

# Analysis of Facial Phenotype Based on Facial Index Classification Using Cone-beam Computer Tomography in the Saudi Population

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## ABSTRACT

**Aim:** To provide normative values of facial height, width, and facial index, and determine the distribution of facial phenotypes among adults in Saudi Arabia.

**Methods:** The sample comprised 261 cone-beam computer tomographic images, examined using vision iCAT software. The facial height and width were measured linearly, from which the facial index was calculated. Facial phenotype was determined based on the facial index classification and the samples were grouped accordingly.

**Results:** The mean facial height was 118.94mm (SD= ±7.73), facial width was 129.27mm (SD = ±6.64), and facial index was 92.09mm (SD= ±5.50). Males show statistically higher means of the variables, (facial height: t=9.66, p=0.001), facial width: t=7.05, p=0.001), and facial index (t=3.25, p=0.021). All five facial phenotypes were observed, distributed as 6 hypereuryprosopic, 18 euryprosopic, 81 mesoprosopic, 96 leptoprosopic, and 60 hyperleptoprosopic. The majority (38% and 29%) of the males in the samples were categorized as leptoprosopic and hyperleptoprosopic, respectively. Of the 96 females, only three were observed to be hypereuryprosopic. Mesoprosopic and leptoprosopic made up 38%, and 34% of the females whereas hyperleptoprosopic and euryprosopic each made up 13%. Persons' gender was found to influence the facial phenotype among the sample.

**Conclusion:** Leptoprosopic was the most common facial phenotype in the samples, whereas the least type was hypereuryprosopic. For males, leptoprosopic was the most common while mesoprosopic was the most common for females. Our study's data may be used as a guide for facial analysis, which will be helpful for forensic investigations, orthodontics and reconstructive surgery, and anthropological studies.

**KEY WORDS:** Bizygomatic width, Cone-beam Computer Tomography Facial index, facial phenotypes, Prosopic classification.

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## INTRODUCTION

In anthropometry, the term "facial index (FI) has been used to characterize the different phenotypic appearance of faces [1].

It is calculated by dividing the morphological

facial height (FH) by the bizygomatic width, also known as the facial width (FW). The FH is determined by measuring the distance from the nasion to the gnation, the lowest point of the jaw [2]. The bizygomatic distance, which is

measured from the maximal terminus of the zygomatic arch to the other, is used to determine the facial width [3]. Facial phenotypes are divided into five categories based on Martin-Saller's scale: hyperleptoprosopic, leptoprosopic, mesoprosopic, euryprosopic, and hypereuryprosopic [2-4]. Term *Prosopic* was devised from the Greek word "prosopon", meaning the face [4].

Numerous factors influence the morphologic aspects of the face, including gender, ethnic background, age, geographical area, surroundings, and genetics [5].

A long history of environmental changes has shaped human cephalofacial features, with inherited factors playing an innately significant influence [5]. Establishing the ethnicity of an individual may be essential for forensic genetic examination, reconstructive facial and orthodontic surgery. This makes anthropologists, plastic surgeons, dentists and anatomists to have long found the shapes of an individual's face to be of utmost significance [6]. Finding the traits of a typical face and the amount of deviation that can be accepted in a regular face is crucial before thinking about orthodontic or combined orthodontic and orthognathic treatment options [6].

Direct anthropometry taken during a patient examination has been demonstrated as being the best technique for assessing craniofacial dysmorphology [7]. Despite this fact, a number of novel technologies have been developed recently to computerize anthropometric data [6]. Conventional direct anthropometry is a non-invasive, low-cost, and dependable method that has been used extensively for determining a person's sex and race [2,8,9]. However, this will require physical measurements taken on the individual. Using radiologic images like the cone beam computer tomographs (CBCT), one may obtain near accurate measurements of the facial dimension, as soft tissue effects may be insignificant [10,11]. What CBCT can do is providing images with a sub-millimeter resolution and higher diagnostic value, with scan times of about 60 seconds. Additionally, the radiation dose from CBCT is ten times lower than the standard computer tomographic (CT) scans performed

during maxillofacial exposure [10].

According to a 2021 study by Muralidhar and associates, anthropometric standards are essential for assessing variations in craniofacial morphology within a specific group [12]. Both male and female workspaces, apparel, and equipment might be designed using the population-specific craniofacial requirements that have been determined [13]. Accordingly, these factors need to be considered when choosing orthodontic biomechanics and face surgeries.

There is no available information that shows the normative values of the facial index and/or facial phenotype in Saudi population; therefore, this study aims to establish reference values for the facial index, using CBCT measurements in order to ascertain facial phenotypes among adult Saudi population. Clinicians could utilize the data generated from this study for surgical purposes and for forensic analyses using the facial phenotypes.

## MATERIALS AND METHODS

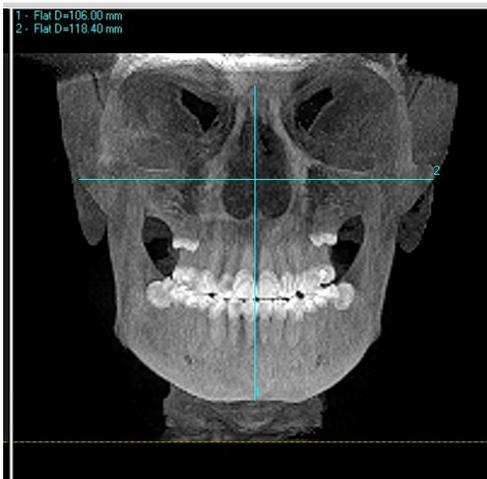
**Study Setting and Design:** The study was conducted at dental college of King Faisal University, AlHassa, Eastern Saudi Arabia. It was a retrospective cross section study, by selecting and examining CBCT images taken in the clinic complex between the year 2021 to 2024.

**Samples selection:** Two hundred and sixty-one (261) cone beam computer tomographic (CBCT) images were randomly selected from the image databank of the Dental Clinic. The images were of male and female adults (aged 20 – 60 years) of Saudi ethnicity. Any obvious anatomical abnormality was excluded before final selection of images. The exclusion also included significant malocclusion, multiple teeth loss and facial asymmetry.

**CBCT Image analysis:** The CBCT machine was a 3D Accuitomo 170 (MORITA, Japan) with 90Kv, 5–8mA. It uses an exposure time of 17.5s, and 0.25mm voxel size. Vision iCAT imaging software, downloaded onto the personal computer, was used in processing the facial images. Preview screens were used in measuring facial dimensions (plate 1). Facial height

(FH) was measured from the midpoint of the nasofrontal suture (nasion, n) to the lowest point on the lower border of the mandible, in the midline (gnation, gn). Facial width (FW) was measured from the outermost point of the right zygomatic arch (zygion, zy) to the same point on the left [4]. Facial index (FI) was calculated for each subject using the formula: [14]

$$FI = \frac{FH}{FW} \times 100$$



**Plate 1:** Preview screen, Facial height and width.

**Banister’s classification was used to determine the facial type based on the facial index.**

- 1 Hypereuryprosopic (very broad face): Facial index below 80%.
- 2 Euryprosopic (broad face): Facial index between 80 and 84.9%.
- 3 Mesoprosopic (round face): Facial index between 85 and 89.9%.
- 4 Leptoprosopic (long face): Facial index between 90 and 94.9%.
- 5 Hyperleptoprosopic (very long face): Facial index above  $\geq$  95%.

**Data analysis:** All measurements obtained were entered into an excel datasheet, recorded and tabulated. Data was then imported into, and analyzed using SPSS, version 25 (IBM Corporation, for Windows). Measurements were expressed in terms of descriptive statistics (minimum, maximum, mean, and standard deviation). Kolmogorov Smirnov tests was done to test for normality. To evaluate the sexual dimorphism Students t-test was employed to analyze the mean difference between males and females

measured and calculated variables. Chi squared test was employed to determine significance of distribution of facial phenotype among the samples based on gender.

**RESULTS**

Among the 261 CBCT images analyzed 165 were males and 96 were for females. Normality test shows normal distribution in all the measured parameters in the study. The Kolmogorov Smirnov test result was not statistically significant ( $p > 0.17$ ), indicating the data was normality distributed. Table 1 shows descriptive statistics of the facial measurements among the sample. Mean facial height was 118.94mm (SD =  $\pm 7.73$ ), facial width was 129.27mm (SD=  $\pm 6.64$ ), and facial index was 92.09mm (SD =  $\pm 5.50$ ).

**Table 1:** Descriptive statistics of facial dimensions among subjects.

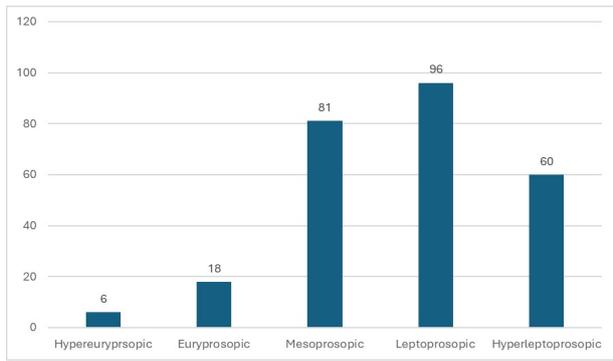
Variable	n	Min	Max	Mean	$\pm$ SD
FH (mm)	261	101	134	118.94	7.73
FW (mm)	261	112	140.75	129.27	6.47
FI (%)	261	73.19	105.44	92.09	5.5

FH: Facial height. FW: Facial width. FI: Facial index  
In table 2, the result of independent sample t-test was shown indicating extent of sexual dimorphism among the Sample. Males show statistically higher means of facial height ( $t= 9.66, p=0.001$ ), facial width ( $t=7.05, p=0.001$ ) and facial index ( $t=3.25, p=0.021$ ).

**Table 2:** Sexual dimorphism of the facial dimensions

Variable	Males n=165		Females n=96		t	p Value
	Mean	sD	Mean	sD		
FH (mm)	122.39	6.487	113.02	5.945	9.66	0.001
FW (mm)	131.64	5.176	125.21	6.539	7.02	0.001
FI (%)	93.08	5.455	90.39	5.239	3.25	0.021

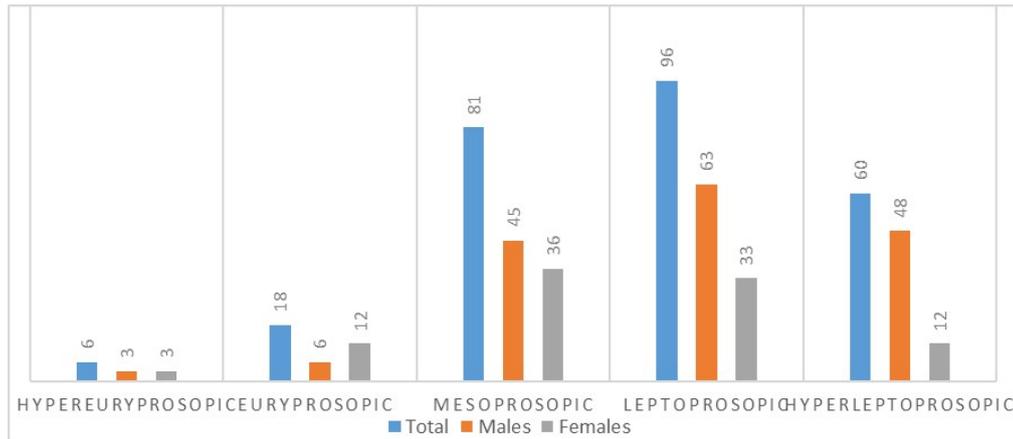
FH: Facial height. FW: Facial width. FI: Facial index  
Based on the facial index classification, all five phenotypes were observed among the sample, namely hypereuryprosopic, Euryprosopic, Mesoprosopic, Leptoprosopic, and Hyperleptoprosopic (Figure 1). Majority, 96 (37%) of the sample were leptoprosopic phenotype, followed by mesoprosopic 81 (30%) and hyperleptoprosopic 60 (23%). Euryprosopic and hypereuryprosopic were the least observed among the subjects (18, 7% and 6, 2% respectively).



**Fig. 1:** Facial phenotype among the sample, based on facial index classification.

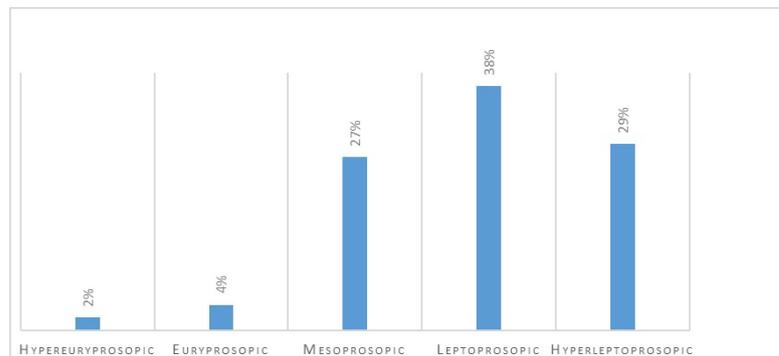
**Table 3:** Chi squared test of independence between facial type and gender

Facial type	Male	Female	$\chi^2$	P value
Hypereuryprosopic	3 (3.9)	3 (2.9)		
Euryprosopic	6 (11.4)	12 (6.6)		
Mesoprosopic	45 (51.3)	36 (29.7)	5.697	0.04
Leptoprosopic	63(60.6)	33(33.8)		
Hyperleptoprosopic	48(36.6)	36(21.2)		



**Fig. 2:** Facial Classification among the samples, based on gender.

**Fig. 3:** Facial classification among male subjects.



**Fig. 4:** Facial Classification among female subjects.

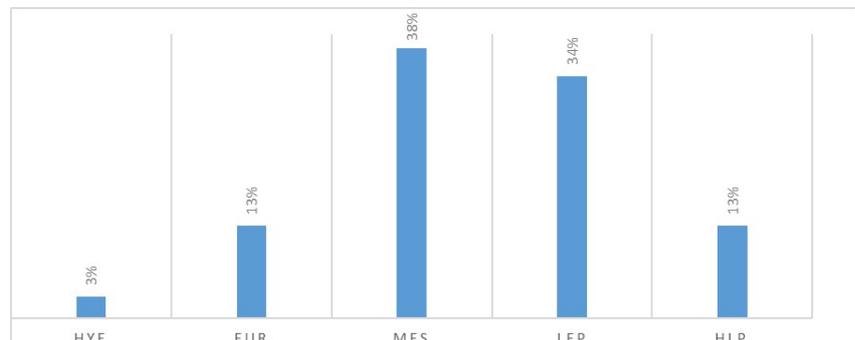


Figure 2 shows the gender distribution of the facial types among the sample. Of the six hypereuryprosopics 3 were males and 3 were females, given a 1:1 gender ratio. For euryprosopic class 13, (67%) were females while six, (33%) were males. Forty-five (56%) of the mesoprosopic and 63 (66%) of the leptoprosopic were males. The females

comprised only about 20% of the hyperleptoprosopic class.

In females, only three (3%) of the 96 subjects were found to be hypereuryprosopic. Euryprosopic and hyperleptoprosopic both comprised 13% each, whereas majority (38%) were mesoprosopic followed by leptoprosopic comprising 33% (figure 4).

Table 3 shows the relationship of the distribution facial type between male and female subjects using a chi squared test of independence. The result shows a chi of 5.697  $p=0.04$  indicating that gender has significant influence on facial phenotype.

## DISCUSSION

This study highlighted the use of CBCT images in obtaining some key facial dimensions; facial height and width, from which facial index (FI) was calculated. The FI was then used to classify the subjects based on a classification method into five types of faces (*prosopics*). We then determined the distribution of these facial phenotypes based on gender.

The average facial height found (118.92 mm  $\pm 7.73$ sd) in this study is lower than that obtained in a study [15] of a population in northeastern part of Nigeria (141.15 mm  $\pm 7.5$ , males and 141.29 mm  $\pm 7.6$ , females), the population of India [16] (130.02 mm  $\pm 7.2$ , males and 125.4 mm  $\pm 6.0$ , females) and in Sri Lanka (140.2 mm  $\pm 10.3$ , males and 138.8 mm  $\pm 12.9$ , females) [17]. Other African population studies by Ese and associates also show higher facial height [3]. Similarly, a study in Iraq show much higher FH in studies among Arabs [18]. Those studies were conducted by physical measurements and soft tissue effect might have caused the differences.

There was strong sexual dimorphism observed in our study subjects, as we found that males have statistically significant facial height and width. This is in consistence with the findings by S. M. Adekunle who found that the difference in facial dimensions in Nigerian adults was statistically significance [19]. In a similar context to our study, Dodangheh [20] also found that there was substantial variation in the face index between males and female students in Tehran University, with males typically having significantly higher mean values. Another study have shown that for all linear metrics, the values for males were considerably higher than those of females in a Brazilian subpopulation [5]. This may be indicative of the fact that females were, in general, having smaller faces than males and may also support the idea that males have an

averagely larger body size and proportion compared to females, which is also manifesting in certain regions of the face. Conversely, studies have shown that gender differences in mesofacial type were not statistically significant in inferior face index or mandibular proportion [21].

The predominant facial index (FI) found in this study was 92%, as determined by the mathematical calculations. It is interesting to observe that, although in this study the FI measurements were obtained using CBCT images, the value is near to with that obtained from studies conducted among a large Indian population [4].

This observation may indicate some accuracy of obtaining the FI measurements using radiologic images instead of physical measurements.

Based on the facial phenotypes, the predominant face shape found in this study was leptoprosopic, accounting for 37%, followed by mesoprosopic (31%). Euryprosopic and hypereuroprosopic types were the least observed among the samples. Shrestha in 2019 have shown that the leptoprosopic type of face was 40.46% and was the most common facial type observed in their study samples, among which 21.39% were males and 33 (19.07%) were females [6]. A study [14] among medical students in Nepal showed that in males, leptoprosopic faces were prevalent ( $n = 33$ , 45.84%), whereas mesoprosopic faces were dominant in the females ( $n = 38$ , 45.79%). This is similar to our finding where we observed the most prevalent face type among males to be leptoprosopic and in females was mesoprosopic.

M Dodangheh have shown that the most frequent face class was the hyperleptoprosopic type based on the total facial index in an Iranian population, demonstrating the variations among the different populations [7].

In Malabar region of Kerala, based on the analysis of the facial index, the mesoprosopic facie was found to be the most common, accounting for 38.3% of subjects examined [12].

In sharp contrast to our study, which found only 2% of our sample to be of

hypereuryprosopic face type and 18% of euryprosopic type, Trivedi in Indian population showed that overall, the majority of the samples they examined had the euryprosopic type (53.2%). This was followed by those having the mesoprosopic type (21.6%), hypereuryprosopic type (19%), leptoprosopic (5.6%), and hyperleptoprosopic type (0.6%) phenotypes [22]. This could highlight the significance of genetic influence in facial phenotype determination. In another Indian population, Kumari [2] reported that the most common face type in males was mesoprosopic and in females was euryprosopic. Additionally, we found that leptoprosopic and hyperleptoprosopic types together comprised more than half of our samples. A study in an Iraqi population, the leptoprosopic type was the predominant facial type, and it is significantly affected by gender [9]. Being an Arab nation similar to our sample's ethnicity, we found a similar trend, with the leptoprosopic type found to be the most common face type. The former finding was almost similar to our findings of leptoprosopic, while the latter was not, as we found only 16% of our sample as euryprosopics.

In Nigeria, Ese and associates [3] showed that the mesoprosopic facial type was the dominant form of face type in males, while the hyperleptoprosopic was the dominant form among females. This, again, is opposite to our findings among our sample, where leptoprosopic and mesoprosopic types were most common among males and females, respectively.

Lakshmi have shown that facial index in males shows mesoprosopic with 20.4%, euryprosopic with 21%, leptoprosopic with 10%, and hyperleptoprosopic and hypereuryprosopic with less percentage. In females, most of the subjects are euryprosopic and 7% leptoprosopic [23].

It is obvious that a variety of studies indicate that the facial morphological typology varies widely; in the ethnic Hungarian population in Vojvodina, Serbia, a study [24] showed the mesoprosopic face is the predominant facial form, the leptoprosopic facial type that is most common in Serbia's central area [13], and the Albanian population of Kosovo shows most

prevalent phenotype as leptoprosopic.<sup>1</sup> The majority of people in Croatia are mesoprosopic facial type [25].

## CONCLUSION

This study has provided the reference values of facial index and have highlighted the most common facial phenotype in the adult Saudi population as leptoprosopic, and the least was hypereuryprosopic. In males leptoprosopic phenotype was most frequent while most females were mesoprosopic. The data obtained in the study may be useful as a reference for facial analyses that will be further useful in anthropological, forensics & genetic research, clinical practice, reconstructive surgery and in cosmetology.

**Conflicts of Interests:** There are no conflicts of interest.

## Author Contributions

**Nuraddeen Jaafar Ibrahim:** Study conception and design, data collection, analysis and interpretation of results, and manuscript preparation. Submission of manuscript and correspondence.

**Prashanth Kumar Katta:** Data collection, analysis, interpretation, and manuscript preparation.

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