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Research Article

ESTIMATION OF STATURE FROM FACIAL ANTHROPOMETRIC MEASUREMENTS IN 800 ADULT HARYANVI BANIYAS

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ABSTRACT
Personal identification means determination of individuality of a person. It may be complete or incomplete. Anthropometric characteristics have a direct relationship with sex, shape and form of an individual. Anthropometric data are believed to be objective and they allow the forensic examiner to go beyond subjective assessments such as ´similar' or ´different'. With an increase in frequency of mass disasters, the identification of an isolated lower extremity and the stature of the person it belonged to have created problems for the investigation of the identity of some of the victims. In spite of a need for such a study, there is a lack of systematic studies to identify fragmented and dismembered human remains. The aim of the present study was to establish data on facial anthropometry of 800 Haryanvi adult Baniyas and to co-relate their facial dimensions with stature and to provide data for use in forensic and other allied sciences. The study was conducted on 800 adult Haryanvi Baniyas (400 of either sex). A series of three somatometric landmarks and three anthropometric measurements were taken. The objectivity of data was ensured by taking the measurement directly from the subjects instead of the photographs which are less reliable. All the measurements were recorded, tabulated and statistically analyzed. Results showed that the mean stature of the males was 168.71 cm and that of females was 155.18 cm. The mean morphological facial length in males was 11.07 cm and 10.21cm in females. The mean bigonial diameter in males was 11.45 cm and 10.33cm in females. All the measurements were found to be more in males as compared to females. There was a significant positive correlation between stature and facial measurements in both sexes. The most reliable facial measurement to estimate stature using regression analysis among males was morphological facial length.

Keywords: *Stature, Facial Anthropometric Measurements, Haryanvi Baniyas, Morphological Facial Length*

INTRODUCTION
Personal identification means determination of individuality of a person. It may be complete (absolute) or incomplete (partial). Complete identification means absolute fixation of individuality of a person. Partial identification implies ascertainment of only some facts about the identity of the person while others still remain unknown. Age, sex and stature are the primary characteristics of identification (Krishan, 2009).
Anthropometric characteristics have direct relationship with sex, shape and form of an individual and these factors are intimately linked with each other and are manifestation of the internal structure and tissue components which in turn, are influenced by environmental and genetic factors. Anthropometric data are believed to be objective and they allow the forensic examiner to go beyond subjective assessments such as ´similar' or ´different'. With measurement data, the examiner is able to quantify the degree of difference or similarity and state how much confidence can be placed in this interpretation (Krishan, 2007). Anthropometric technique commonly used by anthropologists and adopted by medical scientists has been employed to estimate body size over a hundred years. With an increase in frequency of mass disasters, the identification of an isolated lower extremity and the stature of the person it belonged to had created problems for the investigation of the identity of some of the victims. In spite of a need for such a study, there is a lack of systematic studies to identify fragmented and dismembered human remains (Ozasian *et al.*, 2003).

Research Article

Craniofacial anthropometrics have become an important tool used by genetic counselors and in reconstructive surgery. In genetic counseling it is necessary to identify dysmorphic syndromes as accurately as possible. The diagnosis of many dysmorphic syndromes is based only on advanced cytogenetic and molecular techniques, but also on recognition of subtle morphological anomalies in craniofacial region. Measurements taken from a patient can be compared with the values obtained in the normal population, and deviations from the normative values can be evaluated. For instance, anthropometrical data can help in early diagnosis of rather common syndromes. It was shown that children with foetal alcohol syndrome and partial foetal alcohol syndrome had a distinctive facial phenotype that could be characterized anthropometrically. The study done by Nagle *et al.*, showed variations of craniofacial parameters in normal (without any family history of craniofacial parameters or other genetic malformations) Latvian residents (Nagle and Teibe, 2005).

In the past, scientists have used each and every bone of the human skeleton right from femur to metacarpals in estimation of stature. They all have reached a common conclusion that stature can be estimated with great accuracy even from the smallest bone, although they have encountered a small error of estimate in these studies. Some authors have used fragments of the long bones i.e. upper or lower end etc. Long bones have been used in the determination of stature because they relatively give better accuracy in prediction of stature (Krishan, 2007). Establishment of alternative methodologies for personal height estimation is important for a number of reasons such as in instances where height estimates are to be made from fragments of bones in archeological procedures or in forensic examinations after mass disasters or genocide (Ebite *et al.,* 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 and short bones, foot and footprints. Since all these parts of the body and bones are not always available for forensic examination, it becomes necessary to make use of other parts of the body like head and face region. But only a few studies have been conducted on cephalo-facial region with respect to estimation of stature (Bhatnager *et al.,* 1984; Kamel *et al.,* 1990; Duyar *et al.,* 2006; Nagesh and Kumar, 2006; Krishan and Sharma, 2007; Smith, 2007; Restogi *et al.,* 2008).

Aim and Objectives

1 To establish data on facial anthropometry of 800 Haryanvi adult Baniyas.
2 To find out correlation of facial dimensions with stature.
3 To establish the significance of present study for use in forensic and other allied sciences.
4 To compare present observations with accessible previous published data if available and attempt to find out correlation in the observation if any

MATERIALS AND METHODS

The present study was conducted on 800 adult Haryanvi Baniyas (400 of either sex). Prior informed consent both in English & Vernacular were obtained from subjects in writing.

Inclusion Criteria

1. The subjects were apparently healthy and without any craniofacial deformity.
2. The subjects of age group 18 years and above were included in the study.
3. The subjects were taken from only one endogamous group i.e. Haryanvi Baniyas.

Exclusion Criteria

1. The subjects under 18 years of age were excluded from the study.
2. Subjects were not chosen on basis of bodily structure & proportions.
3. Subjects with any apparent physical anomalies (micrognathia, retrognathia etc), inflammation, trauma, deformities and surgery were excluded from the study.

A series of three somatometric landmarks and three anthropometric measurements were taken on 800 Haryanvi Baniyas. The methodology for facial measurements was adopted from Krishan and Kumar[13].

Somatometric Land Marks

1. **Gonion (G)** It is the most posterior, inferior, laterally situated point on the external angles of the mandible.

2. **Nasion (N)** It is the point on nasal root intersected by mid sagittal plane.
3. **Gnathion(GN)** It is the lowest point on the lower margin of lower jaw interesected by the mid-sagittal plane. This point can be palpated by the lower jaw from behind & slightly anterior to chin.

Somatometric Measurements

1. Bigonial diameter:- It is the maximum breadth of the lower jaw between two gonion points on the angle of mandible.
Instrument: spreading caliper
2. Morphological facial length:- It is straight distance from the nasal root (nasion) to the lowest point on the lower border of the mandible in the mid sagittal plane (gnathion).
Instrument: sliding caliper
3. Stature: – It is the vertical distance between highest point on the head (vertex) and the floor.
Instrument: Anthropometric rod
The objectivity of data was censured by taking the measurement directly from the subjects instead of the photographs which are less reliable. All measurements of face were taken with the subject sitting in chair in a relaxed condition & head and face was in Frankfurt Horizontal plane. Measurement of the stature was done by asking this subject to stand on a horizontal platform with his heels together stretching upward to full extent, aided by gentle traction by the measure on the mastoid process. The subject's back was as straight as possible. The subject was advised not to change his position while measurements being taken. All the measurements were taken thrice to ensure accuracy and the mean of the three readings was taken as the final reading. All the measurements were recorded, tabulated and statistically analyzed.

Statistical Analysis

The data thus collected was subjected to statistics like mean, standard deviation, Karl Pearson's correlation coefficient, regression analysis, standard error of estimate etc. and were analyzed using SPSS (Statistical Package for Social Sciences) on windows XP professional.

RESULTS AND DISCUSSION

Observations

In the present study, data on facial anthropometry of 800 Haryanvi Baniyas (400 of either sex) was collected.

Table 5.1: Sample size

Group	No. of subjects
Haryanvi baniya males	400
Haryanvi baniya females	400

The readings were subjected to statistical computation and the stature was estimated using regression models from the facial dimensions. The findings have been presented.

Table 5.2

Measurement	Male Mean ± S.D.	Female Mean ±S.D.
Morphological facial length	11.07±0.698	10.21±0.940
Bigonial breadth	11.45±1.104	10.33±0.753
Height	168.71±5.461	155.18±4.621

Table 5.3: Pearson correlation coefficients between stature and facial measurements in males

Measurements	Pearson correlation coefficient (r)	p- value
Morphological Facial length	0.177	0.0003
Bigonial diameter	0.164	0.0009

Table 5.3 shows that all the facial measurements showed positive significant correlation with stature ($p<0.01$).

Table 5.4: Pearson correlation coefficient between stature and facial measurements in females

Measurements	Pearson correlation coefficient (r)	p- value
Facial length	0.150	0.002
Bigonial diameter	0.119	0.016

Table 5.4 shows that all the facial measurements showed positive significant correlation with stature ($p<0.01$).

Table 5.5: Regression equations for estimation of stature (cms) from facial measurements in males

Regression equation	SEE
HEIGHT= 153.31+ 1.390(MFL)	5.38
HEIGHT= 159.42+ 0.811(BGD)	5.4

Table-5.5 shows regression equations to calculate stature from facial measurements, morphological facial length (MFL) and Bigonial diameter (BGD) by substituting the values of facial measurements in males. A hypothetical regression equation is depicted as follows:
Stature = a + bx where 'a' is the regression coefficient of dependent variable i.e. stature and 'b' is the regression coefficient of independent variable (any of the facial measurement), 'x' is any facial measurement.

Table 5.6: Regression equations for estimation of stature (cms) from facial measurements in females

Regression equation	SEE
HEIGHT= 147.62+ 0.740(MFL)	4.33
HEIGHT=147.61+0.733(BGD)	4.60

**Insignificant*

Table-5.6 shows regression equations to calculate stature from facial measurements (Morphological facial length (MFL), Bigonial diameter (BGD) by substituting the values of facial measurements in females.
A hypothetical regression equation is depicted as follows:
Stature = a + bx where 'a' is the regression coefficient of dependent variable i.e. stature and 'b' is the regression coefficient of independent variable (any of the facial measurement), 'x' is any facial measurement. The standard error of estimate (SEE) is less for morphological facial length as compared to bigonial diameter.

Table 5.7: Comparison of actual stature and estimated stature from facial measurements in males using regression analysis

Estimated stature using regression equations	Minimum estimated stature	Maximum estimated stature	Mean estimated stature
Morphological facial length	165.12	171.51	168.69
Bigonial diameter	166.96	170.93	168.70
Actual stature	152	189	168.71

In the above table**,** the minimum, maximum and mean values of the measurements were substituted in their respective regression equations and estimated stature was calculated. It is evident from the table that in every facial measurement, minimum estimated stature is greater than the actual minimum stature

whereas maximum estimated stature in case of each facial measurement is less than the actual maximum stature. Mean estimated values are closest to the actual stature.

Table 5.8: Comparison of actual stature and estimated stature from facial measurements in females using regression analysis

Estimated stature using regression equations	Minimum estimated stature	Maximum estimated stature	Mean estimated stature
Morphological facial length	153.91	156.94	155.17
Bigonial diameter	153.76	156.69	155.18
Actual stature	141.5	182	155.18

In the above table**,** minimum, maximum and mean values of the measurements were substituted in their respective regression equations and estimated stature was calculated. It is evident from the table that in every facial measurement, minimum estimated stature is greater than the actual minimum stature whereas maximum estimated stature in case of each facial measurement is less than the actual stature. Mean estimated values are closest to the actual stature.

Table 5.9: Comparison of mean actual stature (168.71cm) and mean estimated stature in males

Estimated stature using regression equations for (in cm)	Mean estimated stature	Difference between means=mean actual stature – mean estimated stature
Morphological facial length	168.69	0.02
Bigonial diameter	168.70	0.01

The difference between the mean actual stature and mean estimated stature ranges from 0.01 to 0.02 which is statistically insignificant.

Table 5.10: Comparison of mean actual stature (155.18 cm) and mean estimated stature in females

Estimated stature using regression equations for (in cm):	Mean estimated stature	Difference between means=mean actual stature – mean estimated stature
Morphological facial length	155.17	0.01
Bigonial diameter	155.18	0.00

The difference between the mean actual stature and mean estimated stature ranged from -0.00 to 0.01 which is considered as negligible and statistically insignificant.

Discussion

The present study was conducted to provide baseline data for facial anthropometry on Haryanvi Baniyas & study its correlation with stature. It was based on a sample of 400 adult males and 400 adult females. Two facial measurements were taken and regression equations for estimation of stature were determined. For the purpose of discussion the results of present study were compared with similar available studies on different populations of the world as well as different ethnic groups of India and the data available from various region/ races/ countries has been presented under various headings.

Table 6.1: Studies showing mean face length more than the mean of the present study

Author	Population	Sex	Face length (cm)
		M	12.13
	Azerbaijan	F	11.16
	Singaporean Chinese	M	12.36
		F	11.49
	Vietnamese	M	12.12
		F	11.31
Farkas *et al.,* (2005)	Thai	M	12.35
		F	11.28
	Japanese	M	12.28
		F	11.38
	Polish	M	11.75
		F	11.16
Patil & Mody (2005)	Central Indian population	M	12.677
		F	1.411
Sahni *et al.,* (2010)	Northwest Indian Population	M	11.25
		F	10.80
Jibonkumar & Lilanchandra (2006)	Kabuis of Imphal Valley	M	11.25
		F	----
Pelin *et al.,* (2010)	Turkish Population	M	12.17
		F	------
Aghnihotri *et al.,* (2011)	Indo-Mauritian Population	M	11.58
		F	11.00
Hossain (2011)	Japanese adult females(1975-79) &1998-2001	F	11.164
		F	11.440
Wankhede *et al.,* (2012)	Nagpur Medical college students	M	11.43
		F	10.66
Present Study	Haryanvi Baniyas	M	11.07
		F	10.21

Table 6.1 showed that the mean face length, value in males was 11.07cm & 10.21 cm in females. The mean values were more in males as compared to females. This is in agreement with the studies done by previous authors. The mean facial lengths of all the previous studies done on various population groups of the world are higher than the present study both in males and females.

Table 6.2: Studies showing mean facial length less than present study

Author	Population	Sex	Face length (Cm)
Krishan & Kumar (2007)	North Indian Kolis	M	10.240
		F	-----
Krishan (2008)	North Indian Gujjars	M	10.81
		F	------
Present Study	Haryanvi Baniyas	M	11.07
		F	10.21

Table 6.2 shows that the mean facial length of the present study was more than the mean facial length of North Indian Kolis in the study of Krishan and Kumar (2008) and North Indian Gujjars in the study of Krishan (2011) where it was less than the present study. In females, the mean face length was 10.21cm,

no data available from rest of the studies. From the present study it was concluded that the North Indian Kolis and Gujjars (both endogamous groups) had short face length as compared to the Haryanvi Baniyas.

Table 6.3: Studies showing comparison of mean bigonial diameter of previous studies with present study

Author	Population	Males	females
Jibon & Lilanchandra (2006)	Kabuis of Imphal Valley	14.	---------
Krishan & Kumar (2007)	North Indian Kolis	8.34	------
Krishan (2008)	North Indian Gujjars	9.783	-------
Sahni *et al.,* (2010)	Northwest Indians	10.64	10.26
Pelin *et al.,* (2010)	Turkish Populations	10.361	-------
Agnihotri *et al.,* (2011)	Indo-Mauritian. Populations	10.55	9.90
Present Study	Haryanvi Baniyas	11.45	10.33

Table 6.3 showed that the mean bigonial diameter of present study is more in males as compared to the females. While comparing the present study with the previous studies, the results of present study are in agreement with the previous studies.

In present study, values of mean bigonial diameter of males were found to be higher than the previous studies conducted by Krishan & Kumar (2007), Krishan (2008), Pelin *et al.,* (2010), Sahni *et al.,* (2010) & Aghnotri *et al.,* (2011) but lower than the study of Jibon & Lilanchandra (2006) on Kabuis of Imphal Valley. The mean bigonial diameter of the females of the present study is almost similar to the study of Sahni *et al.,* (2010) on North Indian Populations but higher than the Indo-Mauritian population (Table 6.8).

Table 6.4: Studies showing comparison of mean stature of previous studies with present study

Author	Population	Males	Females
Bale *et al.,* (1991)	Caucasian Populations	178.13	-------
Jadhav & Shah (2004)	Gujarat Populations	165.92	----
Patil & Mody (2005)	Central Indian Populations	164.78	150.55
Ryan& Bidmos (2007)	Indigenous South Africans	153.27	143.08
Jibonkumar & Lilanchandra (2006)	Kabuis of Imphal Valley	162.29	------
Kalia *et al.,* (2008)	Mysorean patients	171.65	155.67
Krishan & Kumar (2005)	North Indain Kolis	152.647	------
Krishan (2008)	North Indian Gujjars	172.31	- ------
Akhter *et al.,* (2010)	Bangladeshi Garo females	--------	152.79
IIayperuma (2011)	Srilankans	162.95	152.48
Sahni *et al.,* (2010)	Northwest Indians	165.90	163.24
Pelin *et al.,* (2010)	Turkish Populations	175.314	-----
Agnihotri *et al.,* (2011)	Indo-Mauritian Populations.	173.40	157.36
Asha and Prabha (2011)	South Indian Populations	169.62	156.82
	North Indian Populations	168.86	156.39
Seema & Mahajan (2011)	Punjabi Populations	166.93	--------
Wankhede *et al.,* (2012)	Medical students of Nagpur	170.97	156.89
Present Study	Haryanvi Baniyas	168.71	155.18

In present study, the mean values of stature in males were 168.71 cm and in females were 155.18cm. The mean values were more in males as compared to females. Table 6.4 also showed that the mean values of stature of the present study were higher than the Indigenous South Africans, Srilankans, but lower than the Caucasian population studied by Bale et al[23], Turkish population, Indo-Mauritian population. The study when compared with Indian studies on the mean values of stature are higher in Haryanvi Banias than the Gujarat Population, central Indian Population, Kabuis of Imphal Valley, North Indian Kolis, Northwest Indians and Punjabi populations but lower than the South Indian population, Mysorean population(south Indians), North Indian Gujjars and almost similar to the North Indian population.

Table 6.4: Comparison of correlation coefficients between stature and facial length of previous studies with present study

Author	Population	Sex	Correlation coefficient (r)	P-value	See
Patil & Mody (2005)	Central Indian Population	M	0.925	<0.01	-----
		F	------	<0.01	-----
Jibon & Lilancnandra (2006)	Kabuis of Imphal Valley	M	0.213	<0.001	0.067
		F	------	----	-----
Krishan & Kumar (2007)	North Indian Kolis	M	0.345	<0.001	0.067
		L	-----	-----	------
Krishan (2008)	North Indian Gujjars	M	0.455	<0.001	0.047
		F	------	------	------
Sahni *et al.*, (2010)	North west Indians	M	0.219	<0.002	3.16
		F	0.181	0.021	290.
Pelin *et al.*, (2010)	Turkish Population	M	0.199	<0.001	---
		F	-------	------	-----
Agnihotri *et al.*, (2011)	Indo –Mauritian Population	M	0.328	0.004	---
		F	0.164	<0.001	-----
Wankhede *et al.*, (2012)	Medical students of Nagpur	M	0.19	0.001	6.68
		F	0.144	0.001	5.84
Present study	Haryanvi Baniyas	M	0.177	0.008	--
		F	0.150	0.002	--

In present study, correlation coefficient (r) between stature and facial length in males was 0.177 & in females 0.150 which is lower than the previous studies in males & females except Mysorean females. No female data is available from Central Indian Population, Kabuis, North Indian Kolis, North Indian Gujjars and Turkish Population.

Table 6.5: Comparison of correlation coefficients between stature and bigonial diameters of various studies with present study

Author	Population	Sex	Correlation coefficient (r)	P-value	See
Jibonkumar & Lilanchandra (2006)	Kabuis of Imphal Velly	M	0.365	<0.001	0.061
		F	---	------	----
Krishan & Kumar (2007)	North Indian kolis	M	0.449	<0.001	0.071
		F	------	------	------
Krishan (2008)	North Indian Gujjars	M	0.462	<0.001	0.081
		F	-------	-----	------
Sahni *et al.*, (2010)	Northwest Indians	M	0.064	0.201*	3.69
		F	0.047	0.299*	2.95
Pelin *et al.*,(2010)	Turkish Population	M	0.164	<0.001	-----
		F	-----	-----	-----
Agnihotri *et al.*, (2011)	Indo- Mauritian Populations	M	0.022	0.057*	---
		F	0.159	0.175*	--
Present Study	Haryanvi Baniyas	M	0.164	0.0009	
		F	0.119	0.016	

In present study, the values of correlation coefficient between stature and bigonial diameter are 0.164 in males and 0.119 in females. This is in agreement with the study done by Pelin *et al.*, (2010) (on Turkish population). Rest other previous studies showed higher correlation coefficient than the present study, but Sahni *et al.*,(2010) and Agnihotri *et al.*,(2011) studies showed insignificant correlation between stature and bigonial diameter which is in contradiction to the present study (Table 6.5).

Table 6.6: Comparison of correlation coefficient of present study in both sexes

Measurements	Sex	Correlation coefficient (R)	p-value
Morphological facial length	M	0.177	0.008
	F	0.150	0.002
Bigonial diameter	M	0.164	0.009
	F	0.119	0.016

Above table showed that the highest correlation coefficient was between morphological facial length and stature in males i.e. 0.177. So it was concluded that the best parameter for stature estimation in males is morphological facial length. The correlation between head breadth and stature in both sexes showed insignificant correlation. The regression formulae obtained for estimation of stature from facial measurements were checked for their accuracy. Table 5.7 and Table 5.8 show a comparison of actual stature and stature estimated from facial measurements using regression analysis. The mean estimated stature values were close to the actual stature in both males and females (Table 5.9 and Table 5.10). While applying these formulae one should keep in mind that these are population specific.

Summary and Conclusion

The present study was conducted on 800 Haryanvi Baniyas (400 of either sex), with the aim to establish database on facial anthropometry and to find out any correlation between stature and facial measurements. Subjects with any apparent physical deformities of the body were excluded from the study. Two measurements were taken. All the data was recorded, tabulated and statistically analyzed.

In present study it was found that the mean stature of the males was 168.71 cm and that of females was 155.18 cm. The mean morphological facial length in males was 11.07 cm and 10.21cm in females. The

mean bigonial diameter in males was 11.45 cm and 10.33cm in females. All the measurements were found to be more in males as compared to females. These observations were in concordance with the earlier studies. Such standards based on ethnic or racial data are desirable because these standards reflect the potentially different patterns of craniofacial growth resulting from racial, ethnic and sexual difference.
The study provides correlation between the facial measurements with stature and also devises regression equations to calculate stature from these measurements as it is the best method as far the accuracy or reliability of the estimate is concerned. The stature estimation in these cases can supplement the other personal identification data like estimation of age, sex, race etc where only head and face are available for examination.
In the present study it was found that there was statistically significant positive correlation between stature and all the facial measurements. The highest correlation coefficient was exhibited by morphological facial length in males. Morphological facial length also had least standard error of estimate (5.38) in males calculated using regression equations. So the facial measurement (Morphological facial length) is the most reliable measurement for estimation of stature in males. But while applying the regression formulae, one should keep in mind that these are population specific (Haryanvi Banias); these cannot be used on other populations of the world.
The regression formulae so obtained were checked for their accuracy by substituting the mean value of the facial measurements in their respective equations and estimated stature was calculated. The mean estimated values were close to the actual stature.
Thus the following conclusions can be drawn from the present study:
1. All the measurements were found to be more in males as compared to females.
2. There is significant positive correlation between stature and facial measurements (Morphological facial length and Bigonial diameter) in both sexes.
3. The most reliable facial measurement to estimate stature using regression analysis among males is morphological facial length.
4. Since regression equations are known to be population and sex specific, there is a need for similar equations to be derived for other endogamous groups of Haryana.
5. Estimation of stature from facial measurements is a supplementary approach when useful samples like extremities and other body parts are not available for examination.

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