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Facial analysis of Indian Americans – A direct anthropometric study

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Abstract
Introduction: Anthropometry technique is widely used to analyze facial morphology in the field of facial cosmetic surgery. Facial anthropometry is well discussed in the western populations, but only a limited number of studies exist for Asian Americans. Indian Americans are the second-fastest growing ethnic group in the United States of America (USA).
Objective: The objectives of the study were to determine the normal average values of linear measurements of the face, determine the number of the individuals with long, normal, and short face, and to determine any significant sex differences that exist in the Indian American students of American University of Antigua (AUA).
Materials and methods: The direct anthropometric measurements (linear measurements, facial shapes and total facial indices) were carried out using digital caliper in 100 male and 100 female Indian American students (18 to 30 years) of American University of Antigua (AUA), Antigua and compared between sexes.
Results: Facial linear measurements showed significant sexual difference in all Indian American subjects. 184 (93 male, 89 female) had a short facial shape and there was no long facial shape found among Indian American females. No significant sexual difference was found in total facial index.
Conclusion: Facial anthropometric data obtained in the present study can be used as a reference value for Indian Americans which can be made use of if they need to undergo facial surgeries.

Keywords: direct anthropometry, linear distances, facial index, digital caliper, facial shape.

1. Introduction

Face is the most important channel of verbal and non-verbal communication in humans. The facial birth defects, injuries or any disorders can affect the facial dimensions. Anthropometry technique is widely used to analyze facial morphology in the field of medicine. Direct facial anthropometry was the first method used in the field of medical and life sciences (Farkas, 1994) [1]. Even now, it is considered to be the gold standard method in assessing the facial dimensions (Zankl *et al*., 2002) [2].

In the field of facial anthropometry, Farkas has done the research extensively in many ethnic groups (Farkas *et al*., 2005) [3]. Facial morphometry is well discussed in Caucasians (Farkas *et al*., 2005) [3] and African Americans (Ofodile *et al*., 1993) [4] but, only a limited number of studies exist for Asian Americans (Sim *et al*., 2000) [5]. The available studies focused mainly on the major group of population in the United States of America (USA). There are very few anthropometric studies that have dealt with different migrant ethnic groups in the USA. Indian Americans are the second-fastest growing ethnic group in the United States. Most of the studies on anthropometric measurements in the USA have been done in Caucasians and therefore may not be applicable for Indian Americans. Aesthetic surgery on Asian Indian American patients relying on Caucasian norms may result in dissonant facial proportions. The challenge for surgeons is to maintain appropriate ethnic facial features. Segher's *et al*., (1964) [6] introduced "golden proportion" as the diagnostic and planning tool in facial surgery. Therefore, in recent years, anthropometric studies have been conducted in different racial/ethnic groups to establish a normative database. Anthropometric data specific to Indian Americans will be useful if in case they need to undergo facial surgeries.

But, the available literature search shows a study performed by Husein *et al*., (2010) [7] dealing only with 100 Indian American womens' face by using photographs. However most

of the studies on facial anthropometric measurements in the USA have been done in Caucasians and therefore may not be applicable for Indian Americans.

The aim of the present study was, to determine the normal average values of linear measurements of the face, determine the number of the individuals with long, normal, and short face, and to determine any significant sex differences that exist in the Indian American students of American University of Antigua (AUA).

1. Methods and Materials
1.1. Subjects
The study group consisted of 200 Indian American students of American University of Antigua (AUA), Antigua, which included 100 males and 100 females. The age of the subjects ranged from 18 to 30 years. This study was approved by the AUA ethics committee. The subjects with previous history of cranio-facial trauma, surgery and bi-racial ethnic origins were excluded in this study. This study was funded by the School of Medicine, AUA, Antigua.

The study was explained and the standard informed consent forms were collected from the participants prior to the study. The anthropometric landmarks were identified on the subjects with careful inspection and were marked on their faces with black liquid eye liner (Table1) (Figure 1).

Table 1: Anthropometric Land marks

| tr	trichion	on the hairline in the middle of the forehead
g	glabella	the most prominent midline point between the eyebrows
n	nasion	the innermost point between forehead and nose
sn	subnasale	midpoint at the union of the lower border of the nasal septum and the upper lip
st	stomion	midpoint of the horizontal labial fissure
gn	gnathion	lowest median point on the lower border of the mandible
zy	zygion	most lateral point of the zygomatic arch
go	gonion	most lateral point on the mandibular angle
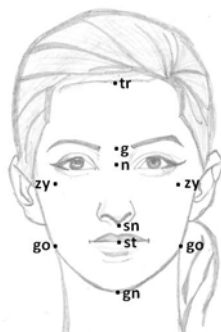
Fig 1: Photograph shows the anthropometric landmarks. tr, trichion; g, glabella; n, nasion; sn, subnasale; st, stomion; gn, gnathion; zy, zygion; go, gonion.

1.2. Position of the subjects
Subjects were asked to sit in an upright relaxed position with "natural and normal" erect posture of head and shoulders and both arms hanging free beside the trunk for the linear measurements of their face (Farkas *et al*., 2005) [3].

1.3. Anthropometric measurements
1.3.1. Manual measurement (Direct method) (Packiriswamy *et al*., 2012) [8]
The following measurements were done up to 0.5 degree and 0.5 mm accuracy on the subjects with maximum care and comfort by using the Neiko 01407A Stainless Steel Digital Caliper with Extra-Large LCD Screen and Instant SAE-

Metric Conversion, New York, USA. Every measurement was obtained twice by the same observer. A third reading was taken if incase the initial two measurements showed a larger discrepancy and finally the two closer readings out of the three were used (Figure 2).
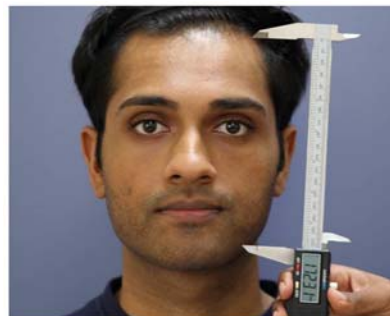

Fig 2: Photograph shows the sample facial linear measurement by using digital caliper.

1.3.2. Linear distances (unit: mm)
The following linear distances were measured and noted. Total face height (tr-gn); morphological face height (n-gn); forehead height 1 (tr-g); forehead height 2 (tr-n); midface height 1 (g-sn); midface height 2 (n-st); lower face height (sn-gn); midface width (zy-zy); mandible width (go-go) (Figures 3 and 4).
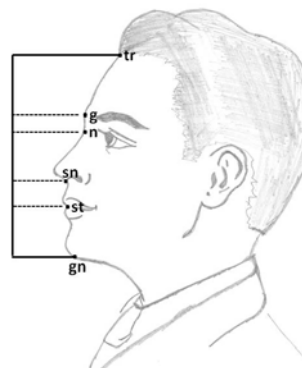

Fig 3: Photograph shows the anthropometric facial linear measurements. tr, trichion; g, glabella; n, nasion; sn, subnasale; st, stomion; gn, gnathion. Total face height (tr-gn); morphological face height (n-gn); forehead height 1 (tr-g); forehead height 2 (tr-n); midface height 1 (g-sn); midface height 2 (n-st); lower face height (sn-gn).
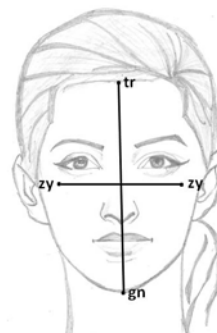

Fig 4: Photograph shows the facial linear measurements of golden proportion and total facial height calculation. tr, trichion; gn, gnathion; zy, zygion. Total face height (tr-gn); midface width (zy-zy).

1.3.3. Shape of the face (unit: mm) (Saraswathi, 2007) [9]
The ratio between the total facial height (tr-gn) and midface width (zy-zy) measurement of each subject was calculated. The golden proportion was 1.6. When the ratio approximated to 1.6, the shape was normal; the shape was long when its ratio was larger than 1.6; and the shape was short when the ratio was smaller than 1.6. (Table 2).

1.3.4. Total facial index (TFI) (unit: mm)
Total facial index was also calculated in all the subjects by using the following standard formula.
Total facial index (TFI) = total facial height (tr-gn) ×100/mid face width (zy-zy).

1.4. Statistical analysis
Data was collected and analyzed in accordance with current law about personal data and privacy. The statistical analysis was performed using the software, Graph Pad Prism version 3.00, Graph Pad Software, Inc. San Diego CA. The linear distance measurements were presented as mean, SEM. The linear distances were compared between Indian American sexes. Values of $P < 0.05$ were considered as significant.

Graphical representation of the subjects with different facial shapes was obtained from Microsoft excel 2010.

2. Results
2.1. Differences in the measurement between sexes: Sexual dimorphism
The linear distance measurements of the Indian Americans (male & female) are presented in Table 2. The total face height (tr-gn); morphological face height (n-gn); forehead height 1 (tr-g); midface height 1 (g-sn); midface height 2 (n-st); lower face height (sn-gn); midface width (zy-zy); mandible width (go-go) showed significant sexual difference in all Indian American subjects, while forehead height 2 (tr-n) showed no significant sexual difference (Table 3).

Table 2: Classification of shape of the face by applying golden ratio

Facial shape	Golden ratio (1.6)
Normal	1.600-1.699
Short	<1.6000
Long	>1.6000

Table 3: Comparison of linear distances in Indian Americans according to sex.

Measurements in millimeter (mm)	Number		Male	Female	P value	95% CI	
	Male	Female	Mean (SEM)	Mean (SEM)		Lower	Upper
Total face height (tr-gn)	100	100	181.3 (0.970)	172.2 (0.807)	p<0.0001	6.702	11.65
Morphological face height (n-gn)	100	100	119 (0.762)	108 (0.670)	p<0.0001	8.977	12.95
Forehead height 1 (tr-g)	100	100	51.95 (0.792)	54.23 (0.758)	p<0.05	0.131	4.429
Forehead height 2 (tr-n)	100	100	62.49 (0.844)	64.29 (0.840)	p>0.05	-0.527	4.137
Midface height 1 (g-sn)	100	100	65.67 (0.394)	61.33 (0.411)	p<0.0001	-5.455	-3.225
Midface height 2 (n-st)	100	100	71.88 (0.540)	67.74 (0.538)	p<0.0001	-5.633	-2.647
Lower face height (sn-gn)	100	100	63.83 (0.592)	56.72 (0.485)	p<0.0001	-8.605	-5.605
Midface width (zy-zy)	100	100	125.9 (1.155)	118.5 (0.786)	p<0.0001	-10.14	-4.666
Mandible width (go-go)	100	100	120.1 (1.030)	111.6 (0.837)	p<0.0001	-11.1	-5.898

p<0.05 was considered to be statistically significant, SEM – standard error of mean, CI –confidence interval.

2.2. Classification of facial shapes based on golden proportion
In the Indian American subjects, 15 (4 male, 11 female) had a normal facial shape, 182 (93 male, 89 female) had a short facial shape and only 3 male had a long facial shape. There was no long facial shape found in Indian American females (Figure 5 and 6).
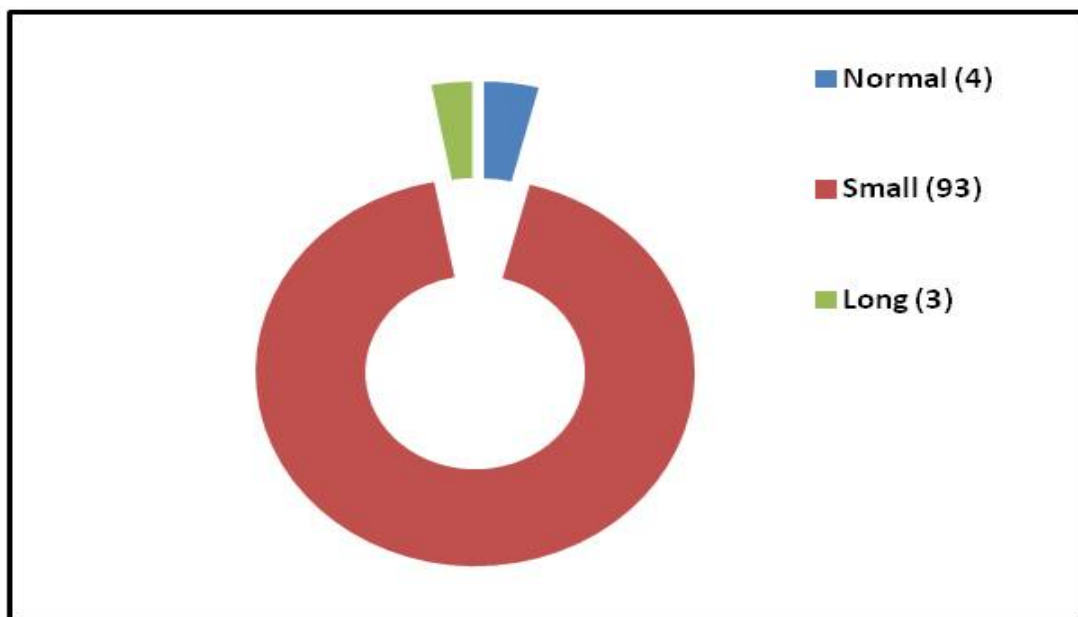

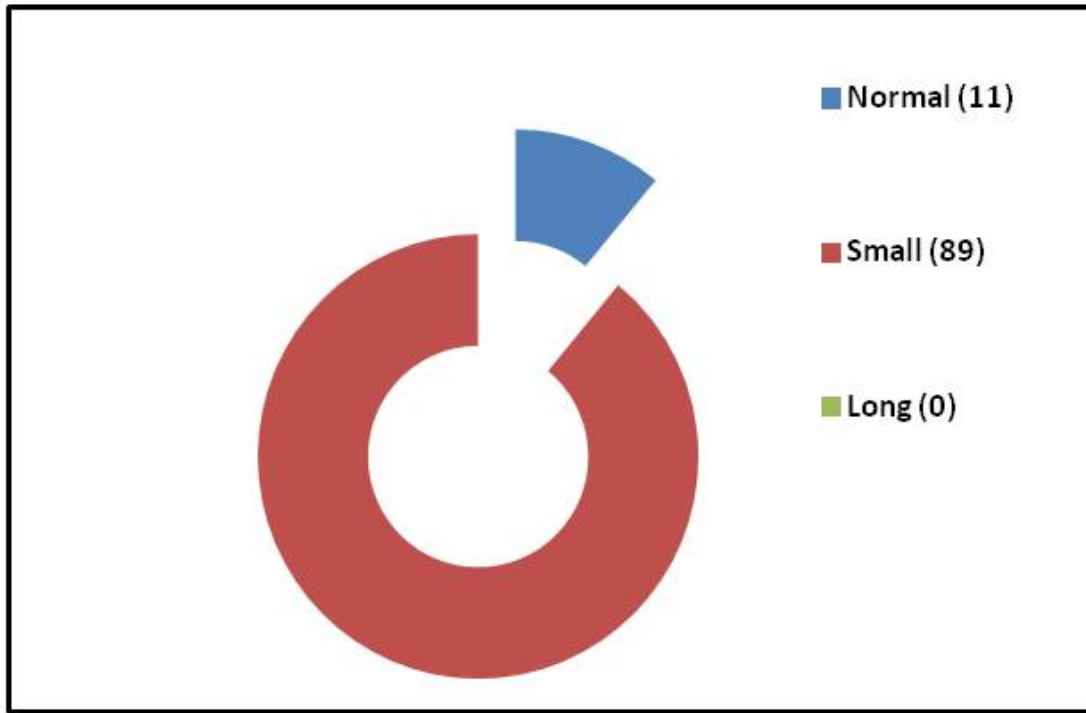**Fig 5:** Face shapes in Indian American male.

Fig 6: Face shapes in Indian American female.

2.3. Total Facial Index (TFI)

Total facial index (TFI) was calculated in all the Indian American subjects and showed no significant sexual difference (Table 4).

Table 4: Comparison of facial index (FI) in Indian Americans according to sex (measurements in mm).

	Male	**Female**
Number of values	100	100
Minimum	113.5	125.7
Median	143.3	146.3
Maximum	191.2	169.4
Mean	144.9	145.8
Std. Deviation	12.23	9.633
Lower 95% CI	142.5	143.9
Upper 95% CI	147.4	147.7

3. Discussion

Currently, cosmetic surgery is the fourth most common surgical procedure in the United States of America (USA). Planning and carrying out the treatment for facial deformities, face alterations is a challenging task in the fields including facial reconstructive surgeries, maxillofacial surgeries and forensic applications (LC *et al*., 2013) [10]. It has been reported that anthropometric measurements may vary based on sex, race, dietary habits, climates and the surrounding environments (Wankhede *et al*., 2012) [11]. Results of the studies conducted in certain ethnic groups or regions may not be applicable to the populations elsewhere (Wankhede *et al*., 2012) [11]. Therefore there is a need for systematic study for each ethnic groups or region. It is desirable that studies should be carried out in different ethnic groups to establish the normal reference values on different anthropometric measurements (Kunjur *et al*., 2006) [12]. Comparison of the present study with other studies on the Indian population revealed variations and similarities in the facial measurement.

In the present study, the total facial height (tr-gn) in the male (181.3) was greater than the female (172.2). In contrast, the two studies performed by Farkas *et al*., (2005) [3] and Wankhede *et al*., (2012) [11] showed lower value for both the male and female in India. In these studies, Farkas *et al*., (2005) [3] had greater value for the female (163.0) than the male (161.3) and Wankhede *et al*., (2012) [11] had greater value for the male (170.97) than the female (156.87).

The present study's total facial height (tr-gn) is similar to the study conducted by Farkas *et al*., 2005 [3] in North American Caucasian population (187.5 in male; 172.5 in female). Husein *et al*., (2010) [7] photographic study on total facial height (tr-gn) of the Indian American female (169.4) and Packiriswamy *et al*., (2012) [8] photographic study on Malaysian Indian female (172.7) were similar to the present study.

In the present study, the morphological facial height (n-gn) in the male (119) was greater than the female (108). In contrast, the Indian study performed by Farkas *et al*., (2005) [3] showed lower values for both the male (112.5) and female (101.5) and LC *et al*., (2013) [10] study showed higher values for both the male (123.6) and female (117.0). The study on the Indian population by Jagdish Chandra *et al*., (2012) [13] showed similar value for the male (119.98) and higher value for the female (119.95). Husein *et al*., (2010) [7] photographic study on morphological facial height (n-gn) of the Indian American female (102.3) showed lower value and Farkas *et al*., (2005) [3] study showed higher value in the North American Caucasian female (111.8) when compared to the present study.

In the present study, the forehead height 1 (tr-g) in the female (54.23) was greater than the male (51.95). Husein *et al*., (2010) [7] photographic study on forehead height 1 (tr-g) of the Indian American female (54.2) and Farkas *et al*., (2005) [3] study on North American Caucasian female (52.7) were similar to the present study.

In the present study, the forehead height 2 (tr-n) showed no significant sexual difference (male 62.49, female 64.29). In contrast, the studies performed by Farkas et al., (2005) [3] showed higher value for the Indian male (65.5) and similar value for the Indian female (64.2) and also higher value for the North American Caucasian male (70.1) than female (63.3). Husein et al., (2010) [7] photographic study on forehead height 2 (tr-n) of the Indian American female (63.9) showed similar value and Farkas et al., (2005) [3] study showed lower value (63.0) in the North American Caucasian female when compared to the present study.

In the present study, the midface height 1 (g-sn) and midface height 2 (n-st) in the male (65.67 and 71.88) was greater than the female (61.3 and 67.74). Husein et al., (2010) [7] photographic study on midface height 1 (g-sn) and midface height 2 (n-st) of the Indian American female (58.1 and 65.0) showed lower value and Farkas et al., (2005) [3] study showed higher value in the North American Caucasian female (63.1 and 69.4) when compared to the present study.

In the present study, the lower facial height (sn-gn) in the male (63.83) was greater than the female (56.72). In contrast, the studies performed by Farkas et al., (2005) [3] showed similar values for both Indian male (62.7) and female (57.2) and higher values for both North American Caucasian male (71.9) and female (65.5). The study on Indian population by Jagdish Chandra et al., (2012) [13] showed lower value for the male (54.54) and higher value for the female (59.12). Husein et al., (2010) [7] photographic study on lower facial height (sn-gn) of the Indian American female (57.8) showed lower value and Farkas et al., (2005) [3] study showed higher value (64.3) in North American Caucasian female when compared to the present study.

In the present study, the midface width (zy-zy) in male (125.9) was greater than the female (118.5). In contrast, the Indian study performed by Jagdish Chandra et al., (2012) [13] showed lower values for both the male (118.65) and female (112.38) and LC et al., (2013) [10] study show lower value for the male (122.2) and similar value for the female (118.5). The studies performed by Farkas et al., (2005) [3] showed higher values for both Indian and North American Caucasian males (135.8 and 137.1) and females (124.9 and 129.9). Packiriswamy et al., (2012) [8] photographic study also showed higher values for both Indian male (130.3) and female (124.0). Husein et al., (2010) [7] photographic study on midface width (zy-zy) of the Indian American female showed similar value (125.9) and Farkas et al., (2005) [3] study showed higher value (130.0) in North American Caucasian female when compared to the present study.

In the present study, the mandible width (go-go) in the male (120.1) was greater than the female (111.6). In contrast, the studies performed by Farkas et al., (2005) [3] showed lower values for both Indian and North American Caucasian males (102.8 and 97.1) and females (97.4 and 91.1). The study on the Indian population by Jagdish Chandra et al., (2012) [13] showed lower value for the male (115.72) and higher value for the female (113.84) when compared to the present study. Husein et al., (2010) [7] photographic study on mandible width (go-go) of the Indian American female (95.2) and Farkas et al., (2005) [3] study on North American Caucasian female (91.1) showed lower value when compared to the present study.

In the present study, among 200 Indian American subjects, 15 (4 male, 11 female) had normal facial shape, 182 (93 male, 89 female) had short facial shape and only 3 male had long facial shape. A study by Saraswathi, (2007) [9] on 75 Indian subjects (37 male, 38 female), showed 14 (5 male, 9 female) had normal facial shape, 50 (26 male, 24 female) had short facial shape, and 11 (6 male, 5 female) had long facial shape. A study by Packiriswamy et al., (2012) [8] on 100 Malaysian Indian subjects (50 male, 50 female), showed 20 (10 male, 10 female) had normal facial shape, 75 (36 male, 39 female) had short facial shape and 5 (4 male, 1 female) had long facial shape.

Deviation from the normal face shape may prone to the development of facial, jaw or respiratory disorders (Packiriswamy et al., (2012) [8]; Saraswathi, (2007) [9]). Interestingly, in our study, there was no long facial shape found whereas the study conducted by Saraswathi, (2007) [9] showed 5 out of 75 Indian female had long facial shape. In the available literature survey, we could not find the study on facial golden proportion in the Indian Americans by using direct anthropometry.

In our study, the facial index showed no significant sexual difference (male 144.9, female 145.8). The facial index study by Packiriswamy et al., (2012) [8] on 100 Malaysian Indians (male 141, female 139) is similar to the present study.

The direct facial anthropometry method is a time consuming process and it necessitates very well trained and experienced examiners. It is very demanding for both the clinician and the patient (White et al., 2004) [14]. But, presently, the advent of digital techniques (indirect anthropometry) for the imaging of the facial skeleton can be combined with direct anthropometry.

4. Conclusion
The linear distance measurement showed significant sexual difference in all Indian American subjects. The present study's facial anthropometric data can be used as a reference value for the Indian Americans incase if they need to undergo facial surgeries in the USA.

5. Acknowledgements

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