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# Cephalometrics For Orthognathic Surgery (Cogs) Analysis For Saudi Arabian Adults

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***ABSTRACT***

***Introduction: The significance of this cephalometric analysis lies in multiple aspects; the first of which is that cephalometric analysis is crucial in the diagnosis of both skeletal and dental anomalies. Secondly it allows clinicians to evaluate operative changes during, and after the treatment period, not to mention its role in simulating orthognathic surgery through what's known as 'Surgical Treatment Objective' (STO), only one other analysis tailored for orthognathic surgery was done on the Saudi Arabian population has been published yet the approach of the researchers lacked the necessary soft tissue measurements categorized under (Lip Position and Form). Therefore, it is imperative to establish comprehensive assessment COGS standards for the Saudi Arabian population which is in fact the aim of this study.***

***A: To provide a comprehensiveassessment of COGS standards for the Saudi Arabian population.***

**MATERIALS AND METHODS:**The sample consisted of (160) lateral cephalometric radiographs in standard configuration of male and female Saudi Arabian adults randomly selected amongst the orthodontic patients of (College of Dentistry, Jouf University). The inclusion criteria were (good quality cephalometric radiographs, with visible landmark) of Saudi Arabian adults aged (20-25) years. All relevant cephalometric landmarks were determined and the necessary analysis was done using the SPSS software. The level of significance was tested using independent t-test. A p value of <5% ($p<0.05$) was considered to be significant.

**Results:**The reliability of the method was analyzed by calculating the Dahlberg's formula. The descriptive statistics of all lateral cephalometric radiographs for (38) measurements were carried out on the entire sample size of (160 subjects). None of the parameters measured showed any significant differences between Saudi Arabian males and females. However significant differences were observed between Saudi Arabian values and Caucasian norms.

**Conclusion:**This study has provided a comprehensive assessment ofcephalometrics for orthognathic surgery for the Saudi Arabian population as well as showing inter-sex dimorphism in a multitude of variables

**KEY WORDS:** Cephalometric analysis, COGS, COGS Analysis, Saudi Arabian cephalometric norms.

## INTRODUCTION:

In current day orthodontic practice, whenever a patient requires a combination of orthodontic treatment and orthognathic surgery, their treatment goals are usually assessed via lateral and anteroposterior cephalometrics, the significance of this cephalometric analysis lies in multiple aspects; the first of which is that cephalometric analysis is crucial in the diagnosis of both skeletal and dental anomalies. Secondly it allows clinicians to evaluate operative changes during, and after the treatment period, not to mention its role in simulating orthognathic surgery through what's known as 'Surgical Treatment Objective' (STO).

(Burstone *et al.,* 1978)[1]Have developed a mode of cephalometric analysis especially designed for patients who require maxillofacial surgery. It has been developed to use landmarks and measurements that can be altered by common surgical procedures. And because measurements are primarily linear, they may be readily applied to prediction overlays and study cast mountings and may serve as a base for the evaluation of post-treatment stability.COGS system describes the horizontal and vertical positions of the facial bones by the use of constant coordinate systems, it can be categorized briefly as follows:

- Size of the bone are represented by direct linear measurements.
- Shape of the bones are represented by the angular measurements.
- Vertical and horizontal (skeletal, and dental) measurements.
- Maxilla/Mandible position.
- Facial form, and lip position and form.

However, soon afterwards it became apparent that values obtained from a specific ethnic population may not be applicable to other ethnic populations, and studies establishing populations-specific standardized values became a necessity for a true scientific approach. The following studies are a prime example of how important it is to establish cephalometric norms for specific ethnic groups: Jarabak-Bjork's[2,3]Holdaway's[4,5], Down's[6], Harvold's[7], Tweed and Witt's[8], combined Steiner's and Down's[9–13] and soft tissue analysis[14–17]. There arehand full of cephalometric analysis studies targeting the Saudi Arabian population[18–20] In addition, only one other analysis tailored for orthognathic surgery was done on the Saudi Arabian population. (AlBarakati et al., 2010) Have published a study establishing cephalometric

norms for orthognathic surgery for the Saudi Arabian population, yet their approach lacked the necessary soft tissue measurements categorized under (Lip Position and Form).[21]

Therefore, it is imperative to establish comprehensive assessment of COGS standards for the Saudi Arabian population which is in fact the aim of this study.

**MATERIALS AND METHODS:**

The following COGS variables (reference points) [Table-1] were used to compare the mean linear and angular values of the horizontal (skeletal and dental), Dental, facial form, lip position and form, and bony profile contour between the Saudi Arabian population and those of other ethnic groups including Caucasians.

**[Table-1]: COGS Parameters, including (2) cranial base measurements, (4) Horizontal (skeletal and dental), (8) Vertical (Skeletal and dental), (5) related to maxilla and mandible, (6) dental, (6) in relation to facial form, and (7) in relation to lip position and form. (38) in total. With a brief description.**

| Parameter | Description |
|---|---|
| **Cranial Base** | |
| Ar-Ptm (//HP) | the distance between Ar and Ptm which is measured parallel to HP. Ar-Ptm indicates the position of mandible in relation to posterior surface of maxilla |
| Ptm-N (//HP) | the distance between Ptm and N which is measured parallel to HP. Ptm-N indicates the position of posterior border of maxilla in relation to Nasion |
| Horizontal (Skeletal, Dental) | |
| N-A-Pog | the angle formed between N-A and A-Pg. A positive angle indicates convex profile while negative angle indicates concave profile |
| N-A (//HP) | A perpendicular to HP is dropped from N (N perpendicular) and horizontal distance parallel to HP is measured from point A. This measurement describes the position of apical base of maxilla in relation to nasion. |
| N-B (//HP) | The distance between Point B and Nasion perpendicular (N perpendicular). This measurement describes the position of apical base of mandible in relation to nasion. |
| N-Pog (//HP) | the distance between Pogonion and Nasion perpendicular (N perpendicular to HP). This measurement describes the position of mandibular chin in relation to nasion. |
| **Vertical (Skeletal, Dental)** | |
| N-ANS (⊥HP) | The istance between N and ANS measured perpendicular to HP gives us the Middle third facial height. Any increase or decrease in this value indicates increased or decreased middle third facial height respectively. |
| ANS-Gn (⊥HP) | The distance between ANS and Gn measured perpendicular to HP gives us the Lower third facial height. Any increase or decrease in this value indicates increased or decreased lower third facial height respectively. |
| PNS-N (⊥HP) | Distance between PNS and HP gives us the posterior maxillary height. Any increase or decrease in this value indicates increased or |

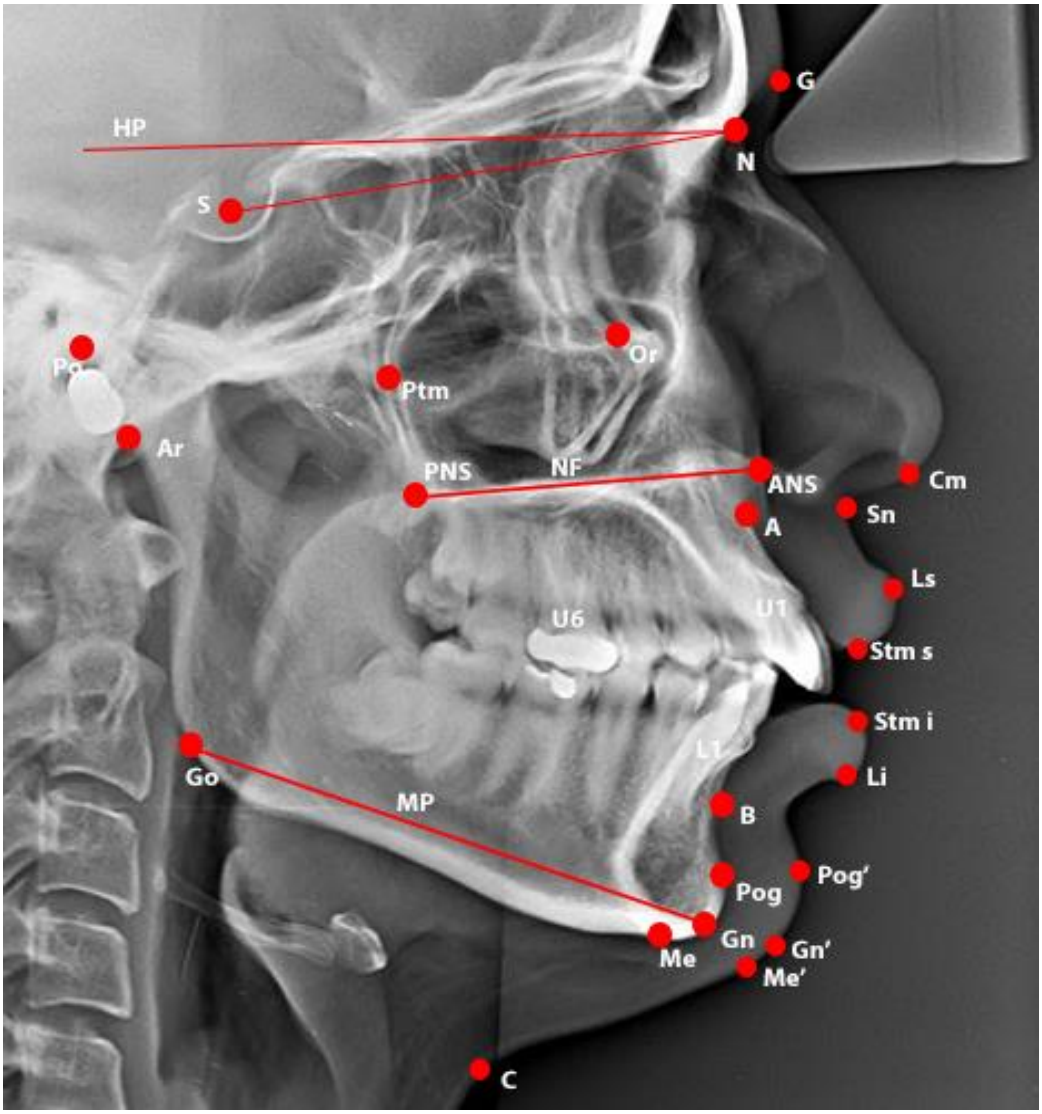
| | |
|---|---|
| | decreased posterior maxillary height respectively. |
| MP-HP | The mandibular plane angle in relation to Horizontal plane intersecting at Gn gives us posterior divergence of mandible. Any increase or decrease in value suggests increased or decreased posterior facial divergence. |
| U1-NF (⊥NF) | The perpendicular distance from incisal edge of upper incisor to palatal plane is measured. Any increase or decrease in this value indicates increased or decreased upper anterior dental height respectively. |
| L1-MP (⊥MP) | The perpendicular distance between incisal edge of lower incisor to MP is measured. Any increase or decrease in this value indicates increased or decreased lower anterior dental height respectively. |
| U6-NF (⊥NF) | A perpendicular line is dropped from the tip of mesiobuccal cusp of upper first molar to palatal plane. Any increase or decrease in this value indicates increased or decreased upper posterior dental height respectively. |
| L6-MP (⊥MP) | A perpendicular line is dropped from the mesiobuccal cusp of lower first molar to MP. Any increase or decrease in this value indicates increased or decreased lower posterior dental height respectively. |
| **Maxilla, Mandible** | |
| PNS-ANS (//HP) | Distance between these two points on HP gives us total effective maxillary length |
| Ar-Go (linear) | Mandibular ramal length is the linear distance between Articulare and Gonion. Variation in Ramal length can be a causative factor for skeletal open bite or deep bite. |
| Go-Pog (linear) | Mandibular body length is the linear distance between Gonion and Pogonion. increase in length denotes skeletal class III, decrease in length signifies skeletal class II. |
| B-Pog (//MP) | The distance between the Pogonion and B point of the mandible parallel to mandibular plane. |
| Ar-Go-Me | This measurment represents the relationship between the ramal plane and mandibular plane. Gonial angle also contributes to skeletal open bite or deep bite. |
| **Dental** | |
| OP-HP | OP is Occlusal Plane constructed from buccal groove of first permanent molars through a point 1 mm apical to the incisal edge of the upper central incisors. The angle between this plane and the Horizontal reference plane is obtained. An increased angle indicates an skeletal open bite, whilst a decreased angle indicates a skeletal deep bite. |
| U1-NF | An angle constructed between a line passing through the tip of incisal edge through the root tip of upper incisor and NF line. Giving us the inclination of the upper incisors in relation to NF plane. |
| A-B (//OP) | The distance between projection of Point A and Point B on OP. This distance gives us relationship between maxillary and mandibular apical bases in relation to OP |

| | |
|---|---|
| L1-MP | An angle constructed by intersecting a line joining the incisal edge of lower incisor passing through its root tip and MP. angle gives inclination of lower incisors in relation to MP. |
| **Facial Form** | |
| Facial Convexity | A line dropped form Glabella 'G' to Subnasale 'Sn' and a line Sn to soft. increased +ve value = convex profile Increased -ve value = concave profile (class III skeletal and dental relationship) |
| MX Prognathism | A line dropped perpendicular to horizontal plane from Glabella. Measure the distance from perpendicular line to Sn (parallel to HP). Describes the amount of maxillary excess/deficiency in anteroposterior dimension. . |
| MD Prognathism | A line dropped perpendicular line to HP from Glabella. Measure the position of the pogonion from this line parallel to HP..Increased –ve value indicated mandibal is retrognathic. |
| Vertical Height Ratio | A line dropped perpendicular line to HP from Glabella, to this line drop a perpendicular line to Sn and M. Measure the distance from G-Sn and Sn – Me ( all perpendicular to HP ) |
| L Face-Throat Angle | Formed by the intersection of lines Sn-Gn&Gn-C. Obtuse lower face neck angle indicates that any procedures that reduce the prominence of chin should not be done. |
| L Face Ht-Depth Rt | A line dropped from Sn to Gn and C to Gn. Measure the distance from Sn– Gn and C –Gn. If the ratio is more than 1 = short neck . |
| **Lip Position and Form** | |
| Naso-labial Angle | A line is drawn from Sn to Cm and drop a line from Sn to Ls. |
| Upper Lip Protrusion | a line is drawn from Sn to soft tissue Pg the amount of lip Protrusion / Retrusion is measured with perpendicular linear distance from this line to the prominent point of the lip. |
| Lower Lip Protrusion | A line is drawn from Sn to Pg and the amount of lip protrusion / retrusion is measured with perpendicular linear distance from this line to the most prominent point of both lips. |
| Mentolabial Sulcus | The perpendicular distance between deepest point on the mentolabial sulcus to Li-Pg' line. |
| Vertical Lip-Chin Ratio | The ratio between these two measurements ( Sn – Stms / Stmi – Me ), it's done to assess the lower third of the face. |
| U1 Exposure | The distance between tip of upper central incisor and Stms. |
| Interlabial Gap | It is the distance between Stms and Stmi, useful in assessing lip competence. |

(// = Parallel), (⊥ = Perpendicular).

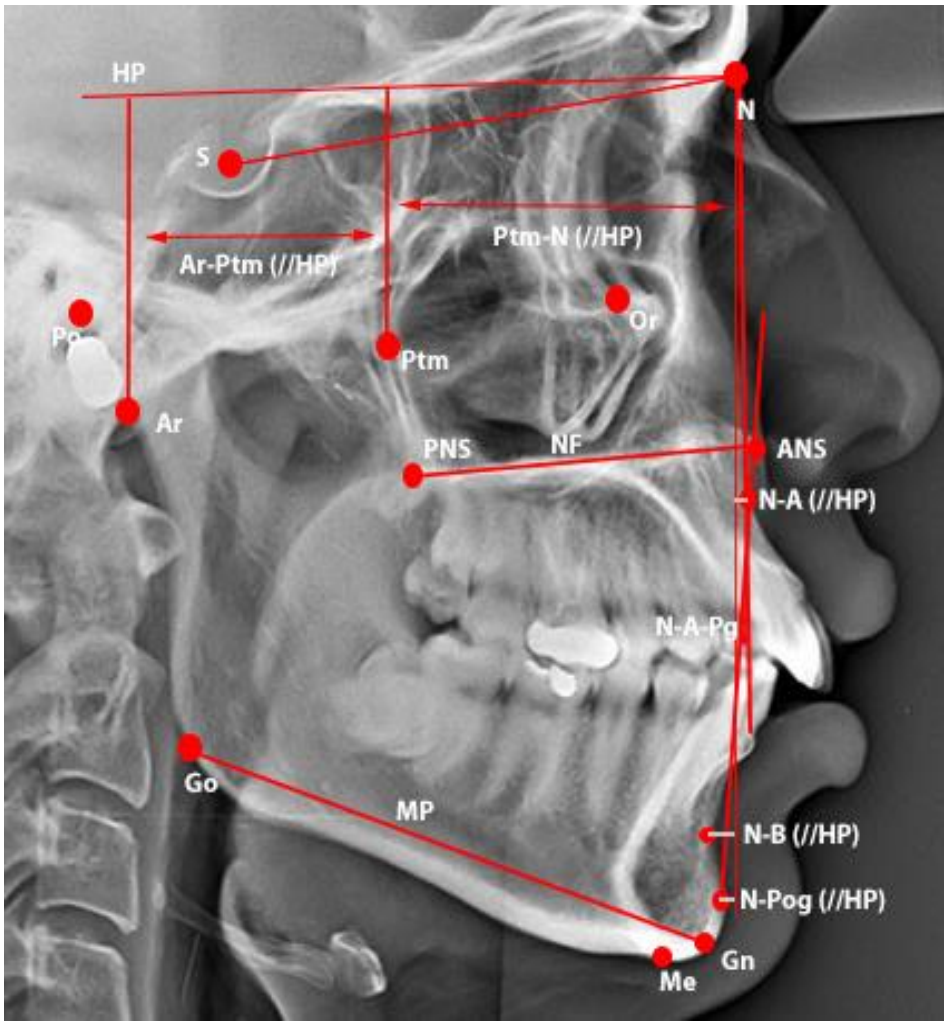
**For assessment:** The lateral cephalometric analysis was done for COGS analysis using a software titled Computer-Assisted Simulation System for Orthognathic Surgery [CASSOSS] 2001, SoftEnable Technology, Ltd, Hong Kong. (28) landmarks and (3)reference planes were chosen and utilized. A total of (38) measurements were made, (2) cranial base measurements, (4) Horizontal (skeletal and dental), (8) Vertical (Skeletal and dental), (5) related to maxilla and mandible, (6) dental, (6) in relation to facial form, and (7) in relation to lip position and form [Figure 1, 2, 3 and 4]. A single well-trained orthodontist assessed and analyzed all the cephalometric points of interest (land marks) and done all measurements.

**[Figure 1]: A diagram illustrating the relevant Points of interest (landmarks). A total of (28) landmarks and (3) reference planes.**



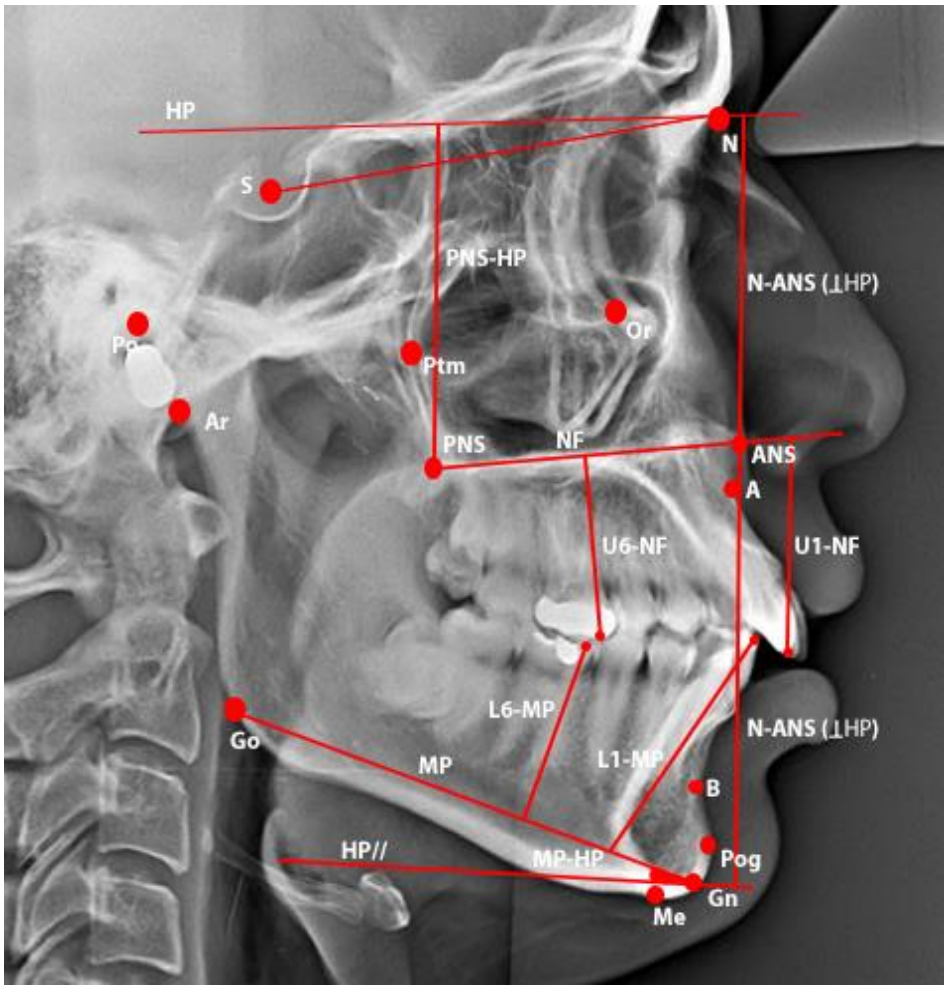

*Po (Porusacustucus externus), S (Sella (Fossa hypophysialis), N Nasion (Suturafrontonasalis), Pt (Pterygomaxillary fissure), Or (Orbitale),Ar (Articulare), ANS (Spina nasalis anterior). PNS (Spina nasalis posterior), A (A point), B (B point), Go (Gonion), Pog (Pogonion), Gn (Gnathion), Me (Mention), U1 (upper incisor), U6 (upper first molar), L1 (lower incisor), HP (Horizontal Plane), NF (Nasal Floor), MP (Mandibular Plane), G (Glabella), Cm (Columella point), Sn (Subnasale), Ls (Labrale superius), Stm s (Stomion superius), Stmi (Stomion inferius), Li (Labraleinferius), Pog' (Soft tissue Pogonion), Gn (Soft tissue Gnathion), Me' (Soft tissue Mention), C (Cervical point).*

**[Figure 2]: A diagram illustrating the measurements regarding the cranial base and the horizontal skeletal/dental relations considered in COGS analysis, (1) of which is angular and (5) linear totaling (6) skeletal measurements.**



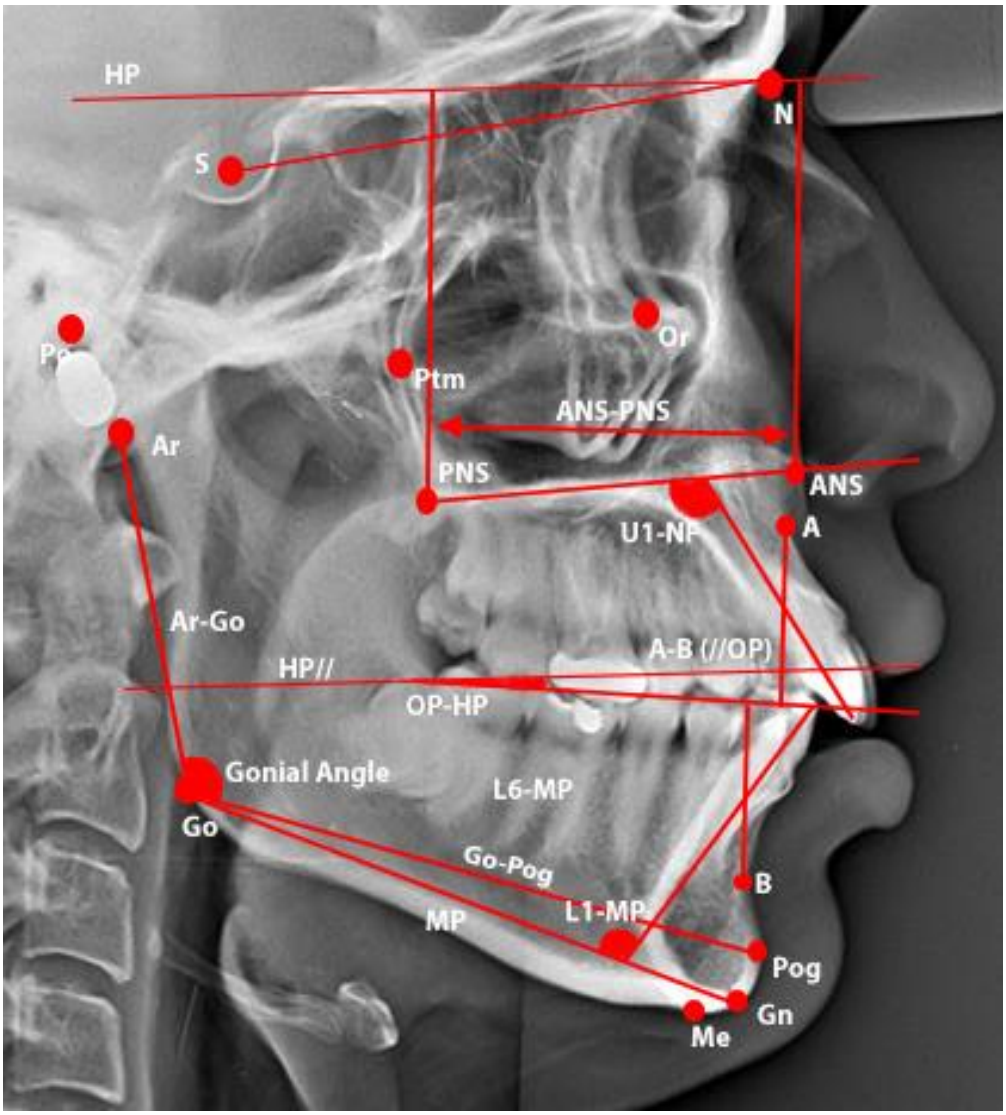

*Ar-Ptm (distance between Ar and Ptm which is measured parallel to HP), Ptm-N (distance between Ptm and N which is measured parallel to HP), N-A-Pg (the angle formed between N-A and A-Pg), N-A (N perpendicular to A, parallel to HP), N-B (N perpendicular to B, parallel to HP), N-Pog (N perpendicular to Pg, parallel to HP).*

**[Figure 3]: A diagram illustrating the vertical skeletal and vertical dental measurements considered in COGS analysis, (4) dental and (4) Skeletal consisting of (7) linear, and (1) angular measurements.**



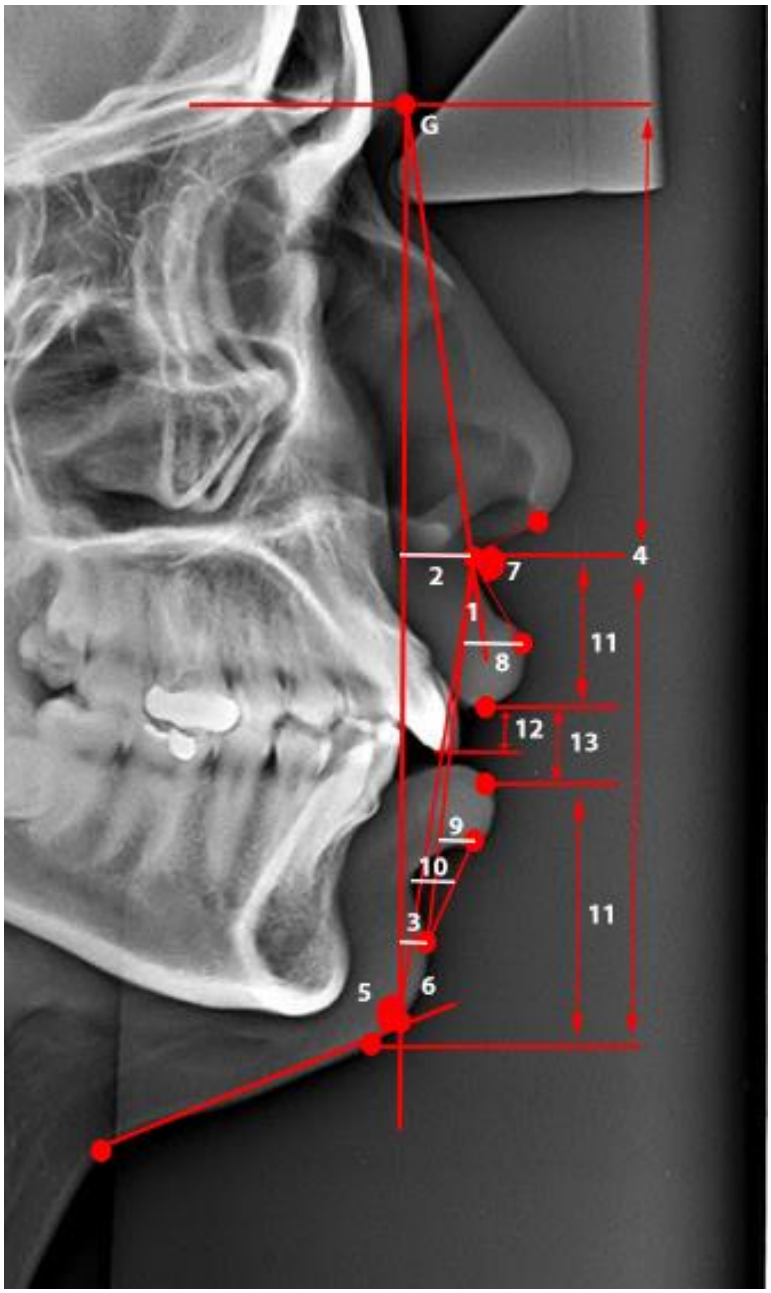

*N-ANS⊥HP (Distance between N and ANS measured perpendicular to HP), ANS-Gn⊥HP (Distance between ANS and Gn measured perpendicular to HP), PNS-N⊥HP (Distance between PNS and HP measured perpendicular to HP), MP-HP (Angle between the Mandibular Plane and the Horizontal Plane), U1-NF (distance between the tip of the upper first incisor to the Nasal floor), L1-MP (distance between the lower first incisor and the mandibular plane), U6-NF (Distance between the upper first molar to the nasal floor), L6-MP (distance between the lower first molar and the mandibular plane).*

**[Figure 4]: A diagram illustrating the maxillary, mandibular and dental measurements considered in COGS analysis, (5) related to the relation between the maxilla/mandible and (4) related to dentition consisting of (5) linear, and (4) angular measurements.**




*ANS-PNS⊥HP (distance between ANS and PNS perpendicular to HP), Ar-Go (distance between Ar and Go), Go-Pog (distance between Go and Pog), Gonial Angle (the angle formed by the intersection of Ar-Go and Go-Gn planes), OP-HP (The angle formed by the intersection of the horizontal plane and OP plane), A-B(//OP) (distance between the A point to OP plane , and B point to OP plane), U1-NF (distance between the upper first incisor and the nasal floor), L1-MP (distance between the lower first incisor and the mandibular plane).*

**[Figure 5]: A diagram illustrating the facial form and lip position and form measurements considered in COGS analysis, (6) related to facial form and (7) related to lop position and form consisting of (7) linear, (3) angular and (3) ratio measurements.**




*1 (Facial convexity), 2 (Maxillary prognathism), 3 (Mandibular prognathism), 4 (Vertical Height ration), 5 (Lower face to throat angle), 6 (Lower face height depth ration), 7 (Nasiolabial angle), 8 (Upper lip protrusion), 9 (Lower lip protrusion), 10 (Mentolabial sulcus), 11 (Vertical lip chin-ratio), 12 (Upper incisor exposure), 13 (Inter labial gap).*

This study has been ethically cleared and approved by the Local Committee of Bioethics (LCBE) with the approval number of 9-16-8/39, Jouf University.

The sample consisted of (160) lateral digital cephalometric radiographs, (86) males, and (74) females with age ranging between (20 and 25). The sample was collected from the orthodontic patients of (College of Dentistry, Jouf University). Both an inclusion and exclusion criteria were applied in this study. The exclusion criteria were (no skeletal or dental deformities, no history of corrective orthodontic therapy, and patients of non-Saudi Arabian descent) and the inclusion criteria were (good quality cephalometric film,

with visible landmark). The interpretation chart in [table-2] will be used as a reference for standardized Caucasian values.

**[Table2]: COGS variables with their mean values for Caucasian ethnic group (Males and Females) ± Standard deviation**

| Variable | Unit | Standard Caucasian Values | | | |
|---|---|---|---|---|---|
| | | Males | | Females | |
| | | Mean | SD | Mean | SD |
| **Cranial Base** | | | | | |
| Ar-Ptm (//HP) | mm | 37.1 | ±2.8 | 32.8 | ±1.9 |
| Ptm-N (//HP) | mm | 52.8 | ±4.1 | 50.9 | ±3 |
| **Horizontal (Skeletal, Dental)** | | | | | |
| N-A-Pog | ° (Degree) | 3.9 | ±6.4 | 2.6 | ±5.1 |
| N-A (//HP) | mm | 0.0 | ±3.7 | -2 | ±3.7 |
| N-B (//HP) | mm | -5.3 | ±6.7 | -6.9 | ±4.3 |
| N-Pog (//HP) | mm | -4.3 | ±8.5 | -6.5 | ±5.1 |
| **Vertical (Skeletal, Dental)** | | | | | |
| N-ANS (⊥HP) | mm | 54.7 | ±3.2 | 50 | ±2.4 |
| ANS-Gn (⊥HP) | mm | 68.6 | ±3.8 | 61.3 | ±3.3 |
| PNS-N (⊥HP) | mm | 53.9 | ±1.7 | 50.6 | ±2.2 |
| MP-HP | ° (Degree) | 23.0 | ±5.9 | 24.2 | ±5 |
| U1-NF (⊥NF) | mm | 30.5 | ±2.1 | 27.5 | ±1.7 |
| L1-MP (⊥MP) | mm | 45.0 | ±2.1 | 40.8 | ±1.8 |
| U6-NF (⊥NF) | mm | 26.2 | ±2.0 | 23 | ±1.3 |
| L6-MP (⊥MP) | mm | 35.8 | ±2.6 | 32.1 | ±1.9 |
| **Maxilla, Mandible** | | | | | |
| PNS-ANS (//HP) | mm | 57.7 | ±2.5 | 52.6 | ±3.5 |
| Ar-Go (linear) | mm | 52.0 | ±4.2 | 46.8 | ±2.5 |
| Go-Pog (linear) | mm | 83.7 | ±4.6 | 74.3 | ±5.8 |
| B-Pog (//MP) | mm | 8.9 | ±1.7 | 8.9 | ±1.7 |
| Ar-Go-Me | ° (Degree) | 119.1 | ±6.5 | 112 | ±6.9 |
| **Dental** | | | | | |
| OP-HP | ° (Degree) | 6.2 | ±5.1 | 7.1 | ±5.1 |
| U OP-HP | ° (Degree) | X | X | X | X |
| L OP-HP | ° (Degree) | X | X | X | X |
| U1-NF | mm | -1.1 | ±2.0 | 0.4 | ±2.5 |
| A-B (//OP) | ° (Degree) | 111.0 | ±4.7 | 112.50 | 5.30 |
| L1-MP | ° (Degree) | 95.9 | ±5.2 | 95.9 | ±5.7 |
| | | Mean | | SD | |
| **Facial Form** | | | | | |
| Facial Convexity | ° (Degree) | 12.0 | | ±4.0 | |
| MX Prognathism | mm | 6.0 | | ±3.0 | |
| MD Prognathism | mm | 0.0 | | ±4.0 | |
| Vertical Height Ratio | % | 100.0 (1:1) | | | |
| L Face-Throat Angle | ° (Degree) | 100.0 | | ±7.0 | |
| L Face Ht-Depth Rt | % | 120.0(1.2:2) | | | |

| **Lip Position and Form** | | | |
|---|---|---|---|
| Naso-labial Angle | ° (Degree) | 102.0 | ±8.0 |
| Upper Lip Protrusion | mm | 3.0 | ±1.0 |
| Lower Lip Protrusion | mm | 2.0 | ±1.0 |
| Mentolabial Sulcus | mm | 4.0 | ±2.0 |
| Vertical Lip-Chin Ratio | % | 50.0 (1:2) | |
| U1 Exposure | mm | 2.0 | ±2.0 |
| Interlabial Gap | mm | 2.0 | ±2.0 |

(// = Parallel), (⊥ = Perpendicular).

**For statistical analysis:** the data was inputted in Statistical Package for the Social Sciences (SPSS), then verified, analyzed, and the mean ± Standard deviation were calculated. The level of significance was tested using independent t-test. A p value of <5% ($p<0.05$) was considered to be significant.

**Error control**: The reliability of the method was analyzed by calculating Dahlberg's formula[22]:

The error test was conducted on 25% of cephalometric radiographs that were randomly selected. The combination error for both types of measurement for any given variable was relatively insignificant and within normal acceptable limits[22].

**Results:**

The descriptive statistics of all lateral cephalometric radiographs for (38) measurement were carried out on the entire sample size of (160 subjects). [Table 3], [Figure 6] Includes the different lateral cephalometric measurements of Saudi male and female adults showing the Mean ± Standard deviation for each of the variables. Comparative statistics between the results of the Saudi Population and Caucasian ethnic group were carried out using independent t-test with 95% confidence intervals [Table 3]/ [Table 4]. None of the parameters measured showed any significant differences between Saudi Arabian males and females.(10) out of (38) variables were larger in females compared to males, these variables are: (N-A-Pog, N-A (//HP), N-B (//HP), N-Pog (//HP), ANS-Gn (⊥HP), U1-NF (⊥NF), Go-Pog (linear), U OP-HP, MD Prognathism and Vertical Lip-Chin Ratio) measuring 12.68 degrees, 2.61mm, 0.56mm, 0.00mm, 21.26mm, 13.00mm, 34.37mm, 3.75 degrees, 2.19mm and 46.13% respectively for females, and the same values for males are 11.04 degrees,1.16-mm, 0.98mm, -2.01mm, 21.60mm, 12.14mm, 32.62mm, 2.50 degrees, -0.50mm and 42.83% respectively. In contrast the following (9) measurements are higher in Saudi Arabian males as compared to females: (MP-HP, OP-HP, L OP-HP, L1-MP, Facial Convexity, L Face-Throat A$_D = \sqrt{\sum_{i=1}^{N} \frac{d_i^2}{2N}}$ace Ht-Depth Rt, Naso-labial Angle and Interlabial Gap) measuring 26.09, 7.08, 11.83, 99.78, 19.91, 105.55 degrees, 128.53%,106.72 degrees and 0.75mm respectively for males, and 25.64, 6.69, 9.95, 97.64, 17.95, 95.28 degrees 124.38%, 101.56 degrees and 0.54mm respectively for females. The remaining measurements are almost identical between the two sexes.

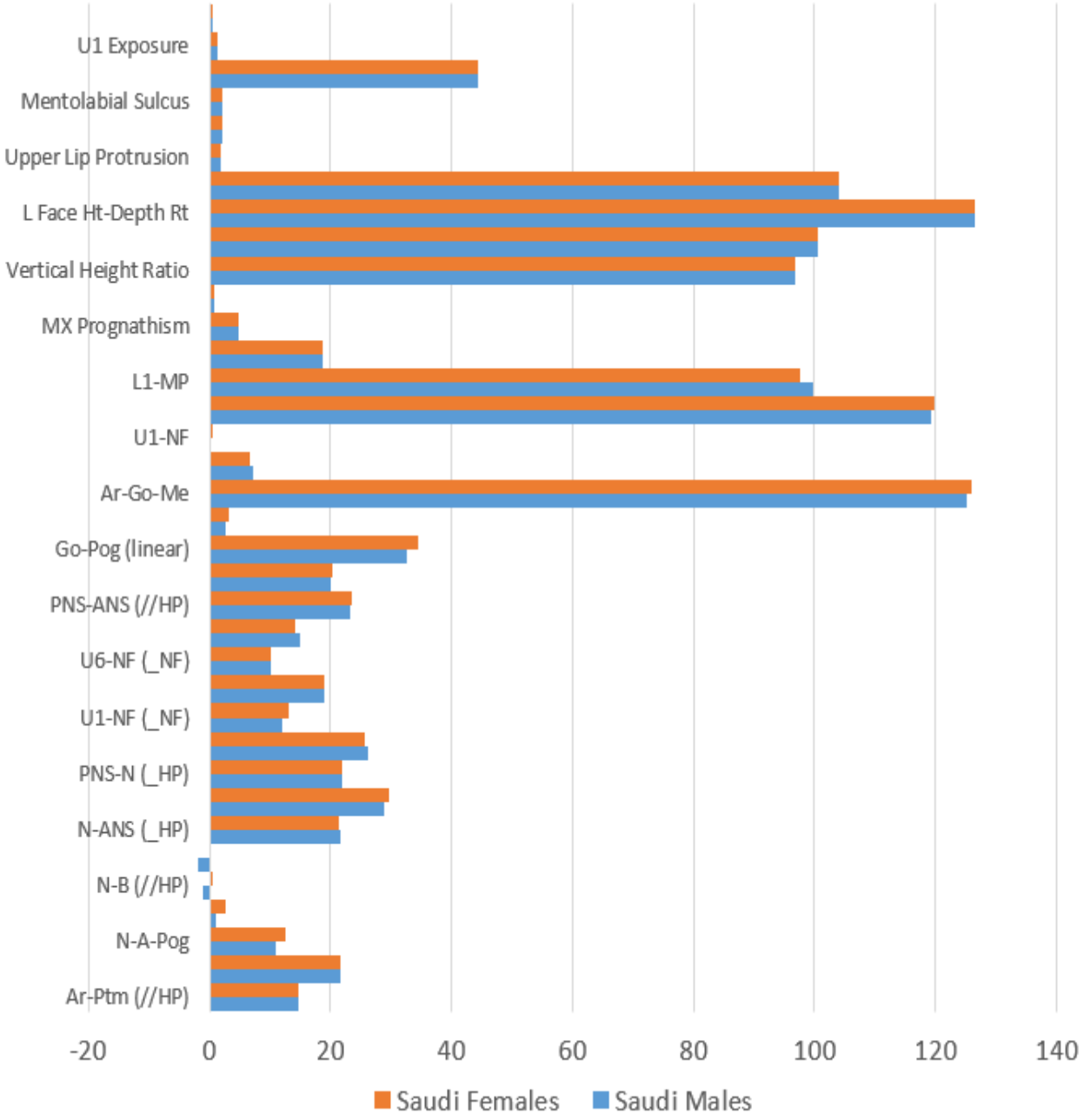
**[Table 3]: Descriptive cephalometric COGS analysis values for Saudi male and females.**

| Variables* | Unit | Saudi Arabian Standard values | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Male | | Female | | | 95% CI | | |
| | | Mean | SD | Mean | SD | SE | Lower | Upper | P-value |
| **Cranial Base** | | | | | | | | | |
| Ar-Ptm (//HP) | mm | 14.57 | 2.87 | 14.78 | 3.72 | .93 | -1.95 | 2.38 | .84 |
| Ptm-N (//HP) | mm | 21.60 | 4.29 | 21.69 | 5.05 | 1.26 | -2.89 | 3.08 | .77 |
| **Horizontal (Skeletal, Dental)** | | | | | | | | | |
| N-A-Pog | ° (Degree) | 11.04 | 7.51 | 12.68 | 7.43 | 1.86 | -2.93 | 6.22 | .84 |
| N-A (//HP) | mm | 1.16 | 1.77 | 2.61 | 2.93 | .73 | -0.20 | 3.09 | .04 |
| N-B (//HP) | mm | -.98 | 3.08 | .56 | 5.25 | 1.31 | -1.41 | 4.47 | .07 |
| N-Pog (//HP) | mm | -2.01 | 3.96 | .00 | 6.66 | 1.67 | -1.73 | 5.75 | .06 |
| **Vertical (Skeletal, Dental)** | | | | | | | | | |
| N-ANS (⊥HP) | mm | 21.60 | 4.32 | 21.26 | 5.49 | 1.37 | -3.55 | 2.86 | .55 |
| ANS-Gn (⊥HP) | mm | 28.88 | 5.84 | 29.55 | 6.67 | 1.67 | -3.30 | 4.64 | .69 |
| PNS-N (⊥HP) | mm | 21.94 | 4.08 | 21.98 | 4.91 | 1.23 | -2.85 | 2.93 | .98 |
| MP-HP | ° (Degree) | 26.09 | 7.99 | 25.64 | 7.82 | 1.96 | -5.28 | 4.39 | .95 |
| U1-NF (⊥NF) | mm | 12.14 | 2.65 | 13.00 | 2.95 | .74 | -0.91 | 2.63 | .67 |
| L1-MP (⊥MP) | mm | 18.93 | 3.69 | 18.95 | 4.80 | 1.20 | -2.77 | 2.81 | .81 |
| U6-NF (⊥NF) | mm | 10.22 | 2.12 | 10.23 | 2.38 | .60 | -1.41 | 1.43 | .94 |
| L6-MP (⊥MP) | mm | 14.95 | 3.04 | 14.12 | 3.51 | .88 | -2.92 | 1.26 | .75 |
| **Maxilla, Mandible** | | | | | | | | | |
| PNS-ANS (//HP) | mm | 23.27 | 4.60 | 23.51 | 5.20 | 1.30 | -2.85 | 3.35 | .76 |
| Ar-Go (linear) | mm | 20.09 | 4.28 | 20.37 | 4.94 | 1.23 | -2.66 | 3.21 | .75 |
| Go-Pog (linear) | mm | 32.62 | 5.84 | 34.37 | 7.95 | 1.99 | -2.83 | 6.33 | .24 |
| B-Pog (//MP) | mm | 2.62 | 1.02 | 3.13 | 1.27 | .32 | -0.23 | 1.26 | .23 |
| Ar-Go-Me | ° (Degree) | 125.14 | 9.78 | 126.00 | 6.88 | 1.72 | -3.93 | 5.65 | .10 |
| **Dental** | | | | | | | | | |
| OP-HP | ° (Degree) | 7.08 | 4.71 | 6.69 | 7.20 | 1.80 | -4.48 | 3.69 | .07 |
| U OP-HP | ° (Degree) | 2.50 | 5.75 | 3.75 | 6.13 | 1.53 | -2.45 | 4.96 | .94 |
| L OP-HP | ° (Degree) | 11.83 | 4.36 | 9.95 | 8.96 | 2.24 | -6.83 | 3.06 | .00 |
| U1-NF | mm | .39 | 1.88 | .40 | 3.01 | .75 | -1.69 | 1.71 | .16 |
| A-B (//OP) | ° (Degree) | 119.27 | 7.20 | 119.84 | 8.23 | 2.06 | -4.33 | 5.47 | .41 |
| L1-MP | ° (Degree) | 99.78 | 8.38 | 97.64 | 9.74 | 2.43 | -7.91 | 3.64 | .83 |
| **Facial Form** | | | | | | | | | |
| Facial Convexity | ° (Degree) | 19.51 | 7.45 | 17.95 | 7.58 | 1.90 | -6.20 | 3.08 | .87 |
| MX Prognathism | mm | 4.37 | 1.72 | 5.14 | 2.75 | .69 | -0.78 | 2.32 | .04 |
| MD Prognathism | mm | -.50 | 4.30 | 2.19 | 7.63 | 1.91 | -1.57 | 6.95 | .05 |
| Vertical Height Ratio | % | 94.68 | 9.85 | 99.08 | 9.58 | 2.39 | -1.53 | 10.33 | .60 |
| L Face-Throat Angle | ° (Degree) | 105.55 | 7.58 | 95.28 | 6.82 | 1.71 | -14.60 | -5.95 | .84 |
| L Face Ht-Depth Rt | % | 128.53 | 9.55 | 124.38 | 9.37 | 2.34 | -9.93 | 1.65 | .73 |
| **Lip Position and Form** | | | | | | | | | |
| Naso-labial Angle | ° (Degree) | 106.72 | 9.40 | 101.56 | 8.37 | 2.09 | -10.49 | 0.16 | .72 |
| Upper Lip Protrusion | mm | 1.59 | 1.01 | 2.29 | 1.03 | .26 | 0.07 | 1.33 | .99 |
| Lower Lip Protrusion | mm | 2.27 | 1.52 | 2.13 | 1.18 | .29 | -0.93 | 0.64 | .22 |
| Mentolabial Sulcus | mm | 1.90 | 1.12 | 2.22 | .94 | .24 | -0.29 | 0.93 | .94 |
| Vertical Lip-Chin Ratio | % | 42.83 | 6.27 | 46.13 | 4.34 | 1.08 | 0.26 | 6.35 | .08 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| U1 Exposure | mm | 1.15 | 1.05 | 1.26 | .95 | .24 | -0.49 | 0.72 | .81 |
| Interlabial Gap | mm | .76 | 1.28 | .54 | .30 | .08 | -0.67 | 0.25 | .26 |

(// = Parallel), (⊥ = Perpendicular), SD: Standard deviation, SE: Standard error, CI: Confidence interval, P: Probability value. For description of variables refer to [table 1]

**[Figure 6]:COGS measurement disparities between Saudi Arabian males and females.**



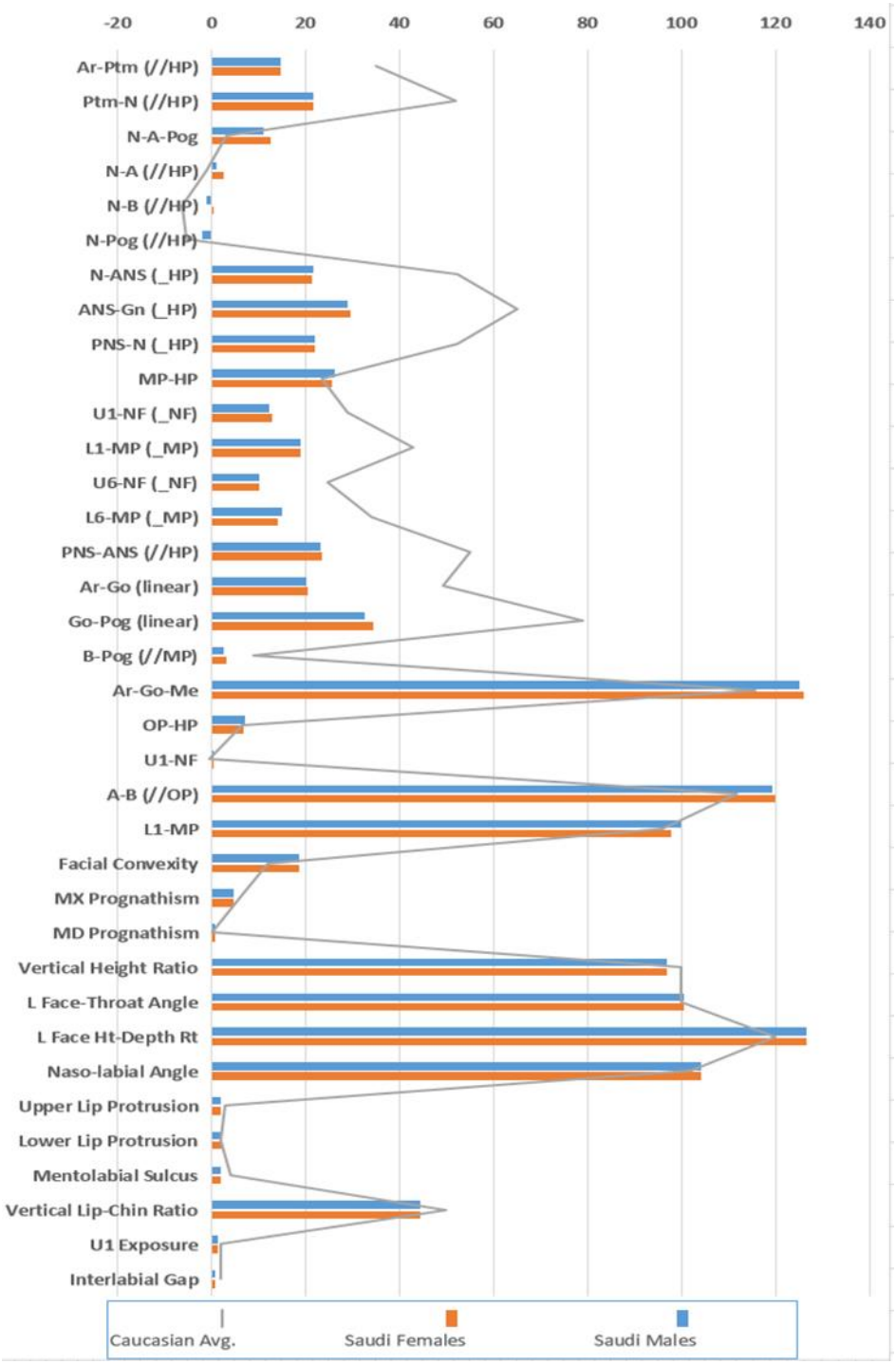

Differences between the mean values of Saudi Arabian males and females, compared to their Caucasian counterparts can be observed in [Table 4]/ [Figure 7].

**[Table 4]: comparative cephalometric analysis of COGS values for Saudi male and female and their Caucasian counterparts.**

| Variables* | | Saudi Arabian Standard values | | | | Caucasian standard values | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Unit | Male | | Female | | Male | | Female | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| **Cranial Base** | | | | | | | | | |
| Ar-Ptm (//HP) | mm | 14.57 | 2.87 | 14.78 | 3.72 | 37.1 | 2.8 | 32.8 | 1.9 |
| Ptm-N (//HP) | mm | 21.60 | 4.29 | 21.69 | 5.05 | 52.8 | 4.1 | 50.9 | 3 |
| **Horizontal (Skeletal, Dental)** | | | | | | | | | |
| N-A-Pog | ° (Degree) | 11.04 | 7.51 | 12.68 | 7.43 | 3.9 | 6.4 | 2.6 | 5.1 |
| N-A (//HP) | mm | 1.16 | 1.77 | 2.61 | 2.93 | 0.0 | 3.7 | -2 | 3.7 |
| N-B (//HP) | mm | -.98 | 3.08 | .56 | 5.25 | -5.3 | 6.7 | -6.9 | 4.3 |
| N-Pog (//HP) | mm | -2.01 | 3.96 | .00 | 6.66 | -4.3 | 8.5 | -6.5 | 5.1 |
| **Vertical (Skeletal, Dental)** | | | | | | | | | |
| N-ANS (_HP) | mm | 21.60 | 4.32 | 21.26 | 5.49 | 54.7 | 3.2 | 50 | 2.4 |
| ANS-Gn (⊥HP) | mm | 28.88 | 5.84 | 29.55 | 6.67 | 68.6 | 3.8 | 61.3 | 3.3 |
| PNS-N (⊥HP) | mm | 21.94 | 4.08 | 21.98 | 4.91 | 53.9 | 1.7 | 50.6 | 2.2 |
| MP-HP | ° (Degree) | 26.09 | 7.99 | 25.64 | 7.82 | 23.0 | 5.9 | 24.2 | 5 |
| U1-NF (⊥NF) | mm | 12.14 | 2.65 | 13.00 | 2.95 | 30.5 | 2.1 | 27.5 | 1.7 |
| L1-MP (⊥MP) | mm | 18.93 | 3.69 | 18.95 | 4.80 | 45.0 | 2.1 | 40.8 | 1.8 |
| U6-NF (⊥NF) | mm | 10.22 | 2.12 | 10.23 | 2.38 | 26.2 | 2.0 | 23 | 1.3 |
| L6-MP (⊥MP) | mm | 14.95 | 3.04 | 14.12 | 3.51 | 35.8 | 2.6 | 32.1 | 1.9 |
| **Maxilla, Mandible** | | | | | | | | | |
| PNS-ANS (//HP) | mm | 23.27 | 4.60 | 23.51 | 5.20 | 57.7 | 2.5 | 52.6 | 3.5 |
| Ar-Go (linear) | mm | 20.09 | 4.28 | 20.37 | 4.94 | 52.0 | 4.2 | 46.8 | 2.5 |
| Go-Pog (linear) | mm | 32.62 | 5.84 | 34.37 | 7.95 | 83.7 | 4.6 | 74.3 | 5.8 |
| B-Pog (//MP) | mm | 2.62 | 1.02 | 3.13 | 1.27 | 8.9 | 1.7 | 8.9 | 1.7 |
| Ar-Go-Me | ° (Degree) | 125.1 | 9.78 | 126.00 | 6.88 | 119.1 | 6.5 | 112 | 6.9 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 4 | | | | | | | |
| **Dental** | | | | | | | | | |
| OP-HP | ° (Degree) | 7.08 | 4.71 | 6.69 | 7.20 | 6.2 | 5.1 | 7.1 | 5.1 |
| U OP-HP | ° (Degree) | 2.50 | 5.75 | 3.75 | 6.13 | X | X | X | X |
| L OP-HP | ° (Degree) | 11.83 | 4.36 | 9.95 | 8.96 | X | X | X | X |
| U1-NF | mm | .39 | 1.88 | .40 | 3.01 | -1.1 | 2.0 | 0.4 | 2.5 |
| A-B (//OP) | ° (Degree) | 119.27 | 7.20 | 119.84 | 8.23 | 111.0 | 4.7 | 112.50 | 5.30 |
| L1-MP | ° (Degree) | 99.78 | 8.38 | 97.64 | 9.74 | 95.9 | 5.2 | 95.9 | 5.7 |
| | | | | | | Mean | | SD | |
| **Facial Form** | | | | | | | | | |
| Facial Convexity | ° (Degree) | 19.51 | 7.45 | 17.95 | 7.58 | 12.0 | | 4.0 | |
| MX Prognathism | mm | 4.37 | 1.72 | 5.14 | 2.75 | 6.0 | | 3.0 | |
| MD Prognathism | mm | -.50 | 4.30 | 2.19 | 7.63 | 0.0 | | 4.0 | |
| Vertical Height Ratio | % | 94.68 | 9.85 | 99.08 | 9.58 | 100.0 | | | |
| L Face-Throat Angle | ° (Degree) | 105.55 | 7.58 | 95.28 | 6.82 | 100.0 | | 7.0 | |
| L Face Ht-Depth Rt | % | 128.53 | 9.55 | 124.38 | 9.37 | 120.0 | | | |
| **Lip Position and Form** | | | | | | | | | |
| Naso-labial Angle | ° (Degree) | 106.72 | 9.40 | 101.56 | 8.37 | 102.0 | | 8.0 | |
| Upper Lip Protrusion | mm | 1.59 | 1.01 | 2.29 | 1.03 | 3.0 | | 1.0 | |
| Lower Lip Protrusion | mm | 2.27 | 1.52 | 2.13 | 1.18 | 2.0 | | 1.0 | |
| Mentolabial Sulcus | mm | 1.90 | 1.12 | 2.22 | .94 | 4.0 | | 2.0 | |
| Vertical Lip-Chin Ratio | % | 42.83 | 6.27 | 46.13 | 4.34 | 50.0 | | | |
| U1 Exposure | mm | 1.15 | 1.05 | 1.26 | .95 | 2.0 | | 2.0 | |
| Interlabial Gap | mm | .76 | 1.28 | .54 | .30 | 2.0 | | 2.0 | |

(// = Parallel), (⊥ = Perpendicular), SD: Standard deviation. For description of variables refer to [table 1].




**[Figure 7]:COGS measurement disparities between Saudi Arabian males, females and Caucasian Average.**

## DISCUSSION:

The mean values between Saudi Arabian males and females were different in most of the measured parameters when compared to standard Caucasian COGS values [Table 3], [Figure 7] (Burstone et al.,

1978), this is to be expected as it is in accordance with other Cephalometric studies that have showed significant racial and ethnic differences like (Flynn *et al.,* 1989)[23] and (Rafael *et al.,* 1998)[13] were Japanese and African American COGS values were compared to standard Caucasian values.

As observed in [Table 2] Saudi Arabian males and females have notable differences when compared to each other in most of the cephalometric variables measured, especially in the horizontal dental and skeletal measurements females have predominately higher values as compared to males, this can be interpreted as Saudi Arabian females on average have a wider horizontal spread of skeletal and dental features anteroposteriorly, or more specifically their anterior facial osseous features are longer anteroposteriorly as compared to their male counterparts.

The cephalometric standardized values play an essential role in diagnosis and treatment planning for both orthodontic and orthognathic corrections, and they are mostly established on the Caucasian population, which of course in turn will lead to incorrect diagnosis and inaccurate treatment plan for that specific ethnic group as it has been shown time and again by studies targeting different racial groups.

Limitations:This study has two main limitations. The first: that it is not inclusive enough to represent the entire Saudi Arabian population as the sample was collected in one institution of a single city in the country. The second limitation is that the size of the sample was small (160 Saudi Arabian adults, 86 males and 74 females) in comparison to the other studies done on other ethnic groups that are more reliable in terms of their number of samples and inclusion/exclusion criteria.

**Conclusion:** This study has provided a comprehensive assessment of cephalometric norms required for orthognathic surgery in the Saudi Arabian population as well as showing inter-sex dimorphism in a multitude of variables. Though the disparities in measurements are large, they are not large enough to be statistically significant. When compared to their Caucasian counterparts however, most variables showed notable difference. Hence, these finding must be taken into consideration when diagnosing and devising treatment plans for the Saudi Arabian adult population.

**Clinical Significance:** Even though there are numerous published studies on Saudi craniofacial cephalometric norms, Caucasian norms are being used as reference when Saudi Arabian patients are being treated.

**Future considerations:** A greater variety of samples along with a larger sample size can be collected with a decent budget or contributions from orthodontic specialists from around the country by submitting standardized data to a main researcher would allow for more inclusive and accurate results to be achieved.

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**REFERENCES:**

1. Burstone C, James R, Legan H, Murphy G, Norton L. Cephalometrics for orthognathic surgery. Journal of oral surgery (American Dental Association : 1965). 1978;36(4):269—277. http://europepmc.org/abstract/MED/273073.
2. Alam M, Basri R, Purmal K, Sikder M, Saifuddin M, Iida J. Determining Cephalometric Norms for Bangladeshi Adults Using Bjork-Jarabak's Analysis. International Medical Journal (1994). 2013;19:329-332.
3. Malik H, Khan Afridi S, Kamran A, Mahroof V, Alam M, Qamruddin I. A Cephalometric Analysis for Pakistani Adults Using Jarabak Bjork's Analysis. International Medical Journal (1994). 2017;24:128-131.
4. Shafi AM, Khan FNA, Khan AG, et al. A soft tissue cephalometric analysis for Pakistani adult using holdaway's analysis. International Medical Journal. 2018;25:51-53.

5. Alam M, Basri R, Purmal K, Sikder M, Saifuddin M, Iida J. A Soft Tissue Cephalometric Analysis for Bangladeshi Adult Using Holdway's Analysis. International Medical Journal (1994). 2013;19:333-336.
6. Alam MK, Basri R, Kathiravan P, Sikder M, Saifuddin M, Iida J. Cephalometric evaluation for Bangladeshi adult by Down's analysis. International Medical Journal. 2012;19(3):258-261.
7. Alam M, Basri R, Purmal K, Sikder M, Saifuddin M, Iida J. Cephalometric Norms in Bangladeshi Adults Using Harvold's Analysis. International Medical Journal (1994). 2013;20:92-94.
8. Alam M, Basri R, Purmal K, Sikder M, Saifuddin M, Iida J. Craniofacial Morphology of Bangladeshi Adult Using Tweed's and Wit's Analysis. International Medical Journal (1994). 2013;20:197-200.
9. Purmal K, Alam M, Mohammad N, Zam Z. Cephalometric Norms of Malaysian Adult Chinese. International Medical Journal (1994). 2013;20:87-91.
10. Purmal K, Alam M, Mohammad Zam Zam N. Cephalometric Norms of Malaysian Adult Indian. International Medical Journal (1994). 2013;20:192-196.
11. Purmal K, Alam M, Mohammad Zam Zam N. Cephalometric Comparison of Skeletal, Dental, Soft Tissue, Nose and Chin prominence between Malaysian Indian and Malaysian Chinese. International Medical Journal (1994). 2013;20:335-341.
12. Adel M, Yamaguchi T. Evaluation of the Craniofacial Morphology of Egyptian Adults Undergoing Orthodontic Treatment. Dentistry. 2016;6. doi:10.4172/2161-1122.1000379
13. E Alcalde R, Jinno T, Pogrel MA, Matsumura T. Cephalometric norms in Japanese adults. Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons. 1998;56:129-134. doi:10.1016/S0278-2391(98)90849-7
14. Alam M, Basri R, Purmal K, Sikder M, Saifuddin M, Iida J. Cephalometric Lip Morphology in Bangladeshi Population. International Medical Journal (1994). 2013;20:201-203.
15. Alam MK, Qamruddin I. Cephalometric Lip Morphology in a Sample from Pakistani Population. International Medical Journal. 2017;24(1):140-143.
16. Ab Talib M, Shaheera Abdul Aziz N, Alam M, Basri R, Purmal K, Rahman S. Linear and Angular Cephalometric Measurement of Lip Morphology among Malaysian Malay. International Medical Journal (1994). 2014;21:41-44.
17. Shaheera Abdul Aziz N, Ab Talib M, Alam M. Linear and Angular Cephalometric Lip Morphology in Malaysian Malay and Malaysian Chinese Population. In: ; 2012.
18. Al-Jasser NM. Cephalometric evaluation of craniofacial variation in normal Saudi population according to Steiner analysis. Neurosciences (Riyadh). 2000;5(4):226-230.
19. Aldrees A. Pattern of skeletal and dental malocclusions in Saudi orthodontic patients. Saudi medical journal. 2012;33:315-320.
20. kundi I, Kumar H, Alam M. Determination of Craniofacial Morphometry of Saudi Adults by Steiner's Analysis. Journal of Clinical and Diagnostic Research. 2019;13:ZC45-ZC48. doi:10.7860/JCDR/2019/36483.12519
21. Albarakati SF, Baidas LF. Orthognathic surgical norms for a sample of Saudi adults: Hard tissue measurements. Saudi Dent J. 2010;22(3):133-139. doi:10.1016/j.sdentj.2010.04.007
22. DAHLBERG G. Statistical Methods for Medical and Biological Students. George Alien and Unwin, Ltd., London; 1940.
23. Flynn TR, Ambrogio RI, Zeichner SJ. Cephalometric norms for orthognathic surgery in black American adults. Journal of Oral and Maxillofacial Surgery. 1989;47(1):30-38