارتباط مع طول القامة (ص = ٠,٣٧، ص = ٠,٨٩على التوالي). ولذلك فإنه يمكن التنبؤ بطول القامه من قياس ابعاد الوجه للذكور المصريين والبنغاليين ومن قياس طول الرأس للإناث المصريات والبنغاليات.

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