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Original Article

Effects of Age and Gender on Hard and Soft Tissue Cephalometric Features of an Iranian Population Over 12 Years Old

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Abstract

Background: This study aimed to investigate age- and gender-specific soft and hard tissue cephalometric features in an Iranian population with normal class I occlusion.

Methods: A total of 111 Iranians (56 females and 55 males) in two age groups including individuals aged between 12-16 years and individuals aged over 16 years, with well-balanced faces and class I occlusion, were selected. Overall, 81 (40 soft tissue and 41 hard tissue) cephalometric measurements of the selected samples were traced on all cephalograms. The obtained values were compared in terms of gender and age differences and also ethnic differences between Iranian and European races.

Results: This study indicated significant differences between Iranian men and women of different ages and Caucasians in terms of hard and soft tissue cephalometric measurements, which should be considered in orthodontic and surgical treatments. Some of the most important differences are greater values of facial convexity angle, nasolabial angle, and soft tissue chin thickness in Iranians than in Caucasians.

Conclusion: In general, slightly more convex profiles, more protruded lips, less prominent noses, higher nose tips, and proclined and protruded central incisors are acceptable in the Iranian population. Also, Iranian women have more convex soft and hard tissue profiles, shorter anterior and posterior facial heights, larger interlabial gaps, less deep superior sulci, thinner and shorter upper lips, and thinner soft tissue chins than men. Also, non-growing adults have more advanced mandibles, larger noses, more sloping nasal tips, and larger skeletal dimensions compared with growing ones.

Keywords: Cephalometry, Face, Sex characteristics, Iranian

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Introduction

Improving facial esthetics and developing harmony between teeth, hard tissue, and soft tissue are essential components of successful orthodontic treatment (1,2). Orthodontic treatments used to be mainly focused on skeletal tissue (3), but nowadays, the importance of soft tissue in improving the appearance and beauty of the face has been more established. Therefore, paying close attention to both components plays a vital role in attaining the ideal treatment (2).

Today, cephalometric radiographs work as aiding tools in orthodontic treatments (4). In order to diagnose and treat dentofacial problems properly, normal ethnic standards can be helpful so that our patient's facial indices can be compared with and treated somewhat accordingly (5,6).

In addition to orthodontic treatments, normal ethnic standards are also used in treatments in other fields, including nose and chin surgery, cosmetic lip injections, and other plastic surgeries (7). Commonly used standards are the result of cephalometric studies on the Caucasian race. Recent studies conducted on different races such as Turkish, Arabic, Iranian, Bulgarian, Japanese, Chinese, Brazilian, Indian, and Pakistani have proved that there are significant differences in cephalometric norms between different ethnicities (1,7-12). These studies depict the importance of having cephalometric norms specific to each population more than ever. Therefore, it is necessary to compare the cephalometric parameters of each patient with their ethnic norms in diagnostic references (13).

Studies have also shown that cephalometric features vary between genders and different age groups (14-16). Studies conducted on Iranian people in recent years have reported significant differences between Iranians and

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Caucasians (6,7,17-19). However, in previous studies, the number of samples has been quite low (6,18) or studies have been limited to either soft or hard tissue examination and have not studied hard tissue along with soft tissue (15,17,20). In general, despite the importance of this subject, the number of comprehensive studies on the Iranian population is relatively low.

Therefore, in the present study, by examining the hard and soft tissue cephalograms of a relatively large number of an Iranian population based on age and gender, we attempted to provide a more accurate standard for examining the dental and facial problems of Iranian patients.

Methods

Sample size

To compare cephalometric measurements in two genders, the sample size was calculated based on the formula below, (with a type I error of $\alpha = 0.05$), power of 90% (type II error of $\beta = 0.1$), a standard deviation of 6.5, a mean difference of 4, and an effect size of 2.64 from a previous pilot study, the minimum number of samples in each gender was calculated as 55.

$$n = 2 \times \left[\frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta} \right) \times \sigma}{\mu_1 - \mu_2} \right]^2$$

Samples were selected from six dental clinics based on the following inclusion and exclusion criteria.

Sample inclusion criteria

Inclusion criteria for samples consisted of having a symmetric and proportional/well-balanced face (no clear asymmetry on both sides of the face), overjet of 1 to 2 mm, overbite of 1 to 3 mm, the dental relationship of molar class 1, having all permanent teeth except the third molar, and crowding and spacing less than 3 mm.

Sample exclusion criteria

Exclusion criteria for samples contained having a systemic disease and/or any history of trauma to the jaw and face that affected the growth pattern and having a history of orthodontic treatments and facial surgery.

Then, samples were divided into two age groups of 12-16 and over 16-year-olds, indicating growing and non-growing individuals.

Cephalometric analysis

Lateral cephalometric images of all samples were taken in natural head position (i.e. all the cephalograms were taken in a position in which the Frankfort horizontal plane was parallel to the floor with teeth in maximum intercuspation, the tongue behind the maxillary incisors, and the lips at rest position).

Lateral cephalograms were taken at 80-90 KVP with an exposure time of 6 to 18 seconds using PaX-I 2D imaging systems (Vatech, Hwaseong, Korea) and Cranex (Soredex, Helsinki, Finland). Cephalometric measurements (Regarding the soft tissue analysis, Legan and Burstone, Holdaway, Epker, Ricketts, and Z angle, and supplementary soft tissue analyses were used. Regarding the hard tissue analysis, Steiner, McNamara, Downs, Tweed, Wits, Bjork, and Jarabak analyses were used) of the selected samples were traced on all cephalograms by two final year dental students using Dolphin imaging software version 10.0.00.53 (Dolphin Imaging and Management Solutions, Chatsworth, Ca., USA).

The anatomic landmarks traced are listed in Table 1 and shown in Figure 1. The measured angular and linear values of the analyses are listed in Table 2.

To evaluate intra-examiner reliability, 25 cephalograms were randomly re-traced by the same operator under the same environmental circumstances two weeks later. To determine inter-examiner reliability, 25 cephalograms were re-traced by another operator (21). To evaluate the validity, the correct location of the landmarks was confirmed by an orthodontist.

Statistical analyses

Windows SPSS software version 26.0.0.1 (SPSS Inc., Chicago, Illinois, USA) was used for statistical analysis. The Kolmogorov-Smirnov test showed normal distribution of parameters. Therefore, parametric analyses were used. Descriptive analyses were acquired. The one-sample *t* test was used to investigate the differences between the cephalometric norms of Iranians and Caucasians. To compare the cephalometric parameters of growing and non-growing patients and that of men and women, two-way

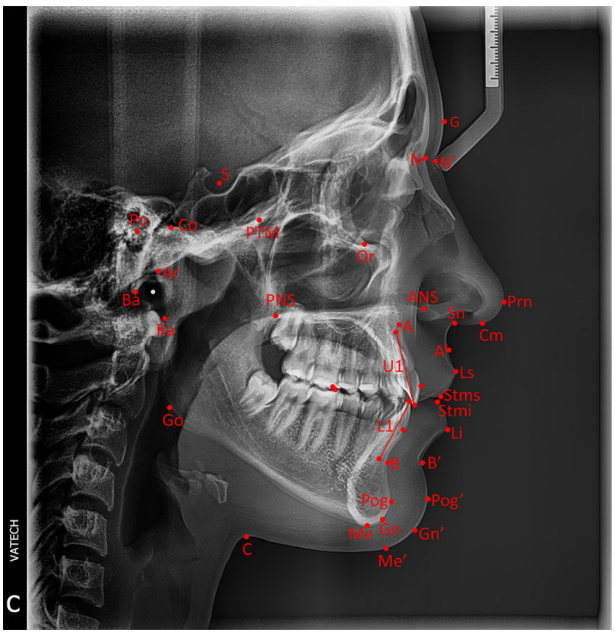

Figure 1. Cephalometric landmarks

Table 1. Definition of anatomic landmarks

Landmark or Plane	Definition
Sella (S)	The midpoint of sella turcica
Soft tissue B point (Si)	The deepest point on the mentolabial sulcus
Nasion (N)	The most anterior serration between the forehead and the nasal bone
Point- A (A)	The innermost part of the concavity of the maxillary curvature between the anterior nasal spine and the upper incisor
Point- B (B)	The deepest part of the curvature of the mandibular symphysis
Glabella (G)	The extreme anterior point of the soft tissue forehead
Columella point (Cm)	The extreme anterior part of the nasal septum
Subnasale (Sn)	The point at which the nasal septum and upper lip meet
Labrale superius (Ls)	The extreme anterior point of the upper lip
Stomion superius (Stms)	The lowest part of the outline of the upper lip
Stomion inferius (Stmi)	The most superior part of the outline of the lower lip
Upper incisal (Ui)	The tip of maxillary central incisor
Labrale inferius (Li)	The extreme anterior part of the lower lip
Soft tissue Pogonion (Pog′)	The most anterior part of the soft tissue chin
Soft tissue Menton (Me′)	The most inferior part of the soft tissue chin
Cervical point (C)	The posterior-superior point between the submental area and the neck in the profile view
Soft tissue Gnathion (Gn′)	The central point between the extreme anterior and inferior points of the soft tissue chin
Horizontal reference plane (HP)	A constructed plane by drawing a line 7 degrees up from SN meeting at the nasion
Porion (Po)	The highest point on the superior border of the external auditory meatus
Or (Orbitale)	The lowest point on the inferior border of the bony orbit
Profile line	A line drawn from the soft tissue chin to the extreme anterior point of either of the lips
Frankfort horizontal line	A line extending from Porion to Orbitale
The H line	Formed by drawing a line from the soft tissue chin to the upper lip
Soft tissue facial line	A constructed line drawn from soft tissue nasion to the soft tissue chin through the suprapogonion point of Ricketts' analysis
The hard tissue facial plane	A constructed plane drawn from nasion to pogonion
The sella-nasion line	A line from Nasion to the midpoint of sella turcica
Constructed line of Holdaway	A constructed line that is perpendicular to the Frankfort horizontal plane and tangent to the outer border of the upper lip
Occlusal plane (OP)	A line connecting the tip of the cusps of the first permanent molars to one-half of the overbite of the permanent incisors
Functional occlusal plane (FOP)	A line connecting the intercuspation of the first permanent premolars and molars
Mandibular plane (MP)	A line joining Gonion to Gnathion
Palatal plane (PP)	A line that connects ANS to PNS
Lower incisor (L1)	A Line that connects the incisal edge and apex of the most protruded mandibular incisor
Upper inciso r(U1)	A line that connects the incisal edge and apex of the most protruded maxillary incisor
Nasion perpendicular (NP)	A line that connects Na to Pog and is perpendicular to the FH plane
Basion (Ba)	Most anterior point on foramen magnum
pterygomaxillary fissure (PTM)	Point where the posterior wall of the maxillary sinus and pterygoid plate meet
Anterior nasal spine (ANS)	A bony projection at which two maxillary bones intersect at the intermaxillary suture
Posterior nasal spine (PNS)	The rearmost point of the hard palate
Menton (Me)	The lowermost point on the outline of the mandibular symphysis
Pogonion (Pog)	The foremost point on the outline of the mandibular symphysis
Gonion (Go)	The most posterior inferior part of the mandibular angle
Gnathion (Gn)	The central point between the lowermost and foremost points of the mandibular symphysis
Condylion (Co)	The most posterior superior part of the mandibular condyle
Articulare (Ar)	The joint between the inferior border of the cranial base and the posterior border of the rami
Infradentale (Id)	The most superior point of the gum between the two mandibular central incisors
Esthetic plane (E-plane)	A line that connects the nose tip to soft tissue pogonion
The tip of the nose (En) = Pronasale (Prn)	The most anterior point of the soft tissue nose
lower lip vermilion (Llv)	The point denoting the vermilion border of the lower lip
Upper lip vermilion (Ulv)	The point denoting the vermilion border of the upper lip
Stomion (sto)	The midpoint of the intralabial fissure
Submental line (Sm)	A line tangent to the submental contour that passes through soft tissue menton
Cervical line (Ce)	A line drawn tangent to the anterior aspect of the soft tissue neck in profile view

Table 2. Definition of measured linear and angular parameters of soft and hard tissues

Parameter	Measurement	Analysis
Facial convexity angle	G-Sn-Pg′ (an angle established at the junction of lines G-Sn and Sn-Pg′)	Legan and Burstone
Maxillary prognathism	G-Sn (the horizontal distance from the subnasale to a line perpendicular to the horizontal plane through the glabella)	Legan and Burstone
Mandibular prognathism	G-Pg′ (the horizontal distance from soft tissue pogonion to a line perpendicular to the horizontal plane through the glabella)	Legan and Burstone
Vertical height ratio	G-Sn/Sn-Me′ (the ratio of the measured distances from glabella-subnasale to subnasale-menton perpendicular to horizontal plane)	Legan and Burstone
Lower facial throat angle	Sn-Gn′-C (an angle established at the junction of lines Sn-Gn′ and Gn-C)	Legan and Burstone
Lower vertical height–depth ratio	Sn-Gn′/C-Gn′ (the ratio between measured distances from subnasale to Gn′ and columella to Gn′)	Legan and Burstone
Nasolabial angle	Cm-Sn-Ls (an angle established at the junction of lines Sn-Cm and Sn-Ls)	Legan and Burstone
Upper lip protrusion	Ls to Sn-Pg′(the perpendicular distance between Ls to a line from subnasale to Pg′)	Legan and Burstone
Lower lip protrusion	Li to Sn-Pg′ (the perpendicular distance between Li to a line from subnasale to Pg′)	Legan and Burstone
Mentolabial sulcus depth	Si to Li-Pog′(The perpendicular distance between the deepest part of the mentolabial sulcus to Li-Pg′ line)	Legan and Burstone
Vertical lip-chin ratio	Sn-Stms/Stms-Me′(the ratio used to assess the lower third of the face)	Legan and Burstone
Maxillary incisor exposure	Stms-Ui (the distance between Ui and Stms)	Legan and Burstone
Interlabial gap	The distance between Stms-Stmi	Legan and Burstone
The Z angle	The inferior angle established at the junction of Frankfort horizontal plane and the profile line	Merrifield's Z angle
Soft tissue facial angle	The inner angle established at the junction of the soft tissue facial line and the Frankfort horizontal plane	Holdaway
H angle	An angle established at the junction of the H line and soft tissue facial plane	Holdaway
Nose prominence	The horizontal distance measured from the nasal tip to the line perpendicular to Frankfort horizontal plane and tangent to the upper lip	Holdaway
Superior sulcus depth	The horizontal distance measured from the deepest point on the curvature of the superior sulcus from a line perpendicular to Frankfort horizontal plane and tangent to the outline of the upper lip	Holdaway
Soft tissue subnasale to H line	The distance from the subnasale to the H line	Holdaway
Skeletal profile convexity	The distance from the A point to the hard tissue facial plane	Holdaway
Basic upper lip thickness	The distance from a point about 3 mm below point A to the outline of the upper lip	Holdaway
Upper lip strain measurement	The horizontal distance from the vermilion border of the upper lip to the foremost part of the maxillary central incisor	Holdaway
Lower lip to H line	The distance from the H line to the most anterior point on the lower lip	Holdaway
Inferior sulcus to H line	The horizontal distance between the deepest part of the mentolabial sulcus and the H line	Holdaway
Soft tissue chin thickness	Distance from hard tissue pogonion to soft tissue pogonion	Holdaway
Lower lip to E-plane	Distance from most anterior point of the lower lip to E-line	Ricketts
Upper lip to E-plane	Distance from most anterior point of the upper lip to E-line	Ricketts
Upper lip length	Distance from Subnasale and Stomion superior	Epker
Subnasale perp to upper lip	Distance from subnasale to Upper lip vermilion	Epker
Subnasale perp to lower lip	Distance from subnasal to lower lip vermilion	Epker
Subnasale perp to chin	Distance from subnasal to soft tissue pogonion	Epker
Nasal tip protrusion	Distance from Sn to Prn	Farkas
Nasal length	The vertical distance from nasion (N′) to the nasal tip (pronasale, Prn)	Wisth PJ, SJ Chakonas
Nasofrontal angle	The angle established at the junction of a line from nasion to glabella and a line tangent to the nasal dorsum through the nasion	Powell N
Nasal tip angle	It is the inner angle formed by the intersection of the columella tangent and the nasal dorsum tangent.	Farkas
Submental-Cervical angle (Sm-Ce)	The angle established at the junction of the Sm line and Ce line	Moreno

Table 2. Continued

Parameter	Measurement	Analysis
Lower lip vermilion height	Distance between Sti and Li	-
Upper lip vermilion height	Distance between Ls and Sts	-
Lower lip thickness at the vermilion border	The distance measured horizontally from infradentale to the vermilion border of the lower lip	-
Upper lip inclination to nasion-perpendicular	A line tangent to the upper lip (Ls to subnasale) extended to intersect the nasion-perpendicular	McNamara
SNA	Sella-Nasion to A Point Angle	Steiner (skeletal)
SNB	The angle between sella-nasion and B point	Steiner (skeletal)
ANB	The angle formed by connecting A point, Nasion, and B point	Steiner (skeletal)
Occlusal plane to SN angle	SN to Occlusal Plane Angle	Steiner (skeletal)
Mandibular plane angle	SN to Mandibular Plane (Go-Gn) Angle	Steiner (skeletal)
U1-NA angle	The angle between the long axis of maxillary central incisors and the NA line	Steiner (dental)
U1-NA distance	Distance from the long axis of maxillary central incisors to the NA line	Steiner (dental)
L1-NB angle	The angle formed by connecting the long axis of lower central incisors and the NB line	Steiner (dental)
L1-NB distance	Distance from the long axis of upper central incisors to the NB line	Steiner (dental)
Interincisal angle	Upper incisor to lower incisor angle (U1-L1)	Steiner (dental) Downs (Dental)
NP to A point	The linear distance between A point to nasion perpendicular	McNamara (Maxilla to mandible)
Mandibular length	Distance from Co to anatomic Gn	McNamara (Maxilla to mandible)
Maxillary length/Midfacial length	Distance from Co to the A point	McNamara (Maxilla to mandible)
LAFH	Distance from ANS to Me	McNamara (Vertical relationship)
Facial axis angle	The angle between PTM-Gn and a line perpendicular to Ba-N	McNamara (Vertical relationship)
Pog to NP	Distance from Pog to NP	McNamara (Mandible to cranial base)
Mandibular incisor position	Distance from the edge of the mandibular incisor and A-Pog	McNamara (Dentition)
Facial angle	The angle between the nasion-pogonion and the FH plane	Downs (skeletal)
Angle of convexity	The angle between nasion-A point and A point-pog	Downs (skeletal)
Y-axis	The angle between the sella-gnathion and the FH plane	Downs (skeletal)
AB plane angle	The angle between A point-B point and nasion-pogonion	Downs (skeletal)
Cant of the occlusal plane	The angle between OP and the FH line	Downs (Dental)
Incisor occlusal plane angle	The angle formed by connecting the long axis of lower incisors and OP	Downs (Dental)
U1 to A-pog line	Distance between the incisal edge of maxillary central incisors and A-pog line	Downs (Dental)
FMIA	The angle between the long axis of the mandibular incisor and the FH plane	Tweed
FMA	The angle formed by connecting the mandibular plane and the FH plane	Tweed
IMPA	The angle between the long axis of the mandibular incisor and the mandibular plane	Tweed
AO	The perpendicular line connecting A point to FOP	Wits
BO	The perpendicular line connecting B point to FOP	Wits
Nasion angle	The angle formed by connecting ANS to the SN plane	Bjork
Saddle angle	The angle formed by a line connecting nasion to sella to articulare	Bjork, Jarabak
Articular angle	The angle obtained by joining sella to articulare to Gonion	Bjork, Jarabak
Gonial angle	The angle obtained by joining Articulare to Gonion to Gnathion	Bjork, Jarabak
Chin angle	The angle obtained by joining infradentale to pogonion to the mandibular plane	Bjork
Anterior cranial base	The line connecting S to N	Jarabak
Posterior cranial base	The line connecting S to Ar	Jarabak
Ramus height	The line connecting Ar to Go	Jarabak
Anterior facial height	The line connecting N to Me	Jarabak
Posterior facial height	The line connecting S to Go	Jarabak
Mandibular corpus	The line connecting Go to Me	Jarabak
Jarabak ratio	Facial height / anterior facial height x 100	Jarabak

ANOVA was used. The level of significance was set at 0.05.

Results

A total of 111 Iranians (56 males and 55 females) were studied. The mean age of females was 17.80 ± 5.11, and the mean age of males was 17.78 ± 5.97. Samples were divided into two age groups (12-16 and over 16-year-olds) indicating growing and non-growing individuals.

The growing group consisted of 28 females in the age group of 12-16 with a mean age of 13.85 ± .53 and 32 males in the age group of 12-16 with a mean age of 13.81 ± 1.35. The non-growing group consisted of 28 females in the age group of over 16 with a mean age of 21.75 ± 4.32 and 23 males in the age group of over 16 with a mean age of 23.30 ± 5.49.

Ethnic differences

Soft and hard tissue cephalometric parameters of Iranians and Caucasians were also compared in Tables 3 and 4. Based on our findings, Iranians had significantly different values for soft and hard tissue cephalometric parameters compared with Caucasians.

Both Iranian women and men had significantly greater values for the below parameters: facial convexity angle, lower facial throat angle, nasolabial angle, upper lip protrusion, lower lip protrusion, mentolabial sulcus depth, maxillary incisor exposure, H angle, skeletal profile convexity, basic upper lip thickness, lower lip to H line, soft tissue chin thickness, lower lip to E-plane, subnasale perp to the upper lip, submental cervical angle, U1-NA distance, L1-NB angle, L1-NB distance, mandibular incisor position, angle of convexity, incisor occlusal plane angle, U1 to A-Pog line, IMPA, chin angle, ramus height, and Jarabak ratio.

Both Iranian women and men had significantly lesser values for the below parameters: Mandibular prognathism, nose prominence, subnasale perp to the chin, the Z angle, nasal tip protrusion, SNA, SNB, interincisal angle, mandibular length, maxillary length, Pog to NP, cant of occlusal plane, FMIA, anterior cranial base, and mandibular corpus.

Gender differences

Cephalometric parameters between Iranian men and women were compared in Table 5 (soft tissue) and Table 6 (hard tissue). There were significant differences between men and women in some soft and hard tissue parameters based on the findings.

The following soft tissue parameters had significantly greater values in men than in women: mandibular prognathism, lower vertical height-depth ratio, soft tissue facial angle, superior sulcus depth, basic upper lip thickness, upper lip strain measurement, soft tissue chin thickness, upper lip length, subnasale perp to lower lip, subnasale perp to the chin, lower lip vermilion height, and upper lip vermilion height.

The following hard tissue parameters had significantly greater values in men than in women: SNB, Upper 1-NA angle, Upper 1-NA distance, mandibular length, maxillary length, lower anterior facial height, Pog to NP, mandibular incisor position, facial angle, AB plane angle, anterior cranial base, posterior cranial base, ramus height, anterior facial height, posterior facial height, and mandibular corpus.

The values for the following soft tissue parameters were significantly lesser in men than women: facial convexity angle, interlabial gap, skeletal profile convexity, and nasofrontal angle.

The values for parameters attributed to the following hard tissue were significantly lesser in men than women: ANB, angle of convexity, and wit's appraisal.

Age differences

Cephalometric parameters between growing and non-growing individuals were compared in Table 5 (soft tissue) and Table 6 (hard tissue). Based on the findings, there were significant differences between growing and non-growing patients.

The values for the following soft and hard tissues parameters were significantly greater in the non-growing group than growing one:

Soft tissue: lower vertical-height depth ratio, nose prominence, subnasale perp to lower lip, and nasal tip protrusion.

Hard tissue: mandibular length, maxillary length, lower anterior facial height, anterior cranial base, ramus height, anterior facial height, posterior facial height, and Jarabak ratio.

The values for the following soft and hard tissues parameters were significantly lesser in the non-growing group than growing one:

Soft tissue: facial convexity angle, H angle, skeletal profile convexity, upper lip to E-plane, nasofrontal angle, and nasal tip angle.

Hard tissue: None.

Reliability

Based on our findings, inter-rater reliability was excellent as all the parameters had an interclass correlation of 0.75 to 0.986, except for nose prominence (ICC = 0.73) which had good reliability. Intra-rater reliability in our study was almost excellent as most parameters had an interclass correlation of 0.75 to 0.990. Superior sulcus depth, interlabial gap, articular angle, ramus height, and lower vertical height depth ratio had fair to good reliabilities (21).

Discussion

Various studies on different races have proved ethnic differences in cephalometric norms (1,7-12). Studies have also shown that cephalometric features vary between

Table 3. Comparison of soft tissue cephalometric values

Soft tissue cephalometric parameter	Iranian females		Caucasian female mean	*P* value*	Iranian males		Caucasian male mean	*P* value*
	Mean	SD			Mean	SD		
Legan and Burstone								
Facial convexity(contour) angle	17.209	5.1611	12	0.000*	15.229	6.3163	12	0.000*
Maxillary prognathism	4.923	3.2677	6	0.017*	5.820	4.5110	6	0.768
Mandibular prognathism	-6.107	6.4954	0	0.000*	-2.649	8.5112	0	0.025*
Vertical height ratio	1.0504	0.12078	1	0.003*	1.0127	0.09823	1	0.341
Lower facial throat angle	107.220	5.8845	100	0.000*	108.162	11.6062	100	0.000*
Lower vertical height–depth ratio	1.198	0.1977	1.2	0.946	1.333	0.4078	1.2	0.019*
Nasolabial angle	111.034	10.9364	102	0.000*	107.736	10.8794	102	0.000*
Upper lip protrusion	3.757	1.5647	3	0.001*	3.887	1.9337	3	0.001*
Lower lip protrusion	3.170	1.9603	2	0.000*	3.244	2.0638	2	0.000*
Mentolabial sulcus depth	5.313	1.2935	4	0.000*	5.304	1.4180	4	0.000*
Vertical lip-chin ratio	0.49	0.04	0.50	0.529	48.211	5.2705	0.50	0.015*
Maxillary incisor exposure	2.995	1.6409	2	0.000*	2.944	1.5660	2	0.000*
Interlabial gap	2.188	1.4369	2	0.333	1.585	1.1324	2	0.000*
Holdaway								
Soft tissue facial angle	90.071	3.0600	91	0.027*	91.840	3.3011	91	0.065
H angle	16.800	3.5686	10	0.000*	16.318	4.9721	10	0.000*
Nose prominence	12.882	2.5941	19	0.000*	12.251	2.7170	19	0.000*
Superior sulcus depth	2.452	1.0526	2.5	0.733	2.967	1.2300	2.5	0.007*
Soft tissue subnasale to H line	4.945	2.0480	5	0.840	5.144	2.5565	5	0.679
Skeletal profile convexity	2.455	2.4557	0	0.000*	1.182	2.8315	0	0.003*
Basic upper lip thickness	15.798	2.0838	15	0.006*	18.024	2.2432	15	0.000*
Upper lip strain measurement	12.013	1.6986	13.9	0.000*	13.738	2.0329	13.9	0.557
Lower lip to H line	1.148	1.7656	0.5	0.008*	1.202	1.7057	0.5	0.004*
Inferior sulcus to H line	4.705	1.6397	5	0.184	4.731	1.8575	5	0.287
Soft tissue chin thickness	11.600	1.9046	11	0.022*	13.491	2.4923	11	0.000*
Ricketts								
Lower lip to E-plane	-.545	2.2701	-2	0.000*	-.675	2.6324	-2	0.000*
Upper lip to E-plane	-3.043	2.0648	-4	0.001*	-3.405	2.8554	-4	0.128
Epker								
Upper lip length	19.650	1.9908	20	0.194	21.060	2.2311	20	0.001*
Subnasale perp to upper lip	1.354	1.8231	0	0.000*	1.873	2.0485	0	0.000*
Subnasale perp to lower lip	-2.555	2.8033	-2	0.144	-1.562	2.7692	-2	0.246
Subnasale perp to chin	-9.511	3.9891	-4	0.000*	-7.855	5.0657	-4	0.000*
The Z angle								
The Z angle	70.098	7.8141	75.5	0.000*	72.285	9.3414	75.5	0.014*
Supplementary analyses								
Nasal tip protrusion	18.666	2.3211	20	0.000*	18.167	2.4280	20	0.000*
Nasal length	45.90	3.96	45	0.095	49.96	4.70	50	0.952
Nasofrontal angle	134.161	9.2181	134	0.897	129.673	11.4083	130	0.832
Nasal tip angle	83.911	7.4107	-	-	82.309	9.6376	-	-
Submental-cervical angle (Sm-Ce)	128.571	11.1630	118	0.000*	129.545	18.6655	118	0.000*
Lower lip vermilion height	8.49	1.81	10	0.000*	9.69	1.95	10	0.252
Upper lip vermilion height	8.42	1.77	8	0.079	9.32	1.60	8	0.000*
Lower lip thickness at the vermilion border	17.39	21.76	12.5	0.098	15.73	1.64	15	0.002*
Upper lip inclination to nasion-perpendicular	6.373	8.2182	14	0.000*	8.133	8.9302	8	0.913

* Significant difference between this study and Caucasian norms.

Table 4. Comparison of hard tissue cephalometric values

Hard tissue cephalometric parameter	Iranian females		Caucasian female mean	*P* value*	Iranian males		Caucasian male mean	*P* value*
	Mean	SD			Mean	SD		
Steiner								
SNA	80.298	3.4507	82	0.001*	80.667	4.3099	82	0.026*
SNB	76.829	3.4928	80	0.000*	78.547	4.0988	80	0.011*
ANB	3.477	2.3935	2	0.000*	2.120	2.6194	2	0.735
Occlusal plane to SN angle	16.418	4.5681	14	0.000*	14.725	5.6654	14	0.347
Mandibular plane angle	32.629	5.3435	32	0.383	31.515	6.3563	32	0.573
U1-NA angle	21.636	6.2632	22	0.665	24.969	7.6935	22	0.006*
U1-NA distance	4.736	2.2051	4	0.016*	6.493	3.0254	4	0.000*
L1-NB angle	27.466	6.6028	25	0.007*	27.260	6.8126	25	0.017*
L1-NB distance	5.463	2.4537	4	0.000*	6.095	2.6805	4	0.000*
Interincisal angle	127.430	9.9988	131	0.010*	125.640	11.5565	131	0.001*
McNamara								
NP to A point	-.957	2.8606	-1	0.911	-1.091	2.9793	-1	0.822
Mandibular length	107.095	5.2645	121.5	0.000*	115.036	7.7775	121.5	0.000*
Maxillary length/Midfacial length	81.804	4.5693	93.5	0.000*	85.791	5.6209	93.5	0.000*
LAFH	63.182	5.4922	66	0.000*	67.567	6.2351	66	0.068
Facial axis angle	-.018	4.8353	0	0.978	-.525	4.5857	0	0.399
Pog to NP	-6.479	5.7666	-2	0.000*	-4.347	5.6708	-2	0.003*
Mandibular incisor position	2.821	2.3361	1	0.000*	4.076	2.8869	1	0.000*
Downs								
Facial angle	86.421	3.1615	87.5	0.013*	87.665	3.0331	87.5	0.687
Angle of convexity	5.402	5.4400	0	0.000*	2.535	6.0118	0	0.003*
Y-axis	60.380	3.6908	59.4	0.052	59.891	3.0520	59.4	0.238
AB plane angle	-5.788	3.2780	-4.6	0.009*	-3.900	3.6791	-4.6	0.164
Cant of the occlusal plane	7.698	4.2406	9.3	0.000*	6.538	4.9494	9.3	0.000*
Incisor occlusal plane angle	24.211	7.0159	14.5	0.000*	23.993	7.3819	14.5	0.000*
U1 to A-Pog line	6.763	2.1691	2.7	0.000*	7.458	2.7280	2.7	0.000*
Tweed								
FMIA	58.082	7.6060	65	0.000*	59.476	7.8394	65	0.000*
FMA	26.838	4.8922	25	0.007*	26.342	5.5972	25	0.081
IMPA	95.077	7.0875	90	0.000*	94.185	7.5739	90	0.000*
Wits								
AO-BO	1.121	3.3400	0	0.015*	-.295	3.7323	-1	0.157
Jarabak and Bjork								
Nasion angle	83.464	4.4750	-	-	85.209	4.4832	-	-
Saddle angle	125.184	6.2281	123	0.011*	123.578	6.0443	123	0.481
Articular angle	141.391	9.2052	143	0.196	139.398	7.8677	143	0.001*
Gonial angle	128.991	8.0272	130	0.351	131.551	6.9650	130	0.104
Chin angle	73.155	5.4583	70	0.000*	73.425	6.7385	70	0.000*
Anterior cranial base	65.745	3.5383	71	0.000*	68.982	4.0278	71	0.000*
Posterior cranial base	30.727	2.8291	32	0.001*	34.229	3.5244	32	0.000*
Ramus height	44.786	6.5336	44	0.372	48.236	6.0543	44	0.000*
Anterior facial height	109.884	6.6941	112.5	0.005*	116.736	7.8135	112.5	0.000*
Posterior facial height	71.186	5.9606	77.5	0.000*	77.333	7.3741	77.5	0.867
Mandibular corpus	67.107	4.3558	71	0.000*	70.422	6.4462	71	0.000*
Sum of angles	395.557	5.5004	396	0.549	394.533	6.3296	396	0.091
Jarabak ratio	64.81	4.23	63.51	0.000*	66.29	5.19	63.51	0.000*

* Significant difference between this study and Caucasian norms.

Table 5. Comparison of soft tissue cephalometric values of growing and non-growing patients

Soft tissue cephalometric measurements	12-16-year-old females		Over 16-year-old females		12-16-year-old males		Over 16-year-old males		*P* value gender	*P* value Age groups	*P* value Gender*age groups
	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Legan and Burstone											
Facial convexity (contour) angle	17.711	5.5470	16.707	4.7927	17.341	5.1352	12.291	6.7276	0.025*	0.005*	0.058
Maxillary prognathism	5.389	3.1807	4.457	3.3443	6.113	4.3838	5.413	4.7509	0.268	0.282	0.878
Mandibular prognathism	-5.596	6.5097	-6.618	6.5593	-3.144	6.5242	-1.961	10.8156	0.016*	0.956	0.450
Vertical height ratio	1.0357	.09894	1.0650	0.13959	1.0281	0.08884	0.9913	0.10835	0.056	0.858	0.119
Lower facial throat angle	107.179	6.6643	107.261	5.1108	106.528	10.0697	110.435	13.3594	0.473	0.257	0.277
Lower vertical height–depth ratio	1.186	0.2289	1.211	0.1641	1.203	0.1492	1.513	0.5643	0.005*	0.007*	0.016*
Nasolabial angle	112.057	9.9609	110.011	11.9268	110.069	10.9925	104.491	10.0666	0.072	0.068	0.395
Upper lip protrusion	3.850	1.1868	3.664	1.8870	4.038	1.7705	3.678	2.1640	0.766	0.422	0.798
Lower lip protrusion	2.986	1.9129	3.354	2.0246	3.275	2.1087	3.200	2.0458	0.861	0.706	0.569
Mentolabial sulcus depth	5.361	1.4985	5.264	1.0761	5.297	1.3994	5.313	1.4750	0.977	0.878	0.830
Vertical lip-chin ratio	0.50	0.04	0.49	0.05	0.48	0.05	0.47	0.05	0.127	0.248	0.824
Maxillary incisor exposure	3.054	1.4950	2.936	1.8007	2.944	1.6531	2.943	1.4727	0.869	0.849	0.850
Interlabial gap	2.375	1.5937	2.000	1.2623	1.566	1.1108	1.613	1.1864	0.018*	0.511	0.397
Holdaway											
Soft tissue facial angle	90.107	3.0765	90.036	3.0994	91.197	3.0404	92.735	3.5048	0.002*	0.228	0.186
H angle	17.107	3.9817	16.493	3.1451	17.591	3.8600	14.548	5.8355	0.367	0.025*	0.135
Nose prominence	11.814	2.4764	13.950	2.2827	11.444	2.0355	13.374	3.1648	0.319	0.000*	0.828
Superior sulcus depth	2.439	1.1223	2.464	0.9986	2.791	1.1811	3.213	1.2804	0.013*	0.309	0.366
Soft tissue subnasale to H line	5.057	1.5147	4.832	2.4946	5.341	2.3449	4.870	2.8563	0.719	0.436	0.783
Skeletal profile convexity	2.539	2.6811	2.371	2.2542	1.822	2.3387	0.291	3.2476	0.006*	0.093	0.176
Basic upper lip thickness	16.057	2.0894	15.539	2.0835	18.059	2.4250	17.974	2.0150	0.000*	0.470	0.604
Upper lip strain measurement	12.214	1.6575	11.811	1.7451	13.616	1.9561	13.909	2.1679	0.000*	0.878	0.335
Lower lip to H line	0.929	1.8455	1.368	1.6866	1.241	1.8208	1.148	1.5698	0.891	0.605	0.427
Inferior sulcus to H line	4.854	1.7285	4.557	1.5631	4.731	1.8471	4.730	1.9135	0.940	0.660	0.662
Soft tissue chin thickness	11.857	1.8800	11.343	1.9282	13.513	2.0786	13.461	3.0261	0.000*	0.508	0.588
Ricketts											
Lower lip to E-plane	-0.425	2.3612	-0.664	2.2120	-0.072	2.5148	-1.513	2.6143	0.594	0.073	0.198
Upper lip to E-plane	-2.443	2.1287	-3.643	1.8456	-2.459	2.1126	-4.722	3.2573	0.224	0.000*	0.238
Epker											
Upper lip length	19.429	1.6034	19.871	2.3239	20.778	2.1094	21.452	2.3817	0.000*	0.170	0.775
Subnasale perp to upper lip	1.486	1.5010	1.221	2.1168	1.763	1.9309	2.026	2.2371	0.150	0.999	0.481
Subnasale perp to lower lip	-2.754	2.6440	-2.357	2.9893	-2.322	2.3843	-0.504	2.9670	0.031*	0.036*	0.177
Subnasale perp to chin	-9.504	4.2072	-9.518	3.8360	-8.975	4.1174	-6.296	5.8933	0.031*	0.124	0.120
The Z angle											
The Z angle	70.379	7.9650	69.818	7.7959	69.997	9.2931	75.470	8.6184	0.106	0.132	0.065
Supplementary analyzes											
Nasal tip protrusion	17.864	2.3413	19.468	2.0394	17.559	2.6415	19.013	1.8311	0.383	0.001*	0.863
Nasal length	45.18	4.07	46.61	3.79	49.02	4.10	51.27	5.23	0.271	0.908	0.533
Nasofrontal angle	136.464	7.0997	131.857	10.5680	132.031	9.9336	126.391	12.6912	0.012*	0.009*	0.790
Nasal tip angle	84.536	7.7817	83.286	7.1069	85.875	8.4729	77.348	9.0885	0.141	0.002*	0.021*
Submental-Cervical angle (Sm-Ce)	127.071	10.9441	130.071	11.3755	129.438	18.8096	129.696	18.8835	0.737	0.582	0.643
Lower lip vermilion height	8.31	2.96	8.67	1.54	9.64	4.10	9.75	2.15	0.001*	0.523	0.730
Upper lip vermilion height	8.32	1.79	8.52	1.78	9.51	1.83	9.06	1.83	0.009*	0.709	0.316
Lower lip thickness at the vermilion border	14.65	2.17	20.12	30.7	15.53	1.41	16.00	1.81	0.586	0.318	0.401
upper lip inclination to nasion-perpendicular	6.986	7.0765	5.761	9.3125	7.781	8.5359	8.622	9.6254	0.271	0.908	0.533

*P values below 0.05 are considered statistically significant.

Table 6. Comparison of hard tissue cephalometric values of growing and non-growing patients

Hard tissue cephalometric measurements	12–16-year-old females		Over 16-year-old females		12-16-year-old males		Over 16-year-old males		*P* value gender	*P* value Age groups	*P* value Gender*age groups
	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Steiner											
SNA	80.257	3.1326	80.339	3.7999	80.438	3.6832	80.987	5.1278	0.583	0.675	0.756
SNB	76.607	3.2983	77.050	3.7243	77.722	3.4178	79.696	4.7336	0.010*	0.097	0.291
ANB	3.657	2.7835	3.296	1.9633	2.716	2.1320	1.291	3.0336	0.002*	0.062	0.264
Occlusal plane to SN angle	16.321	3.8386	16.514	5.2682	15.788	4.5964	13.248	6.7148	0.054	0.232	0.165
Mandibular plane angle	32.704	4.6730	32.554	6.0262	32.881	4.6912	29.613	7.8526	0.216	0.127	0.163
U1-NA angle	21.850	5.1978	21.421	7.2660	24.353	6.4025	25.826	9.2847	0.012*	0.699	0.482
U1-NA distance	4.711	2.1376	4.761	2.3096	6.284	2.6200	6.783	3.5556	0.001*	0.591	0.661
L1-NB angle	27.582	6.9243	27.350	6.3901	27.806	6.2794	26.500	7.5709	0.809	0.553	0.678
L1-NB distance	5.286	2.4591	5.639	2.4803	6.341	2.5352	5.752	2.8929	0.239	0.812	0.342
Interincisal angle	126.918	9.8601	127.943	10.2903	125.113	10.1904	126.374	13.4356	0.419	0.584	0.955
McNamara											
NP to A point	-.943	2.6786	-.971	3.0811	-1.172	2.6269	-.978	3.4700	0.835	0.884	0.844
Mandibular length	105.450	5.9763	108.739	3.8897	112.091	8.1236	119.135	5.0301	0.000*	0.000*	0.110
Maxillary length/Midfacial length	80.907	4.2121	82.700	4.8085	84.544	5.7330	87.526	5.0819	0.000*	0.014*	0.536
LAFH	62.143	6.0593	64.221	4.7424	65.888	5.8830	69.904	6.0698	0.000*	0.006*	0.376
Facial axis angle	.425	4.7990	-.461	4.9183	-1.438	4.4402	.743	4.5761	0.714	0.471	0.090
Pog to NP	-6.643	5.4085	-6.314	6.1992	-5.678	5.5365	-2.496	5.4386	0.029*	0.108	0.190
Mandibular incisor position	2.575	2.0768	3.068	2.5841	4.084	2.6593	4.065	3.2392	0.015*	0.640	0.613
Downs											
Facial angle	86.246	3.0049	86.596	3.3566	86.856	3.0566	88.791	2.6719	0.018*	0.053	0.177
Angle of convexity	5.679	6.0583	5.125	4.8395	3.984	5.0863	.517	6.7041	0.004*	0.065	0.180
Y-axis	60.332	3.4891	60.429	3.9459	60.384	2.8771	59.204	3.2175	0.369	0.406	0.328
AB plane angle	-5.989	3.7748	-5.586	2.7486	-4.534	2.8730	-3.017	4.4938	0.003*	0.151	0.403
Cant of the occlusal plane	7.579	3.5896	7.818	4.8700	7.488	4.9465	5.217	4.7450	.127	.248	0.155
Incisor occlusal plane angle	25.654	7.6054	23.767	6.4824	24.303	6.5301	23.561	8.5634	0.841	0.558	0.959
U1 to A-Pog line	6.796	2.1474	6.729	2.2294	7.816	2.55	6.961	2.9349	0.187	0.330	0.406
Tweed											
FMIA	57.764	8.0920	58.400	7.2219	58.216	7.4124	61.230	8.2400	0.269	0.219	0.422
FMA	26.782	4.5246	26.893	5.3174	27.494	4.5080	24.739	6.6066	0.471	0.187	0.153
IMPA	95.454	7.1869	94.700	7.0979	94.291	6.5615	94.039	8.9498	0.520	0.723	0.859
Wits											
AO-BO	1.464	3.6399	0.779	3.0383	0.113	3.5261	-.861	4.0119	0.030*	0.224	0.832
Jarabak and Bjork											
Nasion angle	83.304	3.8666	83.625	5.0783	85.438	4.1480	84.891	4.9908	0.051	0.897	0.616
Saddle angle	125.604	5.4894	124.764	6.9653	123.559	4.9056	123.604	7.4674	0.178	0.738	0.709
Articular angle	141.279	8.6770	141.504	9.8638	139.175	8.2348	139.709	7.4974	0.24	0.819	0.926
Gonial angle	128.654	7.5770	129.329	8.5796	133.047	6.2071	129.470	7.5497	0.116	0.312	0.140
Chin angle	72.536	4.4160	73.775	6.3555	74.253	6.8119	72.274	6.6095	0.927	0.753	0.172
Anterior cranial base	64.868	3.2969	66.621	3.6108	67.600	4.3143	70.904	2.6364	0.000*	0.000*	0.260
Posterior cranial base	30.936	2.5436	30.518	3.1215	33.578	3.3457	35.135	3.6391	0.000*	0.350	0.106
Ramus height	42.421	4.9216	47.150	7.1512	45.700	5.4245	51.765	5.1120	0.000*	0.000*	0.544
Anterior facial height	107.882	6.6995	111.886	6.1715	114.094	7.3551	120.413	7.0237	0.000*	0.000*	0.378
Posterior facial height	69.125	5.5279	73.246	5.7454	74.231	6.2986	81.648	6.6415	0.000*	0.000*	0.157
Mandibular corpus	66.664	5.3608	67.550	3.0827	68.522	7.0550	73.065	4.3937	0.000*	0.008*	0.074
Sum of angles	395.525	4.7298	395.589	6.2654	395.797	4.6089	392.774	7.9277	0.261	0.191	0.173
Jarabak ratio	64.11	4.07	65.51	4.34	65.07	3.85	67.98	6.34	0.056	0.017*	0.393

**P* values below 0.05 are considered statistically significant.

genders and different age groups (14-16). Therefore, this study investigated the cephalometric norms of soft and hard tissue parameters in Iranian men and women with well-balanced faces and close to ideal occlusion and evaluated possible sexual, ethnic, and age-related dimorphism.

Sexual dimorphism of soft tissue

In general, based on our findings, Iranian women have more convex soft tissue profiles, more retruded mandibles, larger interlabial gaps, less deep superior sulci, thinner and shorter upper lips, and less prominent soft tissue chins than men. Our findings were in line with that of Ahangar et al (18) reporting thinner soft tissue chins in females than in males. Rakhshan and Ghorbanyjavadpour (19) reported significant sexual dimorphism between Iranian males and females, such as thicker soft tissue chin, more prominent noses, and more upper lip lengths in men compared with women. Khosravanifard et al (20) also indicated a considerable sexual dimorphism in Iranians i.e. females have more convex profiles, more protruded mandibles (unlike our findings), more protruded maxillae, and higher nose tips compared to males. Our findings were in contrast with that of Amini et al (6) in terms of nose prominence as no significant difference was shown between males and females in their study, but it was in line with it in terms of the parameter of soft tissue chin thickness and lower lip to H line (no sexual dimorphism was found).

Sexual dimorphism of hard tissue

Our results indicated that women generally have more convex skeletal profiles than men. Due to the similarity of SNA values and significantly different SNB values, this difference might be owing to more retruded mandibles in women than men. Women also have less protruded upper incisors, shorter mandibles and maxillae, shorter ramal heights, and shorter anterior and posterior facial heights. A study on a Bulgarian population showed that males had overall larger values of maxillary and mandibular corpus lengths than women (13), which was consistent with our findings. Hajighadimi et al (22) stated that Iranian males had more protrusive dentition than women, which is the same as our results. Azarbayejani et al (15) reported significant sexual dimorphism in terms of cranial dimensions, which is in line with our findings suggesting males have larger anterior facial height and cranial base than women; however, their results were in contrast with ours in terms of the Y-axis as males had a more pronounced Y-axis than women concerning their study.

Age differences

The majority of earlier research on the Iranian race has studied the adult population (6,18-20). Hajighadimi et al have also studied hard tissue cephalometric norms in Iranian children only (22). Since comprehensive orthodontic treatments usually begin at the age of 12, the norms of this age group should also be examined as well, as some cephalometric measurements might differ. Therefore, we divided our sample into two age groups of 12-16 (as growing) and over 16 (as non-growing) to study the effects of age on cephalometric parameters.

Based on the statistical results of our study, growing individuals had more convex soft and hard tissue profiles compared with non-growing ones. Also, nose prominence and nasal tip protrusion were significantly greater in non-growing adults compared with growing ones, while nasal tip angle was significantly lesser, indicating that non-growing adults have larger noses and more sloping nose tips compared with growing ones. The distance from the upper lip to E-plane was significantly lesser in the older group which could be due to either more protruded nasal tips or more advanced lower jaws in non-growing individuals compared with growing patients. Our findings also showed that in terms of skeletal dimensions, non-growing adults had longer mandibles and anterior cranial bases, and higher anterior and posterior facial heights compared with growing individuals. Jarabak ratio was also significantly greater in non-growing adults compared with growing ones, indicating a horizontal growth pattern in older individuals.

Comparison of Iranian soft tissue norms with Caucasian norms

After statistical studies, it was shown that, in general, Iranians have more convex profiles than Caucasians. This convexity is probably due to the retrusion of the lower face and mandible (according to the values for the distance from the subnasale perp to the chin and mandibular prognathism). Also, Iranian women have a bit more retrusive maxillae. Soft tissue facial angle shows the protrusion of the chin and lower part of the face (23). Iranian women have slightly smaller values of soft tissue facial angle. Khosravani et al (20) indicated that Iranians have more convex profiles and more retruded mandibles and maxillae, as stated in our findings. A study conducted on a Turkish population (10) also showed that Turkish people have more convex profiles and retruded mandibles compared to Caucasians which is similar to our findings. Our findings were in line with Rakhshan and Ghorbanijavadpour (19) in terms of skeletal convexity according to Holdaway's measurement method, but the facial convexity angle obtained using Legan and Burstone's measurement was not significantly different from Caucasians.

Our findings showed that Iranians generally have more obtuse nasolabial angles than Caucasians. The values for the upper lip and lower lip protrusion, H angle, and distance between the upper lip and lower lip to E-line indicated that Iranians have more protruded upper and

lower lips in general. Compared with Caucasians, both men and women have deeper mentolabial sulci, but the superior sulcus depth was significantly greater only in Iranian men. Maxillary incisor exposure was also greater in both sexes, implying possibly shorter upper lips. Also, both males and females had lesser values for lower lip vermilion height and greater values for upper lip thickness, while upper lip vermilion height was significantly greater only in men. Upper lip length and lower lip thickness at the vermilion border were statistically greater only in men. Khosravanifard et al (24) and Rakhshan and Ghorbanyjavadpour (17) demonstrated that protruded upper lip compared to lower lips is considered attractive to Iranian judges, which is in line with our study suggesting that protruded upper lips are accepted. Based on a previous study, the Turkish population also had more protruded upper lips, similar to the Iranian population in the current study (10). Rakhshan and Ghorbanyjavadpour's (19) findings were also in contrast with ours as they indicated Iranians have more retruded upper lips compared to Caucasians.

Our study showed that Iranians have less prominent and less protruded nasal tips. The nasofrontal angle in Iranians is slightly more acute than the Caucasian norm only in men. Both females and males have more obtuse nasolabial angles indicating possibly higher nose tips in Iranians. The study by Rakhshan and Ghorbanijavadpour (19), like our study, stated that Iranians have less prominent noses. Our results contrasted with that of Amini et al (6) in terms of nose prominence, since according to their findings Iranians had more prominent noses than Caucasians. Khosravanifard et al (20) indicated that Iranians have more sloping nasal tips, which is in contrast with our findings.

Both males and females have statistically greater values for soft tissue chin thickness and submental cervical angle. Thicker soft tissue chins may compensate for the retrusive position of the lower face and improve facial harmony (6). Rakhshan and Ghorbanijavadpour (19) and Amini et al (6) indicated that Iranians have thicker soft tissue chins than Caucasians, which is in line with our findings. Our findings were in contrast with that of a study on a Turkish population, reporting they had thinner soft tissue chins compared to Caucasians (10).

Comparison of Iranian hard tissue norms and Caucasian norms

Statistical studies showed that SNA and SNB angles in both sexes among Iranians were significantly lesser than Caucasian norms, meaning that both upper and lower jaws were retruded. But ANB angle was normal in men and was larger than normal only in women, resulting in more convex skeletal profiles in women. Males had greater amounts of U1-NA angle, meaning they had more proclined upper incisors. Values for the L1-NB angle and the incisor occlusal plane angle were more in both sexes, indicating that the lower incisors were proclined. This proclination may have been caused to compensate for the retruded position of the mandible. Women had slightly lesser values for facial angle, implying the retruded positions of their mandibles. Both sexes had higher values for the angle of convexity, meaning their skeletal profiles were slightly more convex. In Iranians, the sum of posterior angles was slightly smaller, and the Jarabak ratio was slightly greater in both sexes, indicating that Iranians had a somewhat horizontal growth pattern compared with Europeans. Azarbayejani et al (15) studied skeletal cephalometric indices of different Iranian age groups. Our findings were in line with that of Aazarbayejani et al in terms of greater values of IMPA, angle of convexity, and ANB and lower values of interincisal angle, indicating that Iranians have possible bimaxillary protrusion tendency and more convex skeletal profiles. Hajighadimi et al (22) stated that Iranian children have slightly lesser values for SNA and SNB angles compared to Caucasians, which is consistent with our findings. He attributed this ethnic difference to the more retruded position of apical bases on the maxilla and mandible of Iranians. The smaller interincisal and FMIA angles and greater IMPA and FMA angles were similar to our findings.

Our findings indicated that U1-NA distance and L1-NB distance were larger in both sexes, i.e., the incisor teeth of both jaws were protruded. The U1-A Pog distance was also larger in both sexes, indicating proclination of the upper incisor teeth. Among Iranians, both males and females have shorter mandibles and maxillae compared with Caucasians. Women have significantly shorter anterior and posterior facial heights, while men have noticeably long anterior facial heights. The height of the ramus is higher in males, which could also be explained by the lesser values of the cant of occlusal plane angle. Our findings were consistent with that of a study on Kuwaiti Arabs in terms of protrusive dentitions (25).

Conclusion

The present study showed that there are significant differences between hard and soft tissue cephalometric norms of Iranian men and women and that of Caucasians that should be considered in orthodontic and surgical treatments. Some of the most important ethnic differences are as follows: slightly more convex profiles, more protruded lips, less prominent noses, higher nose tips, and proclined and protruded central incisors in the Iranian population. In general, Iranian women have more convex soft and hard tissue profiles, more retruded mandibles, shorter anterior and posterior facial heights, larger interlabial gaps, less deep superior sulci, thinner and shorter upper lips, and less prominent soft tissue chins than men. Also, non-growing adults have more advanced mandibles, larger noses, more sloping nasal

tips, and larger skeletal dimensions compared with growing ones.

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Conflict of Interests
The authors declared that there is no conflict of interest

Ethical Approval
The protocol of this study was reviewed and approved by the Ethics Committee of Shahid Beheshti Dental School e (Ref. No. IR.SBMU.DRC.REC.1398.230).

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References
1. Shafi AM, Khan FN, Khan AG, Nadeem M, Khursheed T, Jehan S, et al. A soft tissue cephalometric analysis for Pakistani adult using Holdaway's analysis. Int Med J. 2018;25(1):51-3.
2. Imani MM, Hosseini SA, Arab S, Delavarian M. Characterization of soft tissue cephalometric norms of Kurdish population of Iran. J Res Med Dent Sci. 2018;6(1):335-42. doi: 10.5455/jrmds.20186155.
3. Sarver DM. Interactions of hard tissues, soft tissues, and growth over time, and their impact on orthodontic diagnosis and treatment planning. Am J Orthod Dentofacial Orthop. 2015;148(3):380-6. doi: 10.1016/j.ajodo.2015.04.030.
4. Kumari L, Das A. Determination of Tweed's cephalometric norms in Bengali population. Eur J Dent. 2017;11(3):305-10. doi: 10.4103/ejd.ejd_274_16.
5. Anić-Milošević S, Anić-Milošević S, Lapter-Varga M, Dumancic J, Šlaj M. Analysis of the soft tissue profile in Croatians with normal occlusions and well-balanced faces. Eur J Orthod. 2011;33(3):305-10. doi: 10.1093/ejo/cjq072.
6. Amini F, Razavian ZS, Rakhshan V. Soft tissue cephalometric norms of Iranian class I adults with good occlusions and balanced faces. Int Orthod. 2016;14(1):108-22. doi: 10.1016/j.ortho.2015.12.003. [English, French].
7. Mafi AA, Shahverdiani R, Mafi P. Ideal soft tissue facial profile in Iranian males and females: clinical implications. World J Plast Surg. 2018;7(2):179-85.
8. Shamlan MA, Aldrees AM. Hard and soft tissue correlations in facial profiles: a canonical correlation study. Clin Cosmet Investig Dent. 2015;7:9-15. doi: 10.2147/ccide.s73457.
9. Storniolo-Souza JM, Seminario MP, Pinzan-Vercelino CRM, Pinzan A, Janson G. McNamara analysis cephalometric parameters in White-Brazilians, Japanese and Japanese-Brazilians with normal occlusion. Dental Press J Orthod. 2021;26(1):e2119133. doi: 10.1590/2177-6709.26.1.e2119133.oar.
10. Uysal T, Baysal A, Yagci A, Sigler LM, McNamara JA Jr. Ethnic differences in the soft tissue profiles of Turkish and European-American young adults with normal occlusions and well-balanced faces. Eur J Orthod. 2012;34(3):296-301. doi: 10.1093/ejo/cjq165.
11. Singh R, Awasthy A, Krishna BP, Mazhar H, Soni SK, Thomas AE. Do we vary from Caucasians! Cephalometric analysis for orthognathic surgery in Chhattisgarhi population. J Maxillofac Oral Surg. 2021. doi: 10.1007/s12663-021-01559-4.
12. Cooke MS, Wei SH. A comparative study of southern Chinese and British Caucasian cephalometric standards. Angle Orthod. 1989;59(2):131-8. doi: 10.1043/0003-3219(1989)059<0131:acsosc>2.0.co;2.
13. Todorova-Plachiyska KG, Stoilova-Todorova MG. Lateral cephalometric study in adult Bulgarians with normal occlusion. Folia Med (Plovdiv). 2018;60(1):141-6. doi: 10.1515/folmed-2017-0072.
14. Huang WJ, Taylor RW, Dasanayake AP. Determining cephalometric norms for Caucasians and African Americans in Birmingham. Angle Orthod. 1998;68(6):503-11. doi: 10.1043/0003-3219(1998)068<0503:dcnfca>2.3.co;2.
15. Azarbayejani S, Omrani A, Kalaantar-Motamedi A, Abdellahi M, Taalebi V, Teimoori F. Cephalometric norms for 6-17 year-old Iranians with normal occlusion and well-balanced faces. Dent Res J (Isfahan). 2014;11(3):327-35.
16. Karaca Bozdağ Z, Kurkcuoglu A, Guney AU, Cam Y, Oguz O. An assessment of gender difference in visual cephalometric analysis applied to class I individuals: a preliminary study. East J Med. 2019;24(1):1-7. doi: 10.5505/ejm.2019.40570.
17. Ghorbanyjavadpour F, Rakhshan V. Factors associated with the beauty of soft-tissue profile. Am J Orthod Dentofacial Orthop. 2019;155(6):832-43. doi: 10.1016/j.ajodo.2018.07.020.
18. Ahangar Atashi MH, Kachooei M. Soft tissue cephalometric standards based on NHP in a sample of Iranian adults. J Dent Res Dent Clin Dent Prospects. 2008;2(2):53-7. doi: 10.5681/joddd.2008.011.
19. Rakhshan V, Ghorbanyjavadpour F. Anteroposterior and vertical soft tissue cephalometric norms of Iranians, interethnic comparisons, sex dimorphism, and the effect of age on cephalometric variables. Oral Maxillofac Surg. 2019;23(2):167-78. doi: 10.1007/s10006-019-00755-4.
20. Khosravanifard B, Raeisi E, Kadkhodaei Oliadarani F, Rakhshan V. Soft-tissue anthropometric norms of Iranians with proper occlusion and inter-ethnic norm comparisons. J Maxillofac Oral Surg. 2018;17(4):588-96. doi: 10.1007/s12663-018-1101-8.
21. Khosravani S, Esmaeili S, Malek Mohammadi N, Eslamian L, Dalaie K, Motamedian SR. Inter and intra-rater reliability of lateral cephalometric analysis using 2D dolphin imaging software. J Dent Sch. 2020;38(4):148-52. doi: 10.22037/jds.v38i4.35384.
22. Hajighadimi M, Dougherty HL, Garakani F. Cephalometric evaluation of Iranian children and its comparison with Tweed's and Steiner's standards. Am J Orthod. 1981;79(2):192-7. doi: 10.1016/0002-9416(81)90317-1.
23. Holdaway RA. A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. Am J Orthod. 1983;84(1):1-28. doi: 10.1016/0002-9416(83)90144-6.
24. Khosravanifard B, Rakhshan V, Raeesi E. Factors influencing attractiveness of soft tissue profile. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013;115(1):29-37. doi: 10.1016/j.oooo.2012.03.021.
25. Al-Jame B, Artun J, Al-Azemi R, Behbehani F, Buhamra S. Lateral cephalometric norms for adolescent Kuwaitis: hard tissue measurements. Med Princ Pract. 2006;15(2):91-7. doi: 10.1159/000090910.