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Research Article

COGS ANALYSIS: ARE CAUCASIAN NORMS APPLICABLE TO HARYANA POPULATION?

Shradha Wahi and Ashish Gupta

HOUSE NO. 1803 FIRST FLOOR SECTOR 33-D

A R T I C L E I N F O

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A B S T R A C T

Introduction: The advent of cephalometric radiography into the field of orthodontics led to a better understanding of the hard and soft tissues of the face and has become the gold standard for evaluation of facial skeleton for diagnosis and treatment planning in orthodontic and orthognathic surgery patients. Most of the cephalometric norms are based on data derived from Caucasian samples. Due to morphological difference between different racial groups; the norms derived for Caucasians may not be applicable for other
population groups.
Aim: The COGS analysis is the standard benchmark in cephalometrics for any orthognathic surgical diagnosis and treatment planning. Burstone and colleagues established cephalometric norms for the hard and soft tissue parameters for Caucasian population. These norms however may not be applicable in other ethnic and racial groups. Hence, the aim of the study was to ascertain cephalometric norms for COGS analysis in the Barwala population. **Materials and Methods:** Lateral cephalograms in occlusion of 60 subjects (30
males and 30 females) within the age range of 18-25 years with skeletal Class I jaw bases and Angle's Class I molar relationship bilaterally were obtained. The cephalograms were manually traced and various hard and soft tissue cephalometric landmarks were identified and marked according to the definitions used by Burstone and Legan. Statistical analysis: The statistical analysis was done using SPSS and involved calculation of mean and standard deviation and student t-test.
Results: The Caucasian population had greater linear dimensions than the Barwala population namely, cranial base length, effective maxillary length, mandibular body and ramus length and vertical heights of the face. In dental parameters, Barwala males had more proclined maxillary incisors as compared to Caucasian males. The Barwala population also exhibited a more obtuse chin throat angle. Soft tissue parameters revealed a deep mentolabial sulcus, shorter chins, decreased incisal show as compared to female study group.
Conclusion: The study suggested cephalometric norms for COGS analysis in Barwala population. However, these values should be used as reference and not as absolute standards. Individual preferences and acceptable variation may be necessary in order to achieve optimum aesthetics.

INTRODUCTION

The application of cephalometrics provides a comprehensive evaluation of the face by describing dental, skeletal and soft tissue components. In the current era of evidence based dentistry treatment outcome prediction plays a vital role in practice. Moreover, it provides clear understanding and communication among orthodontists, maxillofacial surgeons and patients.[1]

Burstone and colleagues[2,3] established hard and soft tissue cephalometric norms for orthognathic surgery in Caucasians. Morphological differences between ethnic groups has been depicted by previous studies[4,5,6,7], hence the norms derived for Caucasians may not be applicable for other population groups. Therefore, the purpose of the study was to develop hard and soft tissue cephalometric norms for orthognathic surgery in Haryana population.

Corresponding author:* **Shradha Wahi
HOUSE NO. 1803 FIRST FLOOR SECTOR 33-D

A cross-sectional cephalometric study was conducted at the dental college, with total 60 subjects evenly divided into males and females within the age range of 18-25 years. All the subjects were natives of Haryana with clinically acceptable facial harmony and symmetry with pleasing profile. Full complement of dentition were present except the third molars with minimum arch length and tooth size discrepancies (crowding and spacing $\leq$ 5mm) and proper intercuspation with Angle's Class I molar relationship present bilaterally.

After obtaining the clearance from the institution's ethical board, an informed consent was obtained from each selected subject. Only those subjects who agreed to participate and allowed their radiographs to be taken were included in the study.

The lateral cephalograms for the subjects were obtained in natural head position (NHP)[8] with teeth in maximum intercuspation and lips in repose (Fig1). All radiographs were traced on 0.003″ matte acetate sheets by a single individual and reviewed twice with another investigator for accurate landmark identification. The cephalometric landmarks were

identified and analysed according to the definitions used by Burstone and Legan. Twenty four hard tissue and thirteen soft tissue parameters were assessed for each individual.

The statistical analysis was done using SPSS Version 20 statistical Analysis Software. The data was subsequently compared with COGS study using student t-test. Ten randomly selected lateral cephalograms were re-traced once, by the same observer after four weeks to determine the intra-observer error; and secondly by a different observer to determine the inter-observer error.

RESULTS

The mean values with standard deviation of hard and soft tissue of Haryana males and females are tabulated in Table 1 and 2 respectively. When considering the hard tissue parameters, it was found that the cranial base length was significantly greater in Haryana males as compared to Haryana females where Ar-Ptm showed high level of significance ($p< .001$) while Ptm-N was also found to be significantly more in Haryana males than females at $p< .05$.

Table 1

Hard Tissue Parameters	Indian male (Mean±SD)	Indian female (Mean±SD)	*p*-value
Cranial Base Parameters			
Ar- PTM (ll HP)	37.3± 2.28mm	34.4±2.74 mm	.000†
PTM- N (ll HP)	49.7±3.09 mm	47.8±3.19 mm	.020*
Horizontal Parameters (Skeletal)			
N-A-Pg	3.06 ± 4.67 deg	4.10 ±2.7 deg	.301
N-A (ll HP)	0.13±4.31 mm	-1.03±4.1 mm	.291
N-B (ll HP)	-2.7±7.58 mm	-4.16±7.3 mm	.450
N-Pg (ll HP)	-1.1±6.35 mm	-2.9±7.3 mm	.394
Vertical Parameters (Skeletal)			
N-ANS (⊥HP)	52.2±3.46 mm	49.6±3.1 mm	.003**
ANS – Gn (⊥HP)	60.8±5.32 mm	56.2±4.6 mm	.001**
PNS-N (⊥HP)	49.5±3.33 mm	47.4±3.0 mm	.016*
MP-HP	21.3 ±6.52 deg	23.4 ±4.7 deg	.160
Vertical Parameters (Dental)			
Max. central incisor to NF (⊥ NF)	25.6±2.35 mm	25.9±3.3 mm	.773
Mand. central incisor to MP (⊥ MP)	40.9±3.09 mm	36.1±2.5 mm	.000†
Max. first molar to NF (⊥ NF)	22.5±1.92 mm	21.6±2.5 mm	.109
Mand. first molar to MP (⊥MP)	33.1±2.4 mm	28.3±2.1 mm	.000†
Maxillary and Mandibular Parameters			
PNS-ANS (ll HP)	55.2±2.23 mm	51.7±3.7 mm	.000†
Ar- Go	50.5±4.99 mm	44.9±3.3 mm	.000†
Go-Pg	77±5.03 mm	73.6±5.0 mm	.010*
Ar- Go- Gn	119.7°±6.42 deg	120.2°±3.6 deg	.748
B – Pg (ll HP)	4.4±4.11 mm	4.9±4.3 mm	.660
Dental Parameters			
OP upper – HP	5.5 ±5.04 deg	7.3 ±4.0 deg	.126
OP lower – HP	5.5 ±5.04 deg	7.3 ±4.0 deg	.126
AB- OP (ll OP)	-0.5±1.52 mm	-0.2±1.9 mm	.427
Max. Central Incisor to NF	118.3 ±6.50 deg	116.4 ±7.5 deg	.308
Mand. Central Incisor to MP	98.9 ±6.68 deg	98.7 ±6.7 deg	.909

Table 2

Soft Tissue Parameters	Indian male (Mean±SD)	Indian female (Mean±SD)	*p*-value
Facial Form			
G-Sn- Pg´	15.1 ± 5.9 deg	13.8 ±4.3 deg	.352
G-Sn (ll HP)	8.1±5 mm	6.4±4.5 mm	.180
G-Pg´ (ll HP)	2.8±1 mm	0.9± 2 mm	.438
G-Sn / Sn-Me´ (⊥HP)	0.91± 0.1	0.94±0.7	.215
Sn- Gn´-C	113.4± 5.5 deg	110.7±4.5 deg	.306
Sn- Gn´/ C-Gn´	1.3±.2	1.1±0.2	.004**
Lip position			
Cm- Sn- Ls	104.1±1.4 deg	101.3±1.1 deg	.403
Ls to Sn-Pg´	3.4±1.6 mm	2.9±1.4 mm	.195
Li to Sn-Pg´	2.3±2.0 mm	2.0±2.2 mm	.545
Si to Li-Pg´	5.7±1 mm	3±3.8 mm	.001**
Sn- Stm_s/ Stm_i-Me´ (ll HP)	0.40±0.05	0.40±0.07	.771
Stm_s - upper central incisor	2.2±1.2 mm	3±1.3 mm	.018*
Stm_s – Stm_i (ll HP)	0.53±0.97 mm	0.53±1.1 mm	1.000

Among the vertical skeletal hard tissue parameters it was found that middle third facial height, lower third facial height and posterior maxillary height were greater in Haryana males than Haryana females at $p<.005, <.005$ *and* $<.05$ level of significance respectively. When comparisons were made for vertical dental height parameters there was a highly statistically significant difference $(p<.001)$ between Haryana males and females for both anterior and posterior mandibular dental heights and both values were greater in Haryana males as compared to Haryana females.

The effective maxillary length (PNS-ANS), mandibular ramus length (Ar-Go) and mandibular body length (Go-Pg) were greater in Haryana males than females.

The soft tissue cephalometric analysis for facial form showed that lower vertical height to depth ratio (Sn-Gn'/ C-Gn') was statistically significantly greater in Haryana males than females $(p<.005)$.

On analyzing the soft tissue parameters for lip position, the depth of mentolabial sulcus was greater in Haryana males than females ($p<.005$) while the maxillary incisal exposure was significantly greater in Haryana females than males $(p<.05)$.

A comparison of hard tissue parameters between Caucasian and Haryana males is depicted. The anterior cranial base length (Ptm-N) was increased in Caucasian males ($p< .01$). They had longer faces due to lower third facial height $(p<.001)$, increased dental heights and greater chin prominence. Also maxillary ($p< .005$) and mandibular body lengths $(p< .001)$ were greater in Caucasian males.

The Haryana males showed greater proclination of the upper incisors (U1-NF deg.) in comparison to Caucasian males $(p<.001)$.

The soft tissue norms for Haryana males depicted (Table 4) the following statistically significant differences in comparison to Caucasian males: smaller vertical height ratio $(p<.01)$, larger lower face throat angle $(p<.001)$, greater depth of mentolabial sulcus ($p<.001$) and smaller vertical chin-lip ratio $(p<.001)$.

Haryana females had a shorter anterior cranial base length $(p<.005)$ while Ar-Ptm was greater in Haryana females than Caucasian females $(p<.05)$. The vertical skeletal and dental parameters were increased in Caucasian females namely, lower third facial height ($p<.001$), posterior maxillary height ($p<.001$), vertical dental height ($p<.000$), vertical facial height ratio ($p<.0001$) and vertical lip-chin ratio ($p<.01$).

The lower face throat angle was larger among Haryana females than Caucasian females $(p<.001)$. Similarly, when considering lip position and form, vertical lip-chin ratio was greater for Caucasian females at a high level of significance $(p<.0001)$ (Table 6).

The maxillary incisal exposure was found to be greater among Haryana females at $p<.05$ level of significance when compared to Caucasian females. On comparison, the interlabial gap was found to be greater in Caucasian females $(p<.005)$ as compared Haryana females.

DISCUSSION

One of the primary goals in the treatment of dentofacial deformities is the attainment of facial proportionality. This goal can be achieved by careful diagnosis of facial, skeletal and dental problems followed by a properly planned and executed orthognathic surgery. The principle of cephalometric analysis as a diagnostic aid is to compare the patient with a normal reference group. This comparison reveals the differences observed between the patient's actual dentofacial relationship and those expected for his/her racial and ethnic group. Since the cephalometric norms for orthognathic surgery established by Burstone and associates[8,9] were based on Caucasian population, these cannot be applied to other racial groups.

Differences in ethnic values lead to a difference in perception of a "normal", hence normal in one ethnic group may not be considered normal for another group.[9] Since the same stands true for beauty and aesthetics, in the present study we considered Class I occlusion with minimal crowding as the main criteria for selection of subjects to avoid any ambiguity.
The two-tailed sample t-test was used to compare the norms obtained for hard tissue measurements in Haryana males & females, Haryana males & Caucasian males and Haryana females & Caucasian females. A statistically significant difference was observed for both the measurements of cranial base length i.e. Ar-Ptm and Ptm-N among Haryana males and females as well as Haryana females and Caucasian females but on comparing males of both ethnic groups, only Ptm-N was found to be significantly larger in Caucasian males ($p<.01$). The cranial base length depicted sexual dimorphism among the Haryana subjects where cranial base length was found to be more in Haryana males than females. Purmal *et al*[9] and Agarwal[10] and also observed sexual dimorphism with males having a larger cranial base length than females. Regarding differences observed in the two ethnic groups, a similar result was observed in studies performed by Singh[11].Tikku *et al.*[12] also found that the North Indians had a smaller cranial base length than the Caucasians.

The vertical skeletal hard tissue parameters i.e. middle third facial height, lower third facial height and posterior maxillary height were significantly greater in Haryana males than Haryana females. Caucasian males had significantly larger middle third facial height, lower third facial height and posterior maxillary height as compared to Haryana males, while Caucasian females had greater lower anterior facial height and posterior maxillary height when compared to Haryana females. This finding along with increased cranial base length in Caucasians indicates an overall larger dimension of the face, as was observed in the study done by Tikku *et al.*[12] on North Indian population.

The total effective length of maxilla (PNS-ANS), the mandibular body length (Go-Pg) and mandibular ramus length (Ar-Go) were significantly larger in Haryana males than Haryana females. The fact that majority of the differences observed between Haryana males and females were in linear dimensions, should be emphasized. This was to be expected since males are, in general, larger than females and this finding is in concordance with previous studies performed on Blacks[13], Egyptians[14], Emirates[15] and Japanese[16] where males were found to have larger dimensions than females.

The vertical dental heights i.e. anterior maxillary dental height (U1-NF), posterior maxillary dental height (U6-NF), anterior mandibular dental height (L1-MP) and posterior mandibular dental height (L6-MP) in Haryana population were considerably smaller than Caucasian population in both males and females. This finding is supported by Tikku *et al.*[12] who also observed shorter dental heights in North Indian population compared to Caucasians. This is in concordance with Richardson who stated that parameters of the face which are closer to dental areas show greatest variations among ethnic groups.[17]

The shorter dental heights observed in the Haryana population as compared to the Caucasians could be correlated with a significantly shorter lower third of the face seen in the Haryana subjects. Similarly, the significantly increased anterior and posterior mandibular dental heights in the Haryana males as compared to Haryana females could be correlated with a longer lower third of the face (ANS-Gn) in the Haryana males. Flynn *et al.*[13] observed larger mandibular dental heights in males compared to black females which is in concordance with our study.

The maxillary and mandibular incisor inclination (U1-NF° and L1-MP°) were increased in both Haryana males and females. Agarwal[10] also observed proclined incisors in Jaipur population as compared to Caucasians. Even though the mean values for incisor inclination point at a protrusive dentition in the Haryana subjects, all the subjects had an aesthetically pleasing profile and no significant difference was observed for upper and lower lip protrusion between Haryana population and Caucasians. This implies that while treating Haryana population a slight protrusion of teeth will be optimum for their facial features as compared to Caucasians, as was concluded by Nanda.[5] It is suggested that pre-surgical orthodontics should be carried out with caution in Haryana population as proclined lower incisors put them at risk of developing cortical plate defect during treatment.

The soft tissue norms obtained for Haryana population were analysed for sexual dimorphism and compared to the Caucasian norms given by Legan and Burstone[3] with the help of two tailed sample t-test.

According to the Caucasian norms established by Legan and Burstone[3], the vertical height ratio should be 1:1. The mean values of vertical height ratio in Haryana males and females were found to be 0.91±.1 and 0.94±.7 respectively and a significant difference was observed on comparison with the Caucasian population. This indicated that the lower third of the face is comparatively larger than the middle third in Haryana population.

Disproportion in the vertical height ratio necessitates further evaluation of the lower third of the face i.e. the vertical lip-chin ratio ($Sn\text{-}Stm_s$: $Stm_i\text{-}Me'$). According to the Caucasian norms[3], the length of the upper lip ($Sn\text{-}Stm_s$) should be half the length of the lower lip ($Stm_i - Me'$). The vertical chin-lip ratio in Haryana subjects was 0.4±.05 in males and 0.4±.07 in females, depicting a relatively larger vertical height of the chin compared to upper lip length in Haryana population compared to Caucasians. On the contrary, the studies performed by Jain & Kalra[19] and Mittal *et al.*[18] on North Indian population found no difference in the vertical ratios i.e. the vertical height ratio and vertical lip-chin ratio between the two ethnic groups.

When the vertical lip-chin ratio becomes smaller than one half, vertical reduction genioplasty can be considered and this holds true in case of Haryana population, according to the findings of the present study. If an individual presents with larger lower third of the face with a normal interlabial gap, vertical reduction genioplasty is contraindicated. In case the reduction is carried out, it will result in excessive lip length leading to lip redundancy followed by eversion of the lower lip.

During clinical evaluation one must also consider the ratio between lower facial height (Sn-Me′) and throat length (Pg′-C). In our study, lower vertical height depth ratio (Sn-Gn′: C-Gn′) was significantly greater among Haryana males (1.3±2) than females (1.1±0.2). Similar gender difference was observed by Jain[19] and Celebi *et al.*[20] in their studies on North Indian and Turkish subjects respectively.

The distance between the soft tissue chin and the neck form an important consideration in determining the presence of mandibular prognathism. The lower vertical height depth ratio (Sn-Gn′: C-Gn′) and vertical height ratio (G-Sn: Sn-Me′) when taken together can give an indication of the antero-posterior position of the chin. As the vertical height-depth ratio was greater in Haryana males, it means that they have relatively shorter neck and the anterior projection of the chin probably should not be reduced in these subjects. During the correction of Class III malocclusion in subjects with a shorter neck, it would be undesirable to reposition the chin posteriorly, even if other cephalometric parameters suggest a forwardly placed mandible in relation to other facial structures.[3]

The assessment of the lower face-throat angle (Sn-Gn′-C) useful in determining the feasibility of reducing or increasing the chin prominence. An obtuse lower face-chin angle contraindicates mandibular setback as it would further reduce the chin prominence and might lead to a double chin.[3]

Both the Haryana males and females had significantly more obtuse lower face-throat angles (Sn-Gn'-C) as compared to the Caucasians and indicate that during treatment of Class III Haryana population subjects, mandibular set back procedures should be planned with caution as they have more obtuse lower face-chin angle.[21] In such cases, alternative procedures such as maxillary advancement, mandibular subapical surgical procedure, mandibular set back with advancement genioplasty or camouflage maybe employed.

The depth of the mentolabial sulcus was found to be significantly greater in Haryana males as compared to Haryana females and Caucasians. Scheideman[22] in his study also observed women to have shallower mentolabial sulcus than men. Similarly, Sachan *et al.*[23] found a significantly increased distance of inferior sulcus to the H-line in North Indian males compared to females due to a more protrusive chin. The depth of the mentolabial sulcus is also affected by other factors like flared lower incisors, extruded upper lip, flaccid lower lip and abnormal morphology of the lip.[3] The lower incisor inclination and lower lip protrusion were marginally but not significantly greater in Haryana males in comparison to Caucasians; this could be responsible for increase in the depth of the mentolabial sulcus in Haryana males. Variation in soft tissue thickness between Haryana population and Caucasians could be another factor responsible for the same.

Surgical procedures of the chin such as advancement and reduction genioplasty aid in deepening and reducing the depth of mentolabial sulcus respectively. Since Haryana males have an increased sulcular depth, advancement genioplasty procedures should be planned with caution as it would further deepen the mentolabial sulcus.

The interlabial gap was found to be similar in Haryana males and females while it was significantly lesser as compared to Caucasians. This finding is in concordance with studies by Mittal *et al.*[18] and Jain and Kalra[19] on North Indian population. Although, Burstone[24] in 1967 had enumerated various factors that affected the interlabial gap including-lip length, variation in anterior facial height, dental protrusion and lip posture.

Haryana females had statistically greater incisal show at rest compared to Haryana males and Caucasians. Similar findings were reported by Jain and Kalra[19] and Connor *et al.*[6] in North Indians and Blacks respectively, where females had a greater incisal exposure at rest. The findings of our study are supported by Jadim da Motta *et al.*[25] who found women and younger individuals to have an increased incisal show at rest.

CONCLUSION

The comparison between the values obtained in the present study with those of hard and soft tissue cephalometric norms for orthognathic surgery established by Burstone and colleagues[2,3] led us towards instituting a new and different set of cephalometric norms for Haryana population. Significant differences were observed in linear measurements including cranial base length, effective maxillary length, mandibular body and ramus length, anterior and posterior vertical heights of the face. In Haryana population, males depicted greater dimensions than females, while Caucasians were found to be larger than Haryana population. In dental parameters, only maxillary incisor inclination was found to be significantly greater in Haryana males compared to Caucasian males.

The soft tissue parameters revealed that Haryana males had shorter chins, deeper mentolabial sulcus and decreased incisal show at rest as compared to Haryana females while Haryana population revealed a decreased vertical height and vertical lip-chin ratio, an increased lower vertical height to depth ratio, an obtuse lower face-throat angle, deeper mentolabial sulcus and shorter interlabial gap as compared to Caucasians.

Our study has suggested cephalometric norms for normal male and female adult faces but this does not allow for artistic departure and individual preferences. Therefore, each clinician must decide what variations are necessary to achieve esthetically pleasing faces while treating his or her patients. Knowledge of cephalometric norms should be applied in clinical practice while paying heed to the suggestions made by Burstone[3] and Bishara[14], who stated that cephalometric norms should not be used as absolute values as this would lead to production of assembly line faces with no variation among our patients.

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