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ORIGINAL ARTICLE

Anteroposterior and vertical soft tissue cephalometric norms of Iranians, interethnic comparisons, sex dimorphism, and the effect of age on cephalometric variables

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Abstract

Introduction This study established about 50 anteroposterior and vertical cephalometric norms of five tracing analyses in Iranians, using a large sample.

Methods Lateral cephalographs of 130 subjects (85 females, 45 males, with an average age of 22.77 ± 2.55 years (range 20–29)) were traced manually using the Ricketts, Holdaway, Z-Merrifield, Epker, and Legan-Burstone soft tissue analyses. The role of age and sex on measurements, as well as the comparisons between Iranian norms with Caucasians from European decent, was determined statistically ($\alpha = 0.001$).

Results Age had no significant effect (all P values > 0.01). Sexual dimorphism existed in terms of numerous parameters. Compared to analysis standards, upper lip to E-plane, nose prominence, upper lip thickness, nasomental angle, Z angle, interlabial distance, subnasale perp to chin, subnasale-stomion:stomion-menton, subnasale-lower lip:lower lip-menton, interlabial gap, and vertical lip-chin ratio were smaller in Iranians. Superior sulcus depth, skeletal profile convexity, upper lip strain, upper lip curvature, H-angle, soft tissue chin thickness, nasofacial angle, subnasale perp to upper lip, subnasale perp to lower lip, maxillary prognathism, lower face throat angle, upper lip protrusion, lower lip protrusion, mentolabial sulcus, and lower vertical height-depth ratio were greater in Iranians compared to the norm ($P \leq 0.001$).

Conclusions A great degree of sex dimorphism might exist among Iranians. Many textbook norms might not be the best options for diagnosis or treatment of Iranians.

Keywords Anthropometry · Ethnic groups · Orthodontic norms · Soft tissue profile · Sex dimorphism

Introduction

Facial beauty may be a result of harmony among various facial elements [1, 2]. Due to its importance, facial esthetics is receiving ever-increasing attention in fields concerning with beauty such as maxillofacial surgery and orthodontics [3–6]. Patients are becoming more and more obsessed with esthetics, necessitating the treatment protocols to take into account this significant factor [2, 7–10]. Unlike in the past when orthodontists relied mostly on skeletal relationships to provide facial harmony, it is now understood that there is not a high correlation between skeletal measurements with soft tissue analyses; therefore, relying exclusively on skeletal standards might increase the risk of failure [4, 8, 11–14], causing the dissatisfaction of the patient who might act against the clinician by suing, not paying treatment fees, or even literally attacking the clinician [2, 7, 15–17]. Thus, more emphasis is now being placed on soft tissue evaluations [3, 4, 18, 19]. Analyses and norms of facial soft tissue profile are important to plastic and reconstructive surgeries, orthogenetic surgeries, orthodontic treatments, or art and forensic investigations; they can also be used for optimizing the diagnosis and treatment planning, esthetic evaluation, and documenting anatomical alterations through growth or esthetic changes happened by orthodontic/surgical treatments [2, 4, 6, 8, 17, 20–28]. However, in spite of the significance of soft tissue in the success of esthetic interventions [8,

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21], substantial research on soft tissue norms are a few [4, 24]. Knowledge of the population norm enables the operator to deliver more successful and pleasing treatments [2, 4, 21, 28]. This calls for establishing the norm of the population to address the esthetic and functional needs of patients originating or residing in various populations [4, 8, 17, 23, 27, 28].

Moreover, earlier studies determining profile standards have assessed Caucasians from European ancestries [2, 4, 17]. Currently, such standards are being taught and used in many countries, in procedures such as orthodontic treatment, plastic surgeries, reconstructive surgeries of congenital facial abnormalities/craniomaxillofacial deformities, or trauma [2, 29]. Nevertheless, given the high anatomic variations across ethnicities, such classical norms might not be necessarily relevant to patients from other ethnicities [2, 4, 8, 22, 24, 26–28, 30–42]. The normative values obtained from analyses such as Ricketts [43], Holdaway [5], Epker et al. [44], or Legan and Burstone [26] might not be completely applicable as a reference for Persians or many other ethnic groups. Therefore, documenting various populations is of value [2, 4, 45–49], especially in this modern world where many countries have immigrants from other ethnicities. Clinicians should consider both the ethnicity and opinion of patients while planning for and executing treatment [2, 8, 24, 28].

In this regard, there have been recent studies on different ethnicities, most of which were limited to the Holdaway measurements only [4] and lacking substantial soft tissue analyses in both anteroposterior and vertical dimensions. Hence, this comprehensive study was conducted to assess several non-overlapped anteroposterior and vertical measurements. Also, sex dimorphism (which is not adequately evaluated except in only few studies worldwide [3, 4, 21, 24, 50]) and the role of age were examined.

Materials and methods

The sample of this study consisted of 130 cephalometries including the archive of 70 dental students who had been previously enrolled for another study with a completely different goal [51] as well as cephalometric archives of 60 patients referred to radiology centers and orthodontic clinics of Ahvaz, Iran, for clinical-only purposes and collected retrospectively. Since radiographs were archived and all retrospectively acquired, and since no harms or interventions were done to the owners of the radiographs, no subject consents were needed according to the Helsinki declaration (the consent of the 70 students had been taken previously). The ethics of the study was approved by the research committee of the university. The first step in the evaluation of cases was the assessment of the occlusion and dentoskeletal conditions. The inclusion criteria comprised all cases having class I molar and canine relationships with normal overbites and overjets; all cases being of Persian ethnicity; and having symmetrical faces (based on clinical or photographic evaluation), with no or minor crowding in the anterior segments, without any craniofacial deformities, and with no history of hypodontia or dental extraction except for third molars and no history of facial plastic surgery, no history of orthodontic or prosthodontic treatment, and no history of trauma to the face [51, 52].

Lateral cephalographs had been obtained in natural head position with teeth in maximum intercuspation and lips in repose, the FH plane positioned horizontally, and the eyes looking straight ahead.

Cephalometric analyses

Cephalometric tracings were performed manually on 0.003-mm matte acetate papers (Ortho Organizers Inc., USA), by the corresponding author, at the Department of Orthodontics in Dental School. Landmarks were identified twice (or in some cases, thrice) by the same observer, with an interval of about 2 weeks. Landmarks pertaining to the 70 dental students were also subjected to assessment by two colleagues at the department. Cephalographs were used to establish the Holdaway, Ricketts, Z-Merrifield, Epker, and Legan-Burstone soft tissue measurements (Figs. 1, 2, 3) [5, 26, 43, 44, 53] recorded as norm of Persian Caucasians (PC). The tracings were

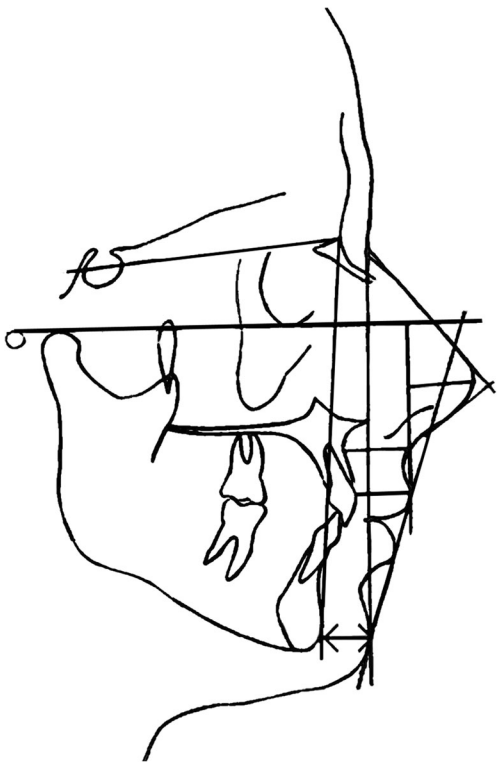

Fig. 1 Holdaway soft tissue analysis. Variables are defined in the methods section

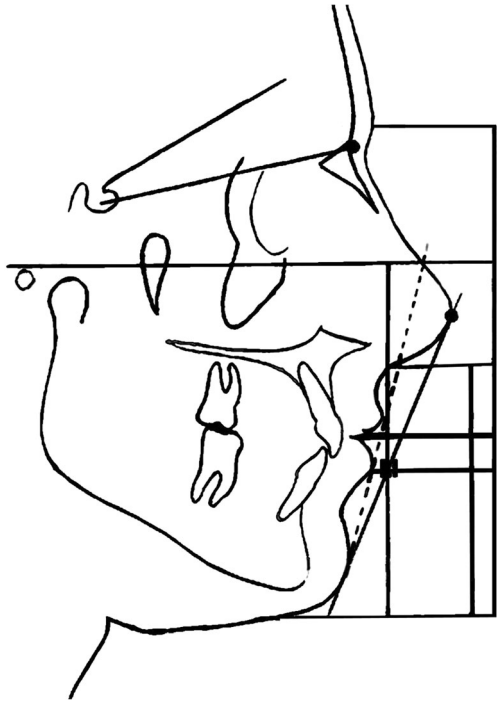

Fig. 2 Ricketts (esthetic plane, a line passing through Pog′ to Pn), Z-Merrifield angle (a line passing through Pog′ to the most prominent point of the lips (upper or lower lip) in profile view), and Epker soft tissue analyses

undertaken twice, and for each measurement, the average of both tracing was calculated and recorded.

The landmarks used in Holdaway analysis were G: glabella; the most prominent anterior point in the mid-sagittal plane

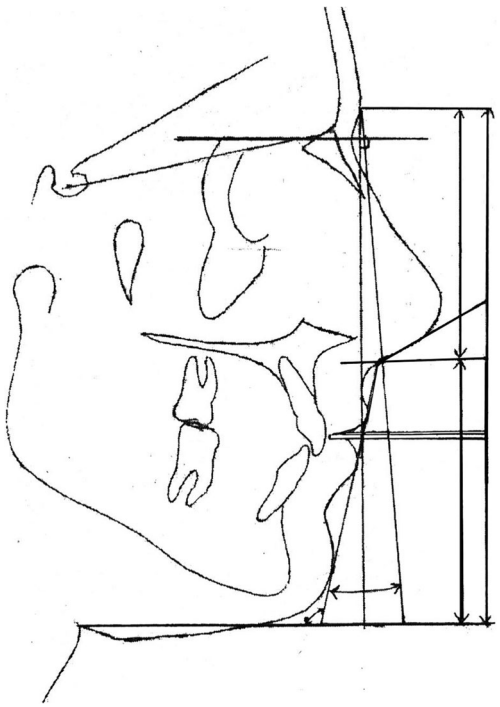

Fig. 3 Legan-Burstone soft tissue analysis

of the forehead, N′: soft tissue nasion; the point of greatest concavity in the midline between the forehead and the nose, Pn: pronasale; the most prominent or anterior point of the nose (tip of the nose), Sn: subnasale; the point at which the columella (nasal septum) merges with the upper lip in the mid-sagittal plane, Sls: superior labial sulcus; the point of greatest concavity in the midline of the upper lip between Sn and labrale superius, Ls: labrale superius; a point indicating the mucocutaneous border of the upper lip, usually the most anterior point of the upper lip, Sts: stomion superius; the lowermost point on the vermilion of the upper lip, Sti: stomion inferius; the upper-most point on the vermilion of the lower lip, Li: labrale inferius; the median point on the lower margin of the lower membranous lip, Ils: inferior labial sulcus; and the point of greatest concavity in the midline of the lower lip between Li and soft tissue, pogonion also known as labiomental sulcus (Si), Pg′: soft tissue pogonion: The most prominent or anterior point on the soft tissue chin in mid-sagittal plane. The Holdaway analysis has the following parameters: (1) Soft tissue facial angle: The inside inferior angle formed by the intersection of soft tissue facial line and the FH-line; (2) nose prominence: The distance from the tip of the nose to the line drawn from Ls perpendicular to the FH-line; (3) superior sulcus depth: The distance from the deepest point of the upper lip sulcus to the line drawn from Ls perpendicular to the FH-line; (4) skeletal profile convexity: The distance between the point A and the hard tissue facial line (N-Pog); (5) basic upper lip thickness: The distance measured approximately 2 mm below point A and the drape of the upper lip; (6) upper lip thickness: The distance between the Ls and the labial surface of the maxillary incisor (upper lip strain: The difference between the basic upper lip thickness and upper lip thickness); (7) soft tissue subnasale to H-Line; (8) H-angle: The angle between the soft tissue facial line (N′-Pog′) and the H-line; (9) lower lip to the H-line: The distance from Li to the H-line; (10) inferior sulcus to the H-line: The distance from the greatest convexity between the vermilion border of the lower lip and the H-line; and (11) soft tissue chin thickness: The distance between the soft and hard tissue facial planes at the level of supra pogonion (Fig. 1). The Ricketts analysis comprised the Esthetic plane, a line passing through Pog′ to Pn (Fig. 2). Z-Merrifield angle was a line passing through Pog′ to the most prominent point of the lips (upper or lower lip) in profile view (Fig. 2). The Epker analysis consisted of upper lip length, interlabial distance, subnasale perp to upper lip, subnasale perp to lower lip, subnasale perp to chin, middle third height:lower third height, subnasale-stomion:stomion-menton, and subnasale-lower lip:lower lip-menton, among others (Fig. 2). The Legan-Burstone analysis consisted of the variables facial convexity angle (G-Sn-Pg′), maxillary prognathism (G-Sn(HP)), mandibular prognathism (G-Pg′(HP)), lower face throat angle (Sn-Gn′-C), upper lip protrusion (Ls to (Sn-Pg′)), lower lip protrusion (Li to (Sn-Pg′)),

Table 1 Descriptive statistics and 95% CIs for the Ricketts and Epker analyses of sample, males, and females, as well as inter-gender comparisons using independent samples *t* test

Ricketts	Sex	*N*	Mean	SD	95% CI		Min	Max	*P*
Upper lip to E-plane	F	85	− 5.01	2.17	− 5.48	− 4.54	− 11.0	− 1.0	0.3226240
	M	45	− 5.40	2.03	− 6.01	− 4.79	− 11.0	− 1.0	
	Both	130	− 5.15	2.12	− 5.51	− 4.78	− 11.0	− 1.0	
Lower lip to E-plane	F	85	− 2.28	2.48	− 2.81	− 1.74	− 9.0	2.5	0.8482135
	M	45	− 2.19	2.48	− 2.93	− 1.45	− 7.0	4.0	
	Both	130	− 2.25	2.47	− 2.67	− 1.82	− 9.0	4.0	
Epker									
Upper lip length	F	85	20.28	2.20	19.80	20.75	15.0	25.5	0.0000000
	M	45	23.50	2.94	22.62	24.38	19.0	32.0	
	Both	130	21.39	2.91	20.89	21.90	15.0	32.0	
Interlabial distance	F	85	1.02	0.45	0.93	1.12	0.5	3.0	0.1309453
	M	45	0.91	0.29	0.82	1.00	0.0	1.5	
	Both	130	0.98	0.40	0.91	1.05	0.0	3.0	
Subnasale perp to upper lip	F	85	1.56	1.76	1.18	1.94	− 3.5	5.5	0.9610779
	M	45	1.54	1.99	0.94	2.14	− 3.6	7.0	
	Both	130	1.55	1.83	1.23	1.87	− 3.6	7.0	
Subnasale perp to lower lip	F	85	− 0.99	2.41	− 1.51	− 0.47	− 7.0	6.0	0.1406153
	M	45	− 1.66	2.51	− 2.41	− 0.90	− 9.0	5.0	
	Both	130	− 1.22	2.45	− 1.64	− 0.79	− 9.0	6.0	
Subnasale perp to chin	F	85	− 5.39	5.60	− 6.60	− 4.18	− 16.0	12.0	0.0005579
	M	45	− 8.89	4.89	− 10.36	− 7.42	− 16.0	8.0	
	Both	130	− 6.60	5.60	− 7.57	− 5.63	− 16.0	12.0	
Middle third height:lower third height	F	85	1.02	0.07	1.00	1.03	0.9	1.3	0.0000058
	M	45	0.95	0.08	0.93	0.97	0.8	1.1	
	Both	130	0.99	0.08	0.98	1.01	0.8	1.3	
Subnasale-stomion:stomion-menton	F	85	0.46	0.04	0.45	0.47	0.3	0.6	0.0131389
	M	45	0.44	0.05	0.42	0.45	0.3	0.5	
	Both	130	0.45	0.04	0.44	0.46	0.3	0.6	
Subnasale-lower lip:lower lip-menton	F	85	0.87	0.12	0.84	0.89	0.7	1.2	0.0004864
	M	45	0.79	0.10	0.76	0.82	0.5	1.1	
	Both	130	0.84	0.12	0.82	0.86	0.5	1.2	
Middle third height	F	85	66.81	6.33	65.44	68.17	48.0	78.5	0.0000001
	M	45	73.89	7.54	71.62	76.15	57.0	88.5	
	Both	130	69.26	7.54	67.95	70.57	48.0	88.5	
Lower third height	F	85	65.94	6.18	64.61	67.27	49.0	81.0	0.0000000
	M	45	78.03	7.30	75.84	80.23	60.0	92.0	
	Both	130	70.13	8.74	68.61	71.64	49.0	92.0	
Stomion to soft tissue menton	F	85	45.16	4.54	44.18	46.14	33.0	55.5	0.0000000
	M	45	54.14	5.46	52.50	55.79	39.0	61.5	
	Both	130	48.27	6.48	47.14	49.39	33.0	61.5	
Sn-LIv	F	85	30.43	3.51	29.67	31.19	23.0	39.0	0.0000005
	M	45	34.11	4.24	32.84	35.39	24.5	46.0	
	Both	130	31.70	4.16	30.98	32.43	23.0	46.0	
LIv-Me	F	85	35.45	3.79	34.63	36.26	26.0	44.0	0.0000000
	M	45	43.43	4.52	42.08	44.79	30.0	50.0	
	Both	130	38.21	5.55	37.25	39.18	26.0	50.0	

Table 2 Descriptive statistics and 95% CIs for the Holdaway and Z-Merrifield analyses of sample, males, and females, as well as inter-gender comparisons using independent samples *t* test

Holdaway + Z-Merrifield angle	Sex	*N*	Mean	SD	95% CI		Min	Max	*P*
Soft tissue facial angle	F	85	91.65	2.68	91.07	92.23	85.0	99.0	0.4105867
	M	45	91.24	2.58	90.47	92.02	86.0	96.0	
	Both	130	91.51	2.64	91.05	91.97	85.0	99.0	
Nose prominence	F	85	14.02	2.92	13.39	14.65	8.0	22.0	0.0010230
	M	45	15.80	2.80	14.96	16.64	10.0	22.0	
	Both	130	14.63	2.99	14.12	15.15	8.0	22.0	
Superior sulcus depth	F	85	4.60	1.15	4.35	4.85	1.5	7.0	0.1181492
	M	45	4.99	1.64	4.50	5.48	1.5	9.0	
	Both	130	4.73	1.35	4.50	4.97	1.5	9.0	
Soft tissue subnasale to H-line	F	85	4.70	2.08	4.25	5.15	0.0	9.0	0.2173665
	M	45	5.19	2.25	4.51	5.87	0.0	10.0	
	Both	130	4.87	2.14	4.50	5.24	0.0	10.0	
Skeletal profile convexity	F	85	2.25	2.56	1.70	2.80	− 5.0	8.0	0.9427979
	M	45	2.29	2.99	1.39	3.19	− 4.0	10.0	
	Both	130	2.27	2.70	1.80	2.73	− 5.0	10.0	
Basic upper lip thickness	F	85	13.64	2.17	13.17	14.10	10.0	21.0	0.0000000
	M	45	16.93	2.67	16.13	17.74	9.0	21.5	
	Both	130	14.78	2.83	14.29	15.27	9.0	21.5	
Upper lip thickness	F	85	11.94	1.89	11.53	12.35	8.0	16.5	0.0000000
	M	45	14.77	2.65	13.97	15.56	8.0	21.5	
	Both	130	12.92	2.56	12.48	13.36	8.0	21.5	
Upper lip strain	F	85	1.69	1.75	1.32	2.07	− 2.0	7.0	0.1900475
	M	45	2.17	2.27	1.49	2.85	− 3.0	7.5	
	Both	130	1.86	1.95	1.52	2.20	− 3.0	7.5	
Upper lip curvature	F	85	2.93	1.08	2.70	3.16	1.0	6.0	0.6085162
	M	45	3.03	1.13	2.69	3.37	0.0	5.5	
	Both	130	2.97	1.09	2.78	3.16	0.0	6.0	
H-angle	F	85	15.00	3.42	14.26	15.74	8.0	22.0	0.9577220
	M	45	15.03	3.38	14.02	16.05	6.0	22.0	
	Both	130	15.01	3.39	14.42	15.60	6.0	22.0	
Lower lip to H-line	F	85	0.75	1.59	0.41	1.10	− 5.0	4.0	0.1502948
	M	45	1.17	1.47	0.73	1.61	− 2.0	4.0	
	Both	130	0.90	1.56	0.63	1.17	− 5.0	4.0	
Inferior sulcus to H-line	F	85	4.57	1.53	4.24	4.90	1.5	8.0	0.0000011
	M	45	6.20	2.06	5.58	6.82	2.0	11.5	
	Both	130	5.13	1.89	4.81	5.46	1.5	11.5	
Soft tissue chin thickness	F	85	11.84	1.98	11.41	12.26	7.5	19.0	0.0000082
	M	45	13.77	2.70	12.96	14.58	7.0	19.5	
	Both	130	12.50	2.43	12.08	12.93	7.0	19.5	
Nasolabial angle	F	85	101.27	10.26	99.06	103.48	78.0	125.0	0.9353208
	M	45	101.11	11.32	97.71	104.51	77.0	124.0	
	Both	130	101.22	10.60	99.38	103.05	77.0	125.0	
Nasofacial angle	F	85	35.36	3.55	34.60	36.13	23.0	45.0	0.9218729
	M	45	35.30	3.62	34.21	36.39	26.0	41.0	
	Both	130	35.34	3.56	34.72	35.96	23.0	45.0	
Nasomental angle	F	85	123.35	4.32	122.42	124.28	113.0	139.0	0.1519780
	M	45	124.56	4.90	123.08	126.03	112.0	135.0	
	Both	130	123.77	4.55	122.98	124.56	112.0	139.0	

Table 2 (continued)

Holdaway + Z-Merrifield angle	Sex	*N*	Mean	SD	95% CI		Min	Max	*P*
Z-angle	F	85	74.02	5.79	72.78	75.27	61.0	85.0	0.6169405
	M	45	73.47	6.45	71.53	75.41	60.0	88.0	
	Both	130	73.83	6.01	72.79	74.87	60.0	88.0	

mentolabial sulcus (Si to (Li-Pg′)), maxillary incisor exposure (Stms-Ui), interlabial gap (Stms-Stmi(VP)), vertical height ratio [G-Sn/Sn-Me′(VP)] lower vertical height-depth ratio, and vertical lip-chin ratio (Fig. 3).

Statistical analysis

To assess the method error, one of the variables was measured in all 130 subjects by the same orthodontist. The intraclass correlation coefficient showed 98.3% intrarater agreement ($P = 0.00000$). Descriptive statistics and 95% confidence intervals (CI) were calculated for the measurements. An independent samples *t* test was used for the comparison between measurements or ages of males and females. Cephalometric values were compared with the standard values of European Caucasians (EC) using a one sample *t* test. Associations between subjects' ages with their measurements were assessed using a partial correlation coefficient controlling for sex. Software in use was SPSS 25 (IBM, Armonk, NY, USA). The level of significance was set at 0.001.

Results

The average and standard deviation (SD) age of the whole sample was 22.77 ± 2.55 years (range 20–29). There were 85 females with an average (SD) age of 22.6 ± 2.6 years (range 20–29), and 45 males with an average (SD) age of 23.1 ± 2.4 years (range 20–29). The age of males and females did not differ significantly ($P = 0.237$).

Role of age

The partial correlation coefficient showed no significant associations between age and any of measurements (all *P* values > 0.15, except for the maxillary prognathism [$r = -0.152$, $P = 0.085$] and lower face throat angle [$r = 0.205$, $P = 0.020$] which became marginally significant).

Sexual dimorphism

Comparisons between males and females revealed significant sex dimorphism in terms of numerous variables. The following parameters were greater or more positive in females: Subnasale perp to chin, middle third height:lower third height, subnasale-lower lip:lower lip-menton, interethnic differences, and vertical height ratio. The following variables were greater in men: Upper lip length, middle third height, lower third height, stomion to soft tissue menton, Sn-LIv, LIv-Me, nose prominence, basic upper lip thickness, upper lip thickness, inferior sulcus to H-line, soft tissue chin thickness, middle third height, lower third height, lower face throat angle, Sn-Gn′, mentolabial sulcus, upper lip length, lower lip and chin length, and lower vertical height-depth ratio (Tables 1, 2, 3).

Differences with the norms of Caucasians from European ancestry

The following variables were smaller in Iranians, compared to the European norms: upper lip to E-plane, nose prominence, upper lip thickness, nasomental angle, Z angle, interlabial distance, subnasale perp to chin, subnasale-stomion:stomion-menton, subnasale-lower lip:lower lip-menton, interlabial gap (Stms-Stmi(VP)), and vertical lip-chin ratio (Table 4).

On the other hand, the following parameters were greater in Iranians: Superior sulcus depth, skeletal profile convexity, upper lip strain, upper lip curvature, H-angle, soft tissue chin thickness, nasofacial angle, subnasale perp to upper lip, subnasale perp to lower lip, maxillary prognathism (G-Sn(HP)), lower face throat angle (Sn-Gn′-C), upper lip protrusion (Ls to (Sn-Pg′)), lower lip protrusion (Li to (Sn-Pg′)), mentolabial sulcus (Si to (Li-Pg′)), and lower vertical height-depth ratio (Table 4).

Some variables were unlikely different between Iranians and European Caucasians ($P > 0.2$): Lower lip to E-plane, soft tissue sub-nasal to H-line, basic upper lip thickness, inferior sulcus to H-line, middle third height:lower third height, facial convexity angle (G-Sn-Pg′), mandibular prognathism (G-Pg′(HP)), and vertical height ratio [G-Sn/Sn-Me′(VP)] (Table 4).

Discussion

This study showed that most of the measurements determined for the European Whites may not be the best standards for diagnosis or treatment of Iranians. This was in agreement with studies on Iranians [4, 25] but unlike some other ones on Iranians [42, 54] or Arabs [35] and Jordanians [28] concluding

Table 3 Descriptive statistics and 95% CIs for the Legan-Burstone analysis of sample, males, and females, as well as inter-gender comparisons using independent samples *t* test

Parameter	Sex	*N*	Mean	SD	95% CI		Min	Max	*P*
Facial convexity angle	F	85	12.42	5.35	11.26	13.57	0.0	25.0	0.3286391
	M	45	11.44	5.45	9.81	13.08	1.0	24.0	
	Total	130	12.08	5.38	11.15	13.01	0.0	25.0	
Maxillary prognathism	F	85	7.68	3.86	6.85	8.52	− 2.0	15.0	0.6820682
	M	45	7.38	4.32	6.08	8.68	− 2.0	17.0	
	Total	130	7.58	4.01	6.88	8.27	− 2.0	17.0	
Mandibular prognathism	F	85	0.91	5.68	− 0.32	2.13	− 15.0	15.0	0.0738985
	M	45	− 0.94	5.36	− 2.55	0.67	− 14.0	9.0	
	Total	130	0.27	5.62	− 0.71	1.24	− 15.0	15.0	
Middle third height	F	85	66.68	6.40	65.30	68.06	47.0	78.5	0.0000001
	M	45	73.73	7.52	71.47	75.99	57.0	88.5	
	Total	130	69.12	7.57	67.81	70.43	47.0	88.5	
Lower third height	F	85	65.94	6.21	64.60	67.28	48.0	81.0	0.0000000
	M	45	78.04	7.29	75.85	80.23	60.0	92.0	
	Total	130	70.13	8.75	68.61	71.65	48.0	92.0	
Lower face throat angle	F	85	100.67	8.59	98.82	102.52	82.0	124.0	0.0000000
	M	45	111.22	9.17	108.47	113.98	94.0	135.0	
	Total	130	104.32	10.10	102.57	106.08	82.0	135.0	
Sn-Gn′	F	85	65.37	6.97	63.87	66.87	48.0	96.0	0.0000000
	M	45	74.83	7.24	72.66	77.01	60.0	90.0	
	Total	130	68.65	8.36	67.19	70.10	48.0	96.0	
Throat length	F	85	52.19	8.99	50.25	54.13	31.0	75.0	0.1076979
	M	45	49.71	6.84	47.66	51.77	35.0	67.0	
	Total	130	51.33	8.37	49.88	52.79	31.0	75.0	
Nasolabial angle	F	85	101.11	9.78	99.00	103.22	78.0	125.0	0.7850878
	M	45	100.60	10.52	97.44	103.76	80.0	122.0	
	Total	130	100.93	10.01	99.19	102.67	78.0	125.0	
Upper lip protrusion	F	85	3.62	1.65	3.27	3.98	− 1.5	7.0	0.0145310
	M	45	4.39	1.72	3.87	4.90	1.0	8.0	
	Total	130	3.89	1.71	3.59	4.18	− 1.5	8.0	
Lower lip protrusion	F	85	2.89	1.96	2.47	3.31	− 2.5	7.0	0.0484203
	M	45	3.60	1.89	3.03	4.17	0.0	8.0	
	Total	130	3.13	1.96	2.79	3.47	− 2.5	8.0	
Mentolabial sulcus	F	85	5.06	1.24	4.80	5.33	1.5	8.0	0.0000000
	M	45	6.86	1.82	6.31	7.40	4.0	12.0	
	Total	130	5.68	1.69	5.39	5.98	1.5	12.0	
Upper lip length	F	85	20.56	2.08	20.12	21.01	16.0	25.5	0.0000000
	M	45	23.49	2.84	22.64	24.34	19.0	31.5	
	Total	130	21.58	2.74	21.10	22.05	16.0	31.5	
Lower lip-chin length	F	85	45.15	5.41	43.98	46.31	33.0	73.0	0.0000000
	M	45	53.62	5.24	52.05	55.20	39.0	61.0	
	Total	130	48.08	6.70	46.92	49.24	33.0	73.0	
Maxillary incisor exposure	F	85	1.64	1.11	1.40	1.87	0.0	4.5	0.0239571
	M	45	2.18	1.58	1.70	2.65	0.0	6.0	
	Total	130	1.82	1.31	1.60	2.05	0.0	6.0	
Interlabial gap	F	85	1.06	0.47	0.96	1.16	0.5	3.0	0.0546693
	M	45	0.91	0.27	0.83	0.99	0.0	1.5	
	Total	130	1.01	0.42	0.94	1.08	0.0	3.0	

Table 3 (continued)

Parameter	Sex	*N*	Mean	SD	95% CI		Min	Max	*P*
Vertical height ratio	F	85	1.01	0.08	1.00	1.03	0.8	1.3	0.0000092
	M	45	0.95	0.08	0.92	0.97	0.8	1.1	
	Total	130	0.99	0.08	0.98	1.01	0.8	1.3	
Lower vertical height-depth ratio	F	85	1.28	0.23	1.23	1.33	0.9	2.1	0.0000001
	M	45	1.53	0.25	1.46	1.61	1.0	2.0	
	Total	130	1.37	0.27	1.32	1.42	0.9	2.1	
Vertical lip-chin ratio	F	85	0.46	0.05	0.45	0.47	0.3	0.6	0.0271405
	M	45	0.44	0.05	0.43	0.45	0.3	0.5	
	Total	130	0.45	0.05	0.44	0.46	0.3	0.6	

that most of classical norms are applicable to their populations [4]. This shows that when a country is large enough or ethnically diverse enough, even different cities may yield different values [4]. Of course, methodological differences such as subjects' age ranges and sample sizes should not be forgotten. The age range of this study could also contribute to the lack of significant correlations observed between subjects' ages with cephalometric variables.

The Ricketts analysis of Persians showed more retruded upper lip in a closed position in relation to the E-plane than in the Caucasian reference. The Z-Merrifield analysis showed significant differences between PC and EC and showed a decrease in this angle that can be due to more retruded position of Pog′ or the lips in closed position. The Holdaway analysis demonstrated no difference between PC and EC in soft tissue facial angle, superior sulcus depth, soft tissue subnasale to H-line, lower lip to H-line, and nasolabial angle. However, significant differences were observed in other landmarks, such as skeletal profile convexity, basic upper lip thickness, upper lip strain, upper lip curvature, inferior sulcus to H-line, soft tissue chin thickness, nose prominence, H-angle (more obtuse), nasofacial angle, and nasomental angle. Epker's soft tissue analysis showed the following vertical relationships in the PC: a larger interlabial distance, increases in lower third facial height, and retruded chin when measured from a line perpendicular to subnasale. According to the Holdaway analysis, the PC had a more convex skeletal profile and a more obtuse H-angle (greater inclination of the H-line).The PC showed a more posterior position of chin point, thicker soft tissue chin, and lower lip sulcus compared to the EC; this might be due to the more retruded position of the bony chin in Persians. These findings were similar to studies of Hajighadimi et al. [55], Taki [54], and Mafi et al. [56], and finding of Anatolian Turkish adults [57]. The PC presented less prominent noses compared to EC; however, the mean value was still within the Holdaway norms. The basic upper lip thickness in PC was greater than that in EC but the upper lip strain and curvature, superior sulcus depth, and the distance of the lower lip to H-line were similar to those in EC. These findings explain the similarity of soft tissue facial angle in PC and EC despite the retruded position of the bony chin. In the SPG, the basic upper lip thickness was closer to EC compared to that in the PC.

Few studies have compared genders statistically [21]. Sex dimorphism is less visible among Americans [24]. Brazilians as well showed few cases of dimorphism; however, similar to Koreans, this study found many cases of dimorphism [21, 24]. In this study and another one [4], there was considerable gender dimorphism among Iranians. Compared to males, Iranian females had taller upper lips, taller lower thirds compared to middle thirds, taller chins (lips closer to the nose), taller faces (longer distances between lips and both the chin and subnasale), deeper superior and inferior sulci, more retruded lower lips and chins, thicker upper lips, and thicker chins.

It was expected to see some linear measurements to be greater in males [50, 58, 59] such as the upper lip, superior sulcus, soft tissue chin, and inferior sulcus [25, 50, 54, 58, 60–63]. Unlike some other studies which showed a limited sex dimorphism [4, 22, 25], this research marked numerous linear measurements to have sexual dimorphism, possibly because of the large sample and high number of variables. The present study found a slight but significant dimorphism in terms of nose prominence which was similar to many studies [6, 42, 54, 61, 63–66] and in contrast to some others [4, 25]. Nose prominence is an important item which influences the presentation of surrounding tissues [4, 6]. The current sample had noses much smaller than European Caucasians, which was similar to Chinese [6, 36] and Iranians [67] but in contrast to another study on Iranians [4].

It is suggested that lips are more protruded in populations such as Chinese, Turks, and Iranians compared to Yemenis, Americans, and Iranians [4, 8, 22, 26, 35–37]. In this study, however, the lower lip position did not differ from the norm, and the upper lip shown to be about 1.15 mm retruded than European standards. Consistent with some other studies, lower lip-chin length was greater in men [4, 50, 68, 69]. Similar to another study [4] but unlike many earlier research [8, 22, 35, 37, 39], lips were not more protruded in females. Compared to the norm, upper lip was thinner in this sample, and this was

Table 4 Cephalometric comparisons between Iranian population and European norms, using the one sample *t* test. Positive differences indicate that the Iranian norm was greater than the norm of Caucasians from European ancestry. A negative difference indicates that the Iranian norm was smaller than the European standard

Ricketts	Norm	Mean diff	95% CI		*P*
Upper lip to E-plane	−4	−1.15	−1.51	−0.78	0.000000
Lower lip to E-plane	−2	−0.25	−0.67	0.18	0.257531
Holdaway + Z-Merrifield					
Soft tissue facial angle	91	0.51	0.05	0.97	0.030254
Nose prominence	19	−4.37	−4.88	−3.85	0.000000
Superior sulcus depth	3	1.73	1.50	1.97	0.000000
Soft tissue sub-nasal to H-line	5	−0.13	−0.50	0.24	0.487964
Skeletal profile convexity	0	2.27	1.80	2.73	0.000000
Basic upper lip thickness	15	−0.22	−0.71	0.27	0.370086
Upper lip thickness	14	−1.08	−1.52	−0.64	0.000004
Upper lip strain	1	0.86	0.52	1.20	0.000002
Upper lip curvature	2.5	0.47	0.28	0.66	0.000004
H-angle	11	4.01	3.42	4.60	0.000000
Lower lip to H-line	0.5	0.40	0.13	0.67	0.004382
Inferior sulcus to H-line	5	0.13	−0.19	0.46	0.418283
Soft tissue chin thickness	11	1.50	1.08	1.92	0.000000
Nasolabial angle	100	1.22	−0.62	3.05	0.193333
Nasofacial angle	32.5	2.84	2.22	3.46	0.000000
Nasomental angle	126	−2.23	−3.02	−1.44	0.000000
Z-angle	80	−6.17	−7.21	−5.13	0.000000
Epker					
Upper lip length	21	0.39	−0.11	0.90	0.126906
Interlabial distance	1.5	−0.52	−0.59	−0.45	0.000000
Subnasale perp to upper lip	0	1.55	1.23	1.87	0.000000
Subnasale perp to lower lip	−2	0.78	0.36	1.21	0.000408
Subnasale perp to chin	−4	−2.60	−3.57	−1.63	0.000000
Middle third height:lower third height	1	−0.01	−0.02	0.01	0.310819
Subnasale-stomion:stomion-menton	0.5	−0.05	−0.06	−0.04	0.000000
Subnasale-lower lip:lower lip-menton	1.11	−0.27	−0.29	−0.25	0.000000
Legan-Burstone					
Facial convexity angle (G-Sn-Pg′)	12	0.08	−0.85	1.01	0.864420
Maxillary prognathism (G-Sn(HP))	6	1.58	0.88	2.27	0.000016
Mandibular prognathism (G-Pg′(HP))	0	0.27	−0.71	1.24	0.591096
Lower face throat angle (Sn-Gn′-C)	100	4.32	2.57	6.08	0.000003
Upper lip protrusion (Ls to (Sn-Pg′))	3	0.89	0.59	1.18	0.000000
Lower lip protrusion (Li to (Sn-Pg′))	2	1.13	0.79	1.47	0.000000
Mentolabial sulcus (Si to (Li-Pg′))	4	1.68	1.39	1.98	0.000000
Maxillary incisor exposure (Stms-Ui)	2	−0.18	−0.40	0.05	0.125662
Interlabial gap (Stms-Stmi(VP))	2	−0.99	−1.06	−0.92	0.000000
Vertical height ratio [G-Sn/Sn-Me′(VP)]	1	−0.01	−0.02	0.01	0.213196
Lower vertical height-depth ratio	1.2	0.17	0.12	0.22	0.000000
Vertical lip-chin ratio	0.5	−0.05	−0.06	−0.04	0.000000

consistent with a study on Kurds [67] and Saudis [6] but unlike another study on Iranians which reported no significant changes from the norm [4] and a study on Turks which indicated an increased upper lip thickness compared to the norm [61]. Similar to a study on Chinese people whose upper and lower lips were more protruded than European norm [36], but unlike a study on Iranians [4], the present sample showed both lips to be more protruded than European norms. Japanese [70], Saudis [6, 71], and Kurds [67] have shown only lower lips to be more protruded than the norm, but not the upper lip.

Mandibular and chin positions can affect the H-angle [4, 6]. Before puberty, boys might have more obtuse H-angles, but

after growth spurt, it becomes similar in boys and girls [4, 42]. The H-angle can increase to maintain facial harmony when convexity increases [4, 5, 25, 42]. Our findings indicated increased skeletal profile convexity together with increased H-angles, in line with many other studies on Saudis [6], Iraqi adults [62], Yemenis [35], Iranians [4, 25, 54], Kuwaiti and Jordanian adolescents (only the H-angle) [25, 28, 72], and also Indians (using convexity parameter of the Burstone analysis [25, 73]). On the other hand, Turks [6, 61] and Japanese [70] might have less convex skeletal profiles [4]. In the case of greater profile convexity, an increased chin thickness may provide harmony [4, 25, 42]. Similar to the present study, some other studies on Turks [61], Iranians [4, 42, 67], Japanese (and Japanese females) [70, 74], and Iraqis [62] showed thicker chins compared to the European norms, while certain others on Turks and Chinese had thinner chins [4, 6, 22, 36]. These differences can be attributed to the ethnical differences, sample sizes, and the average age of selected populations, since many of these measurements can change by age [4].

Conclusion

Persian adults in this study had more retruded upper and lower lip positions and more convex profiles than European Caucasian norms. Aging in the third decade of life might not change the studied cephalometric parameters. Significant differences were observed in skeletal profile convexity, basic upper lip thickness, upper lip strain, upper lip curvature, inferior sulcus to H-line, soft tissue chin thickness, nose prominence, H-angle (more obtuse H-angle), nasofacial angle, and nasomental angle than EC. In the vertical dimension, the Persian group had a larger interlabial distance, increase in lower third face height, retruded chin position in Epker analysis, facial convexity angle, maxillary prognathism, lower face throat angle, upper lip protrusion, lower lip protrusion, mentolabial sulcus, interlabial gap, lower vertical height-depth ratio, and vertical lip-chin ratio. Males had more basic upper lip thickness and lip strain and subnasale perpendicular to chin, inferior sulcus depth, soft tissue chin thickness, and superior sulcus depth compared to females.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included prospectively in the study.

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