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SEXUAL DIMORPHISM FROM THE FACIAL DIMENSIONS: AN IDENTIFICATION PERSPECTIVE

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ABSTRACT

Sexual dimorphism has been of great interest for many years. The aim of the present study is to predict the sexual dimorphism from the facial dimensions among Choudhary Patels of Gujarat. The present study was conducted in Bhiloda (District-Aravalli), Gujarat. The study was carried out on Choudhary Patel with 200 samples including Males=100 & Females=100. Age Group was 18-60 Years. Only healthy subjects without any physical or facial abnormality were included in the study with their informed consent. The Present study provides a population specific technique for sex determination from facial dimensions to establish the identity among Choudhary Patels of Gujarat. Moreover, our study can predict 82% males and 91% females accurately and overall 87% for prediction of sex. Therefore, in the present study, among Twenty four measurements, MHB, MFB, BAB, NB, MHL and BCA have been found best predictors for Sexual dimorphism in Choudhary Patels of Gujarat. Among all the variables, MHL showed the highest Accuracy rates for males (79%) and MHB for females (88%). Discrimination equation can be derived for Sexual dimorphism from facial dimensios for Choudhary Patels of Gujarat. These findings provide a Model for sexual dimorphism through facial dimensions among Choudhary Patels of Gujarat which can be used for identification dynamics for anthropo-forensic purposes.

KEY WORDS: *Identification, Sexual Dimorphism, Facial Dimensions*

INTRODUCTION

Various methods can be used to establish the identity of an individual, including fingerprints, dental records, DNA analysis and anthropological measurements. Every so often, it may be necessary to apply newer and unusual techniques (Murgod et al, 2013). For forensic investigations, it is important to establish better methods of determining sex from the various elements more likely to survive and be recovered. Sex estimation can be accomplished using either morphological or metric methodologies (Mahfouz, et al, 2007). Sexual dimorphism has been of great interest in many years. Such data has been used to analyze size differences between males and females and the social implications thereof (Iscan, 2005). Indian population shows spectra of heterogeneous and homogenous subpopulations across various regions and there is scarcity of forensic data onto facial parameters on Indian population (Naikmasur et al, 2010). Studies conducted on two different populations of North India suggested that cephalo-facial dimensions supplemented by facial morphological features can be employed in determining age, sex, stature and race in Indian population (Krishan and Kumar, 2007, 2008). Jahanshahi et al (2008) studied face shapes of different parts of Iran and stated that the geographical factor, similar to ethical factor, can affect the form of the face. Normally, various facial types are encountered with every population so that a certain number of people have thin, broad or small faces. The aim of the present study is to predict the sexual dimorphism from the facial dimensions among Choudhary Patels of Gujarat.

MATERIALS AND METHODS

The present study was conducted in Bhiloda (District-Aravalli), Gujarat. Bhiloda is a municipality and taluka headquarters situated in Aravalli District in the state of Gujarat in India. It is situated on the banks of the Hathmati River among the Aravalli Hills. As of the 2011 census, Bhiloda had a population of 16,074 and 286/km^2 density. The study was carried out on Choudhary Patel with 200 samples including Males=100 & Females=100. The Age Group was 18-60 Years. Only healthy subjects without any physical or facial abnormality were included in the study with their informed consent. Instruments Used: To carry out the measurements, anthropometer, sliding caliper (with blunt ends), spreading caliper (with blunt ends), skin marker and steel tape have been used. A total of 24 measurements were taken on the subjects. All the measurements were recorded using the standard methods of Martin and Saller adopted by Singh & Bhasin (1968). The measurements with their definition included in the study are as follows:-

Table 1

Variables	Definition
MHC (g-op-g)	It measures the circumference from glabella (g) to Opisthocranium (op) to glabella (g) when the head is oriented in eye-ear plane. Glabella (g): It is the point between the eye brow ridges above nasal root. Opisthocranium (op): It is the most posteriorly placed point on the posterior protuberance of the head in the mid-Sagittal plane.
MHB (eu-eu)	It measures the maximum straight distance between the two eurya (eu) when the head is oriented in eye- ear plane.Euryon (eu): It is the most laterally placed point on the sides of the head and is only determined by measuring maximum head breadth.
MFB (ft-)	It measures the minimum distance between the two frontotemporalia (ft) when the head is oriented in eye-ear plane. Frontotemporale (ft): It is the most anterior and inner point on the linea temporalis on the frontal bone. It usually lies slightly higher than the tangent drawn on the highest elevation of the upper margins of the eye brow ridges.
BAB (t-t)	It measures the straight distance between the two tragia (t).Tragion (t): It is a point on the upper margin of tragus where tangents drawn to the anterior and upper margin of this cartilage cut each other. This point lies 1-2 mm below the helix.
BB (go-go)	It measures the straight distance between two gonia (go) when the head is oriented in eye-ear plane. Gonion (go): It is the most posterio-lateraly placed lowest point on the angle of the lower jaw.
EBB	It measures the straight distance between canthi i.e. outer corners of the eye.
IOB	It measures the straight distance between the internal canthus of the eye, with the eye-lids open.
BB(zy-zy)	It measures the straight distance between the most laterally placed zygia (zy) when the head is oriented in eye-ear plane. Zygion (zy): It is the most laterally placed point on Zygomatic arch and is determined by taking bizygomatic breadth
EB	It measures the straight distance of the two most lateral points on the posterior margin of the helix, i.e. postaurale (pa) when taken at right angle to the ear length.
NB (al-al)	It measures the straight distance between the two laterally placed alaria (al) when the head is oriented in eye-ear plane.
MHL (g-op)	It measures the maximum straight distance from glabella (g) to opisthocranium (op) when the head is oriented in eye- ear plane.
EL (sa-sba)	It is the distance between superaurale to subaurale. Superaurale (sa): It is the highest point on the margin of the helix when the head of the subject is oriented in eye-ear plane. Subaurale (sba): It is the lowest point on the lower margin of the ear lobe.
NL (n-prn)	It measures the straight distance between nasion (n) to pronasale (prn) when the head is oriented in eye-ear plane. Pro-nasale (prn): It is the most anteriorly placed point on the tip of the nose when the head is oriented in mid-sagittal plane.

Table 1 Contd.,	
LL (ch-ch)	It measures the straight distances between two chelion (ch) i.e., corners of the mouth. Chelion (ch): It is the meeting point of upper and lower lateral margins of the lip (Corners of the mouth).
LH(ls-li)	It measures the straight distance between labrale superior (ls) to labrale inferior. Labrale Superior (ls): It is the point on the upper margin of the integumental lip intersected by mid-sagittal plane. Labrale Inferior (li):It is the point on the lower margin of the integumental lip intersected by mid-sagittal plane.
PFH (tr-gn)	It measures the straight distance between trichion (tr) to gnathion (gn) when the head is oriented in eye-ear plane. Trichion (tr): It is the point where the anterior border of the hair on the forehead cut by the mid-sagittal plane. Gnathion (gn): It is the lowest point on the lower margin of the lower jaw intersected by mid sagittal plane when the head of the subject is oriented in eye-ear plane.
MFH (n-gn)	It measures the straight distance between nasion (n) to gnathion (gn) when the head is oriented in eye-ear plane. Nasion (n): It is the point on the nasal root intersected by mid-sagittal plane. Gnathion (gn): It is the lowest point on the lower margin of the lower jaw intersected by mid-sagittal plane when the head of the subject is oriented in eye-ear plane.
PUFH (n-sto)	It measures the straight distance between nasion(n) to stomion (sto) when the head is oriented in eye-ear plane.Stomion (sto): It is the point where the slit of the mouth with close lips cuts the mid-sagittal point.
MUFH (n-pr)	It measures the straight distance between nasion(n) to prosthion (pr) when the head is oriented in eye-ear plane.Prosthion (pr):It is the most downwardly placed point on the lower margin of the gums of upper jaw between the middle incisors in mid-sagittal plane.
HLF	It measures the projective distance between chin and mouth i.e between stomion (sto) and gnathion (gn). Stomion (sto): It is the point where the slit of the mouth with close lips cuts the mid-sagittal point. Gnathion (gn): It is the lowest point on the lower margin of the lower jaw intersected by mid-sagittal plane when the head of the subject is oriented in eye-ear plane.
NH	It measures the straight distance between nasion (n) to subnasale (sn)when the head is oriented in eye-ear plane.Nasion (n): It is the point on the nasal root intersected by mid-sagittal plane. Subnasale (sn): It is the point where lower margin of nasal septum meets the integument of the upper lip in mid-sagittal plane.
BCA	It measures with a tape between the right and left Tragion across the anterior point of the chin.
BFA	It measures with a tape between the right and left Tragion across the forehead just above the supraorbital ridges.
BSA	It measures with a tape between the right and left Tragion across the subnasale on the face.

Variables:- MHC-Maximum Head Circumference; MHB- Maximum Head Breadth; MFB-Minimum Frontal Breadth; BAB-Bi Auricular Breadth; BB- Bigonial Breadth; EBB-External Biocular Breadth; IOB- Inter Ocular Breadth; BZB- Biozygomatic Breadth; EB- Ear Breadth; NB- Nasal Breadth; MHL- Maximum Head Length; EL- Ear Length; NL- Nasal Length; LL- Lip Length; LH- Lip Height; PFH- Physiognomic Facial Height; MFH- Morphological Facial Height; PUFH- Physiognomic Upper Facial Height; MUFH-Morphological Upper Facial Height; HLF- Height of Lower Face; NH- Nasal Height; BCA- Bitragion Chin Arch; BFA- Bitragion Frontal Arch; BSA-Bitragion Subnasale Arch.

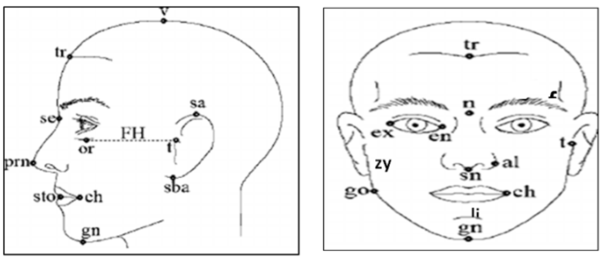

Figure 1: Landmarks for the Measurements

Statistical Analysis: The data was analyzed on SPSS -20. Sex-wise normality test (Shapiro-Wilk) for facial measurements was calculated. All the facial measurements have been found normally distributes with significant p-value ($p<0.05$). Mean, standard deviation, t-test and discriminant function analysis (Univariate and multivariate) was applied to all the facial dimensions separately using the Wilks' lambda minimization procedure.

RESULTS

Assessment of Sexual Dimorphism

Table 2 shows the results for the assessment of sexual dimorphism and represents the mean, standard Deviation and t-test for various facial measurements and stature among males and females of Choudhary Patels of Gujarat. All the facial measurements along with stature have been found higher in males than females and differences were found statically significant ($p<0.001$) but for Inter ocular breadth, bizygomatic breadth, ear length and lip height also have been found higher in males than females and differences were found statically significant ($p<0.05$) with higher mean value 2.95±0.79, 11.18±1.08, 6.18±0.54 & 1.82±0.62 respectively except lip length.

Table 2: Mean, S.D. and t-test Among Patels (Choudhary) of Gujarat

Name of the Measurements (cm)	Mean ± S.D		t-test
	Male	Female	
Maximum Head Circumference	55.52 ±1.88	53.55±1.53	8.069***
Maximum Head Breadth	12.17 ±1.71	11.89±0.73	8.810***
Minimum Frontal Breadth	10.90±1.09	9.85±0.64	8.309***
Bi Auricular Breadth	13.25±0.75	12.41±1.11	6.201***
Bigonial Breadth	10.99±0.85	10.18±0.86	6.571***
External Biocular Breadth	9.88±0.61	9.38±0.56	5.935***
Inter Ocular Breadth	2.95±0.79	2.71±0.29	2.914*
Biozygomatic Breadth	11.23±1.08	10.53±0.86	5.162***
Ear Breadth	3.30±0.33	3.19±0.42	2.110*
Nasal Breadth	3.86±1.07	3.38±0.28	4.250***
Maximum Head Length	18.54±1.03	17.41±0.93	8.101***
Ear Length	6.18±0.54	5.99±0.60	2.184*
Nasal Length	4.77±0.46	4.53±0.48	3.606***
Lip Length	5.13±0.75	5.14±0.63	0.133
Lip Height	1.82±0.62	1.59±0.47	2.858*
Physiognomic Facial Height	17.45±0.88	16.73±1.42	4.272***
Morphological Facial Height	9.85±0.69	8.74±1.21	6.197***
Physiognomic Upper Facial Height	6.57±0.57	6.25±0.50	4.234***
Morphological Upper Facial Height	6.44±0.45	6.14±0.49	4.447***
Height of Lower Face	4.85±0.51	4.57±0.45	4.059***
Nasal Height	4.82±0.56	4.58±0.43	3.426***
Bitragion Chin Arch	29.52±1.92	27.62±1.25	8.323***
Bitragion Frontal Arch	30.66±1.18	29.31± 1.35	7.511***
Bitragion Subnasale Arch	27.79±1.51	26.35±1.19	7.487***

***$p<0.001$; *$p<0.05$

Univariate Analysis

Table 3 shows the accuracies and demarcation points resulting from the univariate analysis. These points are the average of the means of the both sexes for each variable. A measured value higher than the demarking point classifies an individual as male and a lower value than the demarking point classify individuals as male and a lower value indicates female. A univariate analysis provides a demarcation point from which it is possible to determine sex from a single numeric value. For, the original group, MHL showed the highest accuracy rates for males (79%) and MHB for females (88%). Accuracy percentages for cross-validated group were observed similar for the males and females as observed in original accuracy percentage.

Table 3: Accuracies and Demarcation Points Resulted from Univariate Discriminant Function Analysis for Choudhary Patels of Gujarat

Variables	Original Accuracy (%)			Cross Validation Accuracy (%)			Demarcation Points
	Male	Female	Avg.	Male	Female	Avg.	
MHC	77.0	76.0	76.5	77.0	76.0	76.5	F<54.54<M
MHB	58.0	88.0	73.0	58.0	88.0	73.0	F<9.92<M
MFB	68.0	85.0	76.5	68.0	85.0	76.5	F<10.38<M
BAB	68.0	67.0	67.5	68.0	67.0	67.5	F<12.83<M
BB	67.0	67.0	67.0	67.0	67.0	67.0	F<10.58<M
EBB	61.0	74.0	67.5	61.0	74.0	67.5	F<9.63<M
IOB	49.0	73.0	61.0	49.0	73.0	61.0	F<2.83<M
BZB	61.0	72.0	66.5	61.0	72.0	66.5	F<10.83<M
EB	60.0	50.0	55.0	60.0	50.0	55.0	F<3.25<M
NB	68.0	85.0	76.5	68.0	85.0	76.5	F<3.62<M
MHL	79.0	85.0	82.0	79.0	85.0	82.0	F<17.98<M
EL	58.0	56.0	57.0	58.0	56.0	57.0	F<6.09<M
NL	62.0	60.0	61.0	62.0	60.0	61.0	F<4.65<M
LL	40.0	52.0	46.0	40.0	52.0	46.0	F<5.14<M
LH	56.0	66.0	61.0	56.0	66.0	61.0	F<1.71<M
PFH	72.0	55.0	63.5	72.0	55.0	63.5	F<17.09<M
MFH	75.0	73.0	74.0	75.0	73.0	74.0	F<10.52<M
PUFH	62.0	65.0	63.5	62.0	65.0	63.5	F<6.41<M
MUFH	69.0	61.0	65.0	69.0	61.0	65.0	F<6.29<M
HLF	59.0	68.0	63.5	59.0	68.0	63.5	F<4.71<M
NH	63.0	53.0	58.0	63.0	53.0	58.0	F<4.69<M
BCA	75.0	80.0	77.5	75.0	80.0	77.5	F<28.57<M
BFA	69.0	71.0	70.0	69.0	71.0	70.0	F<29.98<M
BSA	66.0	68.0	67.0	66.0	68.0	67.0	F<27.07<M

Variables:- MHC-Maximum Head Circumference; MHB- Maximum Head Breadth; MFB-Minimum Frontal Breadth; BAB-Bi Auricular Breadth; BB- Bigonial Breadth; EBB-External Biocular Breadth; IOB- Inter Ocular Breadth; BZB- Biozygomatic Breadth; EB- Ear Breadth; NB- Nasal Breadth; MHL- Maximum Head Length; EL- Ear Length; NL- Nasal Length; LL- Lip Length; LH- Lip Height; PFH- Physiognomic Facial Height; MFH- Morphological Facial Height; PUFH- Physiognomic Upper Facial Height; MUFH-Morphological Upper Facial Height; HLF- Height of Lower Face; NH- Nasal Height; BCA- Bitragion Chin Arch; BFA- Bitragion Frontal Arch; BSA-Bitragion Subnasale Arch

Direct Multivariate Discriminant Function Analysis

Table 4 presents the direct multivariate discriminant function analysis for five functions i.e. facial breadths, facial lengths, facial heights, facial archs, and head circumference. The analysis shows the unstandardized coefficients, constants and centroids that were used to formulate the discriminant function equation. For the original group, the tested accuracy of sex determination by these combinations of variables ranged from 69% to 80% for males and 72% to 90% for females. Function-1 (facial breadths) being the best combination from all of the rest of the functions gave the best accuracies for the cross validated group (83%). In the original group, the breadth (83.5%) and the length (81.5%) variables show higher degrees of accuracy for sexual dimorphism than the height (70.5%), arch (75%) and circumference

(76.5%) variables respectively. In the cross validated group, the breadth (83%) and the length (81%) variables show higher degrees of accuracy for sexual dimorphism than the height (67%), arch (75%) and circumference (76.5%) variables respectively.

Table 4: Direct Multivariate Discriminant Function Analysis

Functions	Variables	Unstand. Coefficient	Wilks' lambda	Centroids	Original Accuracy (%)			Cross Validated Accuracy (%)		
					M	F	Avg.	M	F	Avg.
1.	MHB	0.351	0.526***	M=0.945 F=-0.945	77	90	83.5	76	90	83.0
	MFB	0.560								
	BAB	0.518								
	BB	0.182								
	EBB	0.143								
	IOB	0.032								
	BZB	-0.169								
	EB	0.301								
	NB	0.327								
	Constant	-19.668								
2.	MHL	0.907	0.708***	M=0.640 F=-0.640	80	83	81.5	80	82	81.0
	EL	0.387								
	NL	0.758								
	LL	-0.165								
	Constant	-21.347								
3.	PFH	0.059	0.788***	M=0.517 F=-0.517	69	72	70.5	64		67.0
	MFH	0.604								
	PUFH	0.276								
	MUFH	0.311								
	HLF	0.180								
	LH	1.063								
	NH	0.226								
	Constant	-14.744								
4.	BCA	0.377	0.709***	M=0.637 F=-0.637	70	80	75	70	80	75
	BFA	0.311								
	BSA	0.097								
	Constant	-22.690								
5.	MHC	0.582	0.753***	M=0.57 1 F=-0.571	77	76	76.5	77	76	76.5
	Constant	-31.739								

Functions: 1- Facial Breadths; 2-Facial Lengths; 3-.Facial Heights; 4-Facial Arches; 5- Circumference
***Significant ($p<0.0001$)

Variables:- MHC-Maximum Head Circumference; MHB- Maximum Head Breadth; MFB-Minimum Frontal Breadth; BAB-Bi Auricular Breadth; BB- Bigonial Breadth; EBB-External Biocular Breadth; IOB- Inter Ocular Breadth; BZB- Biozygomatic Breadth; EB- Ear Breadth; NB- Nasal Breadth; MHL- Maximum Head Length; EL- Ear Length; NL- Nasal Length; LL- Lip Length; LH- Lip Height; PFH- Physiognomic Facial Height; MFH- Morphological Facial Height; PUFH- Physiognomic Upper Facial Height; MUFH-Morphological Upper Facial Height; HLF- Height of Lower Face; NH- Nasal Height; BCA- Bitragion Chin Arch; BFA- Bitragion Frontal Arch; BSA-Bitragion Subnasale Arch

Stepwise Discriminant Function Equation

Table- 5 shows the unstandardized coefficients, constants and centroids that were used to formulate the discriminant function equation. All the twenty four measurements were entered into the stepwise discriminant function analysis. The function-6 included all the variables and predicted 82% males and 92% females for the original groups. While, cross validated group determined the 80% males and 87% females. The stepwise method selected the best variables from the twenty four measurements: MHB, MFB, BAB, NB, MHL and BCA.

y= (0.241*MHB) + (0.410*MFB) + (0.396*BAB) + (0.309*NB) + (0.325*MHL) + (0.259*BCA) -26.092

Where y= Discriminant Function Score

A y-value greater than the sectioning point will indicate a male while a y-value less than the sectioning point will indicate a female. For the original group, when males and females were combined, the tested accuracy of sex determination from the facial measurements (MHB, MFB, BAB, NB, MHL and BCA) by stepwise discriminant function analysis was 85%. When males and females were analysed separately, accuracy rates were higher in females (91%) than the males (79%) for the original & cross-validated group respectively.

Table 5: Stepwise Discriminant Function Equation

Function-6 (All Variables combined)	Unstand. Coefficient	Wilks' lambda	Centroids	Original Accuracy (%)			Cross Validated Accuracy (%)		
				M	F	Avg.	M	F	Avg.
MHC	-.089	0.428***	M=1.150 F=-1.150	82	92	87	80	87	83.5
MHB[a]	.266								
MFB[a]	.494								
BAB[a]	.409								
BB	.049								
EBB	-.097								
IOB	.142								
BZB	-.171								
EB	.137								
NB[a]	.271								
MHL[a]	.393								
EL	-.049								
NL	.648								
LL	-.136								
PFH	.317								
MFH	-.037								
PUFH	.133								
MUFH	-.005								
HLF	-.186								
LH	-.087								
NH	-.445								
BCA[a]	.203								
BFA	.094								
BSA	.046								
(Constant)	-24.244								
Function-7	Stepwise Multivariate Discriminant Function Equations								
MHB	.241	0.458***	M=1.082 F=-1.082	79	91	85	79	91	85
MFB	.410								
BAB	.396								
NB	.309								
MHL	.325								
BCA	.259								
Constant	-26.092								

***p<0.001; *p<0.05; ns=Non-Significant; M=Male; F=Female

[a=] variables included in Analysis; A discriminant function score greater than 0.000 indicates male and less than 0.000 indicates females. All sectioning points are zero.

Variables:- MHC-Maximum Head Circumference; MHB- Maximum Head Breadth; MFB-Minimum Frontal Breadth; BAB-Bi Auricular Breadth; BB- Bigonial Breadth; EBB-External Biocular Breadth; IOB- Inter Ocular Breadth;

BZB- Biozygomatic Breadth; EB- Ear Breadth; NB- Nasal Breadth; MHL- Maximum Head Length; EL- Ear Length; NL- Nasal Length; LL- Lip Length; LH- Lip Height; PFH- Physiognomic Facial Height; MFH- Morphological Facial Height; PUFH- Physiognomic Upper Facial Height; MUFH-Morphological Upper Facial Height; HLF- Height of Lower Face; NH- Nasal Height; ST-Stature; BCA- Bitragion Chin Arch; BFA- Bitragion Frontal Arch; BSA-Bitragion Subnasale Arch

Multivariate Discriminant Function Equations

Table 6 presents the multivariate discriminant function equations for all the six functions. The function equations were derived for sexual dimorphism through the unstandardized coefficients multiplied by the facial variable and adding the constant.

Table 6: Multivariate Discriminant Function Equations

Functions: 1- Facial Breadths
y=(0.351*MHB)+(0.560*MFB)+(0.518*BAB)+(0.182*BB)+(0.032*IOB)+(0.169*BZB)+(0.301*EB)-19.668
Functions: 2- Facial Lengths
y=(0.907*MHL)+(0.387*EL)+(0.758*NL)+(-0.165*LL)-21.347
Functions: 3- Facial Heights
y=(0.059*PFH)+(0.604*MFH)+(0.276*PUFH)+(0.311*MUFH)+(0.180*HLF)+(1.063*LH)+(0.226*NH)-14.744
Functions: 4- Facial Archs
y=(0.377*BCA)+(0.311*BFA)+(0.097*BSA)-22.690
Functions: 5- Circumference
y=(0.582*MHC)-317.739
Functions: 6- All Variables Combined
y=(0.089*MHC)+(.266*MHB)+(0.494*MFB)+(0.409*BAB)+0.049*BB)+(0.097*EBB)+(0.142*IOB)+ (0.171*BZB)+(0.137*EB)+(0.271*NB)+(0.393MHL)+(-0.049*EL)+(0.648*NL)+(0.317PFH))+(0.037*MFH)+ (0.133*PUFH)+(0.005*MUFH)+(-0.186*HLF)+(-0.087*LH)+(0.145*NH)+(0.203*BCA)+(.094*BFA) +(0.046*BSA)-24.244

Variables:- MHC-Maximum Head Circumference; MHB- Maximum Head Breadth; MFB-Minimum Frontal Breadth; BAB-Bi Auricular Breadth; BB- Bigonial Breadth; EBB-External Biocular Breadth; IOB- Inter Ocular Breadth; BZB- Biozygomatic Breadth; EB- Ear Breadth; NB- Nasal Breadth; MHL- Maximum Head Length; EL- Ear Length; NL- Nasal Length; LL- Lip Length; LH- Lip Height; PFH- Physiognomic Facial Height; MFH- Morphological Facial Height; PUFH- Physiognomic Upper Facial Height; MUFH-Morphological Upper Facial Height; HLF- Height of Lower Face; NH- Nasal Height; BCA- Bitragion Chin Arch; BFA- Bitragion Frontal Arch; BSA-Bitragion Subnasale Arch.

DISCUSSION

Differentiation of sex in the anthropological research or forensic context is the keystone to establish a biological profile of human remains. Indian population shows spectra of heterogeneous and homogenous subpopulations across various regions. Krishan and Kumar studied on two different populations of North India suggest that cephalo-facial dimensions supplemented by facial morphological features can be employed in determining age, sex, stature and race in Indian population (Scheuer, 2002; Krishan & Kumar, 2007; Krishan, 2008).

Sexual dimorphism is one of the important parameter for forensic identification. Choudhary and Kapoor (2014, 2015) studied different population groups in India through Identification Marks for Personal Identification. Although sex determination has been attempted from skeleton remains in different parts of the world but facial measurements have not been used in particular population group. Sex is generally inferred from facial morphology which is highly reliable. Many researchers have made use of different measurements widely in the estimation of sex from different body segments like the skull, long bones, pelvis, clavicle, phalanges, ribs etc. The most popular statistical model in sex determination is the recently developed discriminant function analysis which encouraged many forensic scientists to assess their anthropometric data accordingly. The present study was aimed to see the sexual dimorphism from the facial dimensions among Choudhary Patels of Gujarat.

Overall twenty four variables measured on the Choudhary Patels of the Gujarat and showed significant differences between males and females indicating that the facial dimensions are sexually dimorphic in this population. Therefore, multivariate discriminant function equations that were derived from the variables may be used for sex determination (Table-6). In order to analyse effectiveness of the functions, a "leave-one out classification" technique was applied to the sample to measure accuracy of multivariate classification. This jackknife approach takes one case aside and develops a discriminant function formula to classify that case. The process continues for all cases, one at a time (Iscan & Steyn, 1999).

Discriminant function analysis have been used for determination of sex/population groups through different parts of body like sexing of fragmentary femur of South African blacks (Asala et al, 2004), sexing of the mandible of Indigenous South Africans through discriminant function (Franklin, 2006), morphometric study of the human mandible in the Indian population for sex determination (Sharma et el, 2016) and sexual dimorphism of the craniofacial region in a south Indian population (Bhaskar et al, 2013) and determination of sex using cephalo-facial dimensions by discriminant function and logistic regression equations (Shah et all, 2015) and sex determination from the calcaneus in a 20th century greek population using discriminant function analysis (Peckman et al, 2015).

In the present study, overall accuracies for sexual dimorphism using demarking points for individual variables for the cross validated group (57% to 82%) have been found similar to the study of the Shah et al, 2016 (61.3%-67.1%) as they studied only eight cephalo-facial dimensions for sex determination. In the original as well as cross validated group, MHL (82%) was shown to be the best discriminator of sexual dimorphism while analyzing the individual variable. The original accuracy percentage from the univariate discriminant functional analysis for Choudhary Patels of Gujarat have been found between 49% to 79% in males while 50% to 88% in females for original as well as cross validated group. Overall, accuracy percentages obtained from the original & cross validated groups ranged from 46% to 82% (table-3). Direct multivariate and stepwise discriminant function analysis has been carried out on six functions i.e. facial breadths, facial lengths, facial heights, facial archs, circumference and all variables combined together. Out of the six functions, function-6 (all variables combined together) gave the overall highest accuracy percentage (83.5%) for sexual dimorphism (table-4 & 5).

For the anthropo-forensic identification purposes, methods like discriminant function analysis, logistic regression or demarking points/sectioning points have been used for sexual dimorphism from skull, pelvis, mandible or photograph of the face. All the studies can be accurately determined sex up to 99.9% from different skeleton/bone/measurements on the bones. Due to the difference in methodology, our study cannot be compared with others studies as it highlights the sex determination on living population.

CONCLUSION

Several studies have been carried out on osteometric dimensions between populations and it is well established that in determination of sex from various skeletal parts, standards specific to the population under study should be used (Soni et al, 2010). India is a heterogeneous populated country where different ethnic/population groups existed. So, in such country there is a need of population specific models for sexual dimorphism. The present study provides a population specific technique for sex determination from facial dimensions to establish the identity among Choudhary Patels of Gujarat. Moreover, our study can predict 82% males and 91% females accurately and overall 87% for prediction of sex. Therefore, in the present study, among twenty four measurements, MHB, MFB, BAB, NB, MHL and BCA have been found best predictors for sexual dimorphism in Choudhary Patels of Gujarat. Among all the variables, MHL showed the highest accuracy rates for males (79%) and MHB for females (88%).Discrimination equation can be derived for sexual dimorphism from facial dimension for Choudhary Patels of Gujarat (table-6). These findings provide a model for sexual dimorphism through facial dimension among Choudhary Patel of Gujarat which can be used for identification dynamics for anthropo-forensic purposes.

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REFERENCES

1. *Vinita Murgod, Punnya Angadi, Seema Hallikerimath & Alka Kale (2013) Anthropometric study of the external ear and its applicability in sex identification: assessed in an Indian sample, Australian Journal of Forensic Sciences, 45:4, 431-444, DOI: 10.1080/00450618.2013.767374.z*
2. *Mahfouz, M., Badawi, A., Merkl, B., Fatah, E.E.A., Pritchard, E., Kesler, K., Moore, M., Jantz, R. and Jantz, L., 2007.Patella sex determination by 3D statistical shape models and nonlinear classifiers.Forensic science international, 173(2), pp.161-170.*
3. *Jahanshahi, M., Golalipour, M.J., & Heidari K.2008.The effect of ethnicity on facial anthropometry in Northern Iran. Singapore Med. J.49 (11) : 940*
4. *İşcan, M. Y. (2005).Forensic anthropology of sex and body size. Forensic Science International, 147(2), 107-112.*
5. *Naikmasur, V. G., Shrivastava, R., & Mutalik, S. (2010). Determination of sex in South Indians and immigrant Tibetans from cephalometric analysis and discriminant functions. Forensic Science International, 197(1), 122-e1.*
6. *Krishan, K. & R. Kumar. 2007. Kumar, Determination of stature from cephalo-facial dimensions in a North Indian population, Leg. Med. (Tokyo) 9 (3) 128–133.*
7. *K. Krishan, 2008. Estimation of stature from cephalo-facial anthropometry in north Indian population, Forensic Sci. Int. 81 (1–3) 52.e1–6.*

8. *L. Scheuer, 2002. Application of osteology to forensic medicine, Clin. Anat. 15 (4) 297–312.*
9. *Sharma, M., Gorea, R. K., Gorea, A., & Abuderman, A. (2016).A morphometric study of the human mandible in the Indian population for sex determination. Egyptian Journal of Forensic Sciences, 6(2), 165-169*
10. *Bhaskar, B., Nidugala, H., Bhargavi, C. & Avadhani, R. (2013).Sexual dimorphism of the craniofacial region in a South Indian population. Singapore Med J, 54(8), 458-462.*
11. *Singh, I. P., & Bhasin, M. K. (1968).Anthropometry. Bharti Bhawan.*
12. *İşcan, M. Y., & Steyn, M. (1999).Craniometric determination of population affinity in South Africans. International Journal of legal medicine, 112(2), 91-97.*
13. *Asala SA. Sex determination from the head of the femur of South African whites and blacks. Forensic SciInt 2001;117(1–2):15–22.*
14. *Franklin, D., O'Higgins, P., Oxnard, C. E., & Dadour, I. (2008).Discriminant function sexing of the mandible of indigenous South Africans.Forensic science international, 179(1), 84-e1.*
15. *Soni, G., Dhall, U., & Chhabra, S. (2010). Determination of sex from femur: discriminant analysis. J AnatSoc India, 59(2), 216-221.*
16. *Shah, T., Patel, M. N., Nath, S., & Menon, S. K. (2016). Determination of sex using cephalo-facial dimensions by discriminant function and logistic regression equations. Egyptian Journal of Forensic Sciences, 6(2), 114-119.*
17. *Choudhary, V., & Kapoor, A. K. (2014). Identification marks: biological and psychological dynamics. Int J Res advent Technol 2, 2(7), 155-163.*
18. *Choudhary, V., & Kapoor, A. K. (2015).Forensic VS Psychological Dynamics among Ethnic Groups of Daman and Diu, India.Int J Forensic SciPathol, 3(5), 119-122.*
19. *Choudhary, V. and Kapoor, A. K. (2015): Relevance of Moles, Scars, Tattoo Marks, Birthmarks and Dimples in Ethnic Groups of Nagpur (Maharashtra). Galaxy International Inter disciplinary Research Journal. Vol.3 (6), pp. 122-129*
20. *Choudhary, V. and Kapoor, A. K. (2015): Variability of Identification Marks among Population Groups of Delhi. Human Development: Anthropological Insights. Volume-II.Nirmal Publication (India).ISBN-978-81-931751-9-4.*
21. *Choudhary, V. and Kapoor, A. K. (2015): Forensic Variability of Identification Marks among Indian Population. Environment, Development, Public Policy and Health: Anthropological Perspectives. Vol (I). B.R. Publishing House, Delhi. ISBN 9789350502754.*
22. *Peckmann, T. R., Orr, K., Meek, S., & Manolis, S. K. (2015).Sex determination from the calcaneus in a 20th century Greek population using discriminant function analysis. Science & Justice, 55(6), 377-382.*