Original Article

Racial Variations in Cephalometric Analysis between Whites and Kuwaitis

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Abstract: The objective of this study is to determine whether (1) Kuwaiti adolescents differ from Caucasian adolescents with respect to their cephalometric values; (2) sex plays a role in the differences between the two groups; and (3) a need exists to develop cephalometric standards for the Kuwaiti population. Standardized cephalometric films were obtained from 36 Kuwaiti females and 32 Kuwaiti males between the ages 11 and 14 years. Only subjects with Class I molar occlusion and a positive overjet of no more than 4 mm were selected. Each subject was age matched with White cephalometric values. Intraexaminer error, paired, and two-sample *t*-tests were made. The results show that there were significant differences between the Kuwaiti population and the Caucasian population for the majority of the variables tested ($P < .01$). Sex produced no significant effect on any of the variables studied. The Kuwaiti population has fuller lips, more facial convexity, greater dental protrusion, a more retruded and smaller mandible, and shorter posterior face height than the Caucasian population. (*Angle Orthod* 2006;76:406–411.)

Key Words: Cephalometrics; Racial variation; Kuwaitis; Whites

INTRODUCTION

The relationship between malocclusion and facial form has been a focus of orthodontists since the early 20th century. Cephalometric radiography was introduced by Broadbent in 1931 and rapidly became an integral method to study normal and abnormal human craniofacial growth and development as well as a powerful diagnostic tool to identify the structural determinates of malocclusion.

The cephalometric technique has been used by numerous researchers to produce standard mean values for skeletal, dental, and soft tissue structures for different ethnic groups.[1,2] Skeletal and facial balance with an ideal dental relationship to the cranial base have been more objectively assessed through the comparison of an individual's cephalometric measurements with the means and standard deviations derived from population-based samples of the same race, sex, and chronological age. These standards have been developed from years of cephalometric data collection.

Standard values for craniofacial structures have been presented for White adolescents.[1,3–11] Skeletal and dental development and changes throughout adulthood were reported by Behrents[12] in 1985.

It is well established that a single standard of facial esthetics is not appropriate for application to diverse racial and ethnic groups.[13–15] Therefore, other researchers have compared cephalometric characteristics of different races with Whites, with an intention to establish race-specific cephalometric values for populations with different ethnic backgrounds.[16] There have been few attempts to establish cephalometric standards for Middle Eastern populations such as Iranians,[17] Saudis,[18] Jordanians,[19] and Egyptians.[20,21]

Although previous studies[17–21] indicate some similarities among different Middle Eastern populations, there is certain homogeneity within each group, illustrating the need for separate cephalometric standards for each group. The Kuwaiti population is a product of

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TABLE 1. Results of Paired *t*-test for Males and Females Combined (n = 68)

Variable	Mean Differences (Kuwaiti − White)	Standard Error	*P* value	Percentage of the Measurement of Error
Upper lip protrusion (ULP)	0.983	0.323	.0033*	4.052
Lower lip protrusion (LLP)	2.201	0.408	.0001**	2.802
Facial convexity angle (Conv)	3.457	0.990	.0008**	1.818
Mentolabial sulcus (MLS)	0.881	0.201	.0001**	11.317
E-plane	2.554	0.491	.0001**	2.895
ANB	1.196	0.337	.0007**	6.055
Mx-Md differential	−0.585	0.607	.3388	4.4173
SNA	−0.668	0.748	.3756	5.987
SNB	−1.859	0.650	.0056*	3.426
Co-Gn	−3.758	0.826	.0001**	6.828
Ar-Gn	−2.043	0.790	.0119*	1.585
Interincisal angle	−12.318	1.544	.0001**	5.211
U1-NA angle	4.044	1.013	.0002**	6.066
U1-SN angle	3.356	1.142	.0045*	3.780
U1-PP angle	5.129	1.012	.0001**	4.698
L1-NB (mm)	3.240	0.379	.0001**	3.991
L1-Apog (mm)	2.954	0.384	.0001**	5.089
L1-MP angle	3.260	1.086	.0038*	8.369
L1-NB angle	7.101	0.879	.0001**	11.72
MP-SN angle	5.712	1.072	.0001**	2.325
MP-FH angle	6.937	0.889	.0001**	3.612
MP-PP angle	3.937	0.953	.0001**	2.935
SN-PP angle	1.769	0.529	.0014**	4.892
N-Me (mm)	1.971	1.052	.0652	1.695
UFH/TFH%	−0.660	0.342	.0577	1.612
LFH/TFH%	0.654	0.342	.0599	1.612

* Significant difference $P < .01$.
** Highly significant difference $P < .001$.

migrants from Saudi Arabia, Iran, and Iraq.[22] Immigrants and interracial marriages have increased in the modern Kuwaiti population especially since the discovery of oil and economic development.[22,23] There is little to no cephalometric information about this racial mix.[24]

This purpose of this study was to identify differences, if any, in the cephalometric values between Kuwaiti and White adolescent populations; identify sex differences between the two populations, if they exist; and evaluate the need to conduct a larger study to develop specific cephalometric standards for different groups of the Kuwaiti population.

MATERIALS AND METHODS

Lateral cephalometric films of 36 Kuwaiti females and 32 Kuwaiti males were matched for age (within 6 months) and sex with those from a White group. The selection criteria were: initial cephalometric film of patients with no history of prior orthodontic treatment; films with good quality that have no distortion or soft tissue cut out; subjects between the ages of 11 and 14 years; Class I molar occlusion (except one female and three males with end-on molar relation and presence of the lower primary second molar; the end-on molar films of the Kuwaitis were matched with films presenting with an end-on molar relation in the White group); and positive overjet of no greater than 4 mm.

An intraexaminer reliability test was conducted. The primary investigator hand-traced, digitized, and analyzed 18 consecutive films of the Kuwaiti sample two times with a 4-week interval in between. A one-way analysis of variance was used to determine significant differences between variables. The coefficient of variation was calculated for each variable by dividing the variability within each subject by the variability among the subjects. The coefficient of variation was then multiplied by 100 to find the percentage of the measurement of error. Scores for the measurement of error test were less than 7.0% for 23 variables and slightly more than 7.0% for three other variables (Table 1).

Because the films of the Kuwaiti sample and the White sample were taken by two different machines, the enlargement percentage for the linear measurements was calculated,[25] and compensation was applied. All linear measurements for the Kuwaiti sample were multiplied by 0.9096 to compensate for 9.31% enlargement, and those of the White sample were multiplied by 0.9267 to compensate for 7.33% enlargement.

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TABLE 2. Results of the Two-Sample *t*-test of the Differences Between Males and Females

Variable	Mean Differences for Females (Kuwaiti − White)	Mean Differences for Males (Kuwaiti − White)	*P* value
Upper lip protrusion (ULP)	1.428	0.483	.1456
Lower lip protrusion (LLP)	2.450	1.922	.5220
Facial convexity angle (Conv)	4.175	2.650	.4459
Mentolabial sulcus (MLS)	1.105	0.628	.2393
E-plane	2.934	2.127	.4154
ANB	1.533	0.816	.2915
Mx-Md differential	−1.042	−0.071	.4286
SNA	0.253	−1.703	.1943
SNB	−1.269	−2.522	.3396
Co-Gn	−4.614	−2.794	.2750
Ar-Gn	−2.697	−1.306	.3837
Interincisal angle	−13.103	−11.434	.5934
U1-NA angle	4.539	3.487	.6083
U1-SN angle	4.805	1.725	.1801
U1-PP angle	6.044	4.100	.3413
L1-NB (mm)	3.355	3.110	.7500
L1-Apog (mm)	3.025	2.874	.8460
L1-MP angle	2.814	3.762	.6663
L1-NB angle	7.005	7.209	.9089
MP-SN angle	5.486	5.966	.8252
MP-FH angle	6.389	7.553	.5176
MP-PP angle	4.244	3.591	.7347
SN-PP angle	1.247	2.356	.2991
N-Me (mm)	1.099	2.952	.3832
UFH/TFH%	−1.328	0.091	.0374
LFH/TFH%	1.328	−0.103	.0357

* Significant difference $P < .01$.

TABLE 3. Cephalometric Values for Kuwaiti Males 11–14 Year Old, Based on 9.31% Magnification

Cephalometric Measurement	Mean	SD
Upper lip protrusion (ULP)	4.5	2.4
Lower lip protrusion (LLP)	5.0	2.6
Facial convexity angle (Conv)	17.5	5.4
Mentolabial sulcus (MLS)	−5.0	1.6
E-plane	2.0	3.1
ANB	3.5	1.9
Mx-Md differential	24.0	3.9
SNA	78.0	3.8
SNB	74.5	3.7
Co-Gn	106.0	5.6
Ar-Gn	99.5	5.2
Interincisal angle	122.0	9.7
U1-NA angle	24.5	5.5
U1-SN angle	103.0	7.0
U1-PP angle	114.0	6.0
L1-NB (mm)	6.5	2.0
L1-Apog (mm)	4.0	2.1
L1-MP angle	95.5	6.6
L1-NB angle	29.5	5.3
MP-SN angle	39.5	7.0
MP-FH angle	30.5	5.6
MP-PP angle	28.0	6.0
SN-PP angle	11.0	3.6
N-Me (mm)	114.0	7.0
UFH/TFH%	45.7	1.7
LFH/TFH%	54.3	1.7

All films were hand-traced by the primary investigator, digitized, and analyzed by the Dolphin Imaging System. The 26 cephalometric variables (Table 1) tested in this study are part of The University of Kentucky cephalometric analysis described by Hicks.[26]

The differences between Kuwaiti and White cephalometric values were calculated by subtracting the White cephalometric value from the Kuwaiti cephalometric value (Kuwaiti − White) for each variable in each paired films. Then, the mean of the differences was calculated for each cephalometric variable. Therefore, positive mean differences in Tables 1 and 2 indicate that the cephalometric value is larger for the Kuwaitis. Paired *t*-tests were performed to determine significant differences between the Kuwaitis and Whites (Table 1). Two-sample *t*-tests were performed to evaluate for sex differences between the two groups (Table 2). The mean and standard deviation for each of the variables tested was calculated for the Kuwaiti sample (Tables 3 and 4).

RESULTS

The results show that there are significant differences between the Kuwaiti population and the White population for the majority of the variables tested ($P < .01$) (Table 1). The Kuwaiti population has fuller lips, more

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TABLE 4. Cephalometric Values for Kuwaiti Females 11–14 Year Old, Based on 9.31% Magnification

Cephalometric Measurement	Mean	SD
Upper lip protrusion (ULP)	5.0	2.1
Lower lip protrusion (LLP)	4.5	2.7
Facial convexity angle (Conv)	16.5	7.0
Mentolabial sulcus (MLS)	−4.5	1.2
E-plane	1.0	3.0
ANB	3.5	2.0
Mx-Md differential	25.0	3.4
SNA	79.0	3.9
SNB	75.0	3.3
Co-Gn	105.0	5.0
Ar-Gn	98.5	4.8
Interincisal angle	120.0	10.0
U1-NA angle	27.0	6.0
U1-SN angle	105.5	6.4
U1-PP angle	116.5	7.0
L1-NB (mm)	6.5	3.0
L1-Apog (mm)	4.0	2.8
L1-MP angle	94.5	7.6
L1-NB angle	29.0	7.2
MP-SN angle	39.5	6.5
MP-FH angle	28.5	5.6
MP-PP angle	28.5	5.6
SN-PP angle	11.0	3.0
N-Me (mm)	112.0	5.8
UFH/TFH%	44.4	2.0
LFH/TFH%	55.6	2.0

facial convexity, more bimaxillary protrusion, more retruded and smaller mandibles, and a shorter posterior face height than the White population (Table 1).

The results of the intraexaminer error test are also presented in Table 1. There is no significant effect of sex on any of the variables (Table 2). The cephalometric norms (mean and SD) for the Kuwaiti sample are presented separately for males and females (Tables 3 and 4).

The results of the study show more protrusive upper and lower lips and more facial convexity for the Kuwaiti sample. This soft tissue difference coincides with the dental bimaxillary protrusion found in the Kuwaiti sample. All the measurements relating the upper and lower incisors to the maxilla and the mandible, respectively, showed a significant bimaxillary protrusion. Although the lower lip is more protrusive, the mentolabial sulcus is flatter in the Kuwaitis. This finding is associated with the small size and retruded position of the mandible in the Kuwaitis.

The Kuwaiti sample showed a slightly greater Class II skeletal pattern. ANB was significantly larger and SNB was significantly smaller. The maxillomandibular differential (Mx-Md differential) showed no significant difference between the two ethnic groups, but variables measuring the size of the mandible such as Codylion to Gnathion (Co-Gn) and Articulare to Gnathion (Ar-Gn) indicate a trend toward a smaller mandible in the Kuwaitis (Table 1). The increased Class II pattern in the Kuwaitis is because of a retruded and small mandible (Table 1). There was no significant difference between the two groups with respect to the sagittal position of the maxilla. SNA showed no significant difference (Table 1).

The skeletal, angular measurements relating to the vertical dimension (MP-SN, MP-FH, MP-PP, and SN-PP) were significantly larger in the Kuwaitis. These increased angular measurements indicate a smaller posterior facial height, larger anterior facial height, or a combination of both. In this study, there was no measurement used to assess the posterior facial height, but the anterior facial height measure from Nasion to Menton (N-Me) showed no significant difference between the two ethnic groups. Thus, we can conclude that the posterior facial height was smaller in the Kuwaitis. This decrease of the posterior facial height in the Kuwaitis may contribute to the mandibular retrusion and may explain why there was not much difference in the values for Mx-Md differential. Not surprisingly, the proportion of upper facial height to total facial height (UFH/TFH%) and lower facial height to total facial height (LFH/TFH%) did not show a significant difference between the two ethnic groups.

DISCUSSION

The results of this study agree with many other studies that compared other Middle Eastern populations with North American Whites. One such study of an Iranian sample showed very similar results to our findings, ie, a more retruded skeletal pattern, increased bimaxillary dental protrusion, greater facial convexity, and steeper mandibular plane.[17] Sarhan's analysis of a Saudi sample[27] concurred with our findings that SNA was no different between Saudis and Whites and that there was greater positive angulation of the upper and lower incisors in the Saudis. However, in contrast to our results, Sarhan found no significant differences in SNB, ANB, MP-PP, and SN-MP angles.

Most of the findings of Loutfy et al[20] in an Egyptian sample are in agreement with our results. Loutfy et al found that the Egyptians have more facial convexity, a steeper mandibular plane, and more bimaxillary protrusion than Whites. Bishara et al[21] agreed that the Egyptians have more facial convexity and more bimaxillary protrusion. However, they concluded that there is great similarity in the overall facial morphology between the Egyptians and Whites.

In this study, cephalometric films for the Kuwaitis and Whites were paired according to age and sex. Then the mean difference between the Kuwaiti sample and the White sample was calculated for each variable (Mean Difference = Kuwaiti − White), followed by a

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paired *t*-test. This method makes this study unique from other similar studies[17–20,24,27] that compared the mean of each variable in their Middle Eastern sample to published norms of the same variable for Whites.

To decrease variability among the subjects, only Class I molar cases with no more than a 4-mm overjet were included. Also included in the sample were three males and one female who presented with end-on permanent molars and the mandibular primary second molars present. These end-on molar cases were included because they most likely will develop into a Class I molar, assuming normal mesial migration of the lower permanent first molars into the Leeway space, once the deciduous molars exfoliated.[15] These end-on molar cases were matched with end-on molar cases in the Caucasian sample.

Low measurement error was found for the majority of the variables tested (Table 1). However, variables measuring the mentolabial sulcus, angle between lower incisor and mandibular plane (L1-MP), and angle between lower incisor and a line passing through Nasion and B point (L1-NB) demonstrated relatively large measurement error (11.32%, 8.37%, and 11.72%,respectively). One explanation for the large measurement error for L1-MP and L1-NB is the difficulty associated with locating the most prominent lower incisor on a lateral film because of the superimposition of other incisors and cuspids.[28] Despite their relatively large measurement of error, these three variables were not excluded from the study because of their significance in the assessment of the position of lower incisors relative to the lower jaw and the position of the lower lip relative to the chin. Such variables can significantly influence the extraction vs nonextraction decision in orthodontic treatment planning.

All films were taken with the patients instructed to look forward in a relaxed manner to register their natural head posture. The intracranial plane, Frankfort Horizontal (FH)[6,29] was used to orient the films for the cephalometric analysis. Knowing that there is an inherent error in this method because of possible differences between the registered head posture and the natural head posture,[30–32] this method was nevertheless adopted because there were no profile photos and no clinical information about the natural head posture for the Kuwaiti subjects.

Moorrees and Chadha[33] recommended the use of physiologic age as a measure of precision in growth diagnosis. Various tissue systems, such as the dentition or the skeleton, can be used for assessment of the physiologic age. It was difficult to match the samples according to the physiologic age in this study. There was no skeletal maturity indicator, such as the hand-wrist radiograph, for the majority of the patients in this study. There were no dental casts or panoramic films for the majority of the patients in the Kuwaiti sample. Matching samples by physiologic age would strengthen future prospective studies.

Although we presented the cephalometric norms (mean and standard deviation) for 11- to 14-year-old Kuwaitis, an age when most of orthodontic treatment starts (Tables 3 and 4), we are of the opinion that a larger sample with different age groups and more strict selection criteria need to be evaluated to establish Kuwaiti cephalometric norms.

CONCLUSIONS

- Sex had no significant effect on the variables tested.
- When compared with Whites, the Kuwaitis in this study had increased lip protrusion; increased facial convexity; greater dental protrusion in both arches; shorter posterior facial height; and slightly more Class II skeletal pattern associated a with small and retruded mandible.
- There is a need to develop age-dependent cephalometric standards for the Kuwaiti population.

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