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Cephalometric Norms in an Arabic Population

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Abstract
Aim: To identify cephalometric norms for a Jordanian population.
Design: A cross sectional study using a sample selected on the basis of a balanced face and a Class I occlusion.
Materials and Methods: 65 subjects aged 14–17 years were selected from a larger sample on the basis of Class I incisors, a balanced profile and no previous orthodontic treatment. Lateral skull radiographs were digitised directly to produce values for SNA, SNB, ANB, UI/MX, LI/MN, UI/LI, MMPA and LI/A-Pog.
Results: SNA and SNB were very close to the Eastman Standards. MMPA was significantly lower in Jordanians whilst UI/MX and LI/MN were significantly higher. Lower incisors were 4·6mm further forward in relation to A-Pog in Jordanians.

Index words: Cephalometry, Standard values.

Introduction

It is well established that cephalometric standard values provide useful guidelines in orthodontic diagnosis and treatment planning. However, it is possibly incorrect to make rigid applications of these values since they represent population averages that may be inappropriate as individual treatment goals. Furthermore, it has been suggested that an analysis is misused if it is applied to a patient of different age or race (Moyers, 1988).

It is useful, therefore, to review the origin of some of the currently used cephalometric standard values and consider how these origins influences their usefulness when applied to people of different races.

1. Bjork (1947) published definitive and often quoted cephalometric values taken from 322 boys aged 12 years and from 281 army conscripts aged 21 years.
2. Downs (1948) introduced the concept of standard values for cephalometric measurements when he described the sense of balance and harmony to be seen in the films of individuals who possessed excellent untreated occlusions. He developed a method of analysis based on a study of 20 individuals with excellent occlusions. This was an early example of standard values being suggested on the basis of a small and selected study group. Over the years suggested standard values have proved to be remarkably consistent despite variation in the methods of their derivation.
3. Steiner (1953) developed a system of cephalometry based on simplicity and ease of use, with the SN plane providing a basic reference line.
4. Riedel first mentioned standard values in 1950. In 1957 he took the concept of the selected sample to extremes when he studied girls chosen as Princesses during the Seattle Seafair Week. Finalists were chosen on the basis of appearance, personality, and poise to represent their communities. The skeletal patterns of the girls were similar to those recorded in previous studies of normal occlusion, indeed the Seafair Queens of 1954 and 1955 had cephalometric measurements within 1degree or 1mm of the mean for most values, supporting the view that the public concept of facial aesthetics agrees with standards established by orthodontists on the basis of normal occlusion.
5. Ballard (1956) published results based on a study of children and adults at the Eastman Dental Hospital, London (MacAllister and Rock, 1992). The values produced by Ballard were later rounded to the nearest whole numbers as the Eastman Standard Values (Mills, 1982).
6. The Alabama Analysis was based on a study of 40 Caucasian children aged 8–12 with normal occlusions (Taylor and Hitchcock, 1966). Peck and Peck (1970) studied a sample of 52 adults who had been acclaimed as facially attractive, either as models, beauty contest winners, or performing artistes. The authors concluded that the general public admired a fuller, more protrusive dentofacial pattern than was usual in cephalometric standards, although their published values were close to the overall means.
7. Cephalometric standards published by the University of Michigan (Riolo *et al*., 1974) were derived by longitudinal study of children and young adults. Table 1 shows figures for boys and girls aged 12–15 years. These are reliable data from a carefully drawn sample.
8. The Bolton sample data (Broadbent *et al*., 1975) were derived from a group of males and females aged 18 years considered as having good faces and occlusions.
9. Bishara (1981) used longitudinal data to develop normative cephalometric standards for 35 subjects with clinically acceptable occlusion and no apparent facial disharmony. Figures in Table 1 are combined averages for males and females aged 10–17 years.
10. McNamara (1988) studied the records of 125 white males and females over the age of 16 who possessed ideal facial aesthetics and Class I occlusions. Fifty-seven

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of the records were from the normal occlusion study of the Foundation for Orthodontic Research at Ann Arbor Michigan, previously used by Christie (1977). The relevant figures in Table 1 are sometimes referred to as the Michigan Standards, an American counterpart to the Eastman Standards.

11. MacAllister and Rock (1992) redefined the appropriateness of the Eastman Standards by selecting cephalometric radiographs on the basis of the values for SNA and SNB. The incisor angulations in their study were very close to the Eastman values.

The values of commonly used measurements derived from these samples are included in Table 1. Importantly, all of these values are derived from Caucasian populations.

To date there are no published cephalometric norms for an Arabic population. The aim of the present study was to provide such data for a Jordanian population and to compare these to the Eastman Standards and other published values.

Material and methods

The sample comprised 65 subjects aged 14–17 years (mean 15·5 years, SD 0·5 years) from Amman, Jordan. They were almost equally divided into males and females, and were of similar Middle East Arabic ethnic background. The sample was derived from a previous study investigating the prevalence of malocclusion in Amman school children when a random and representative sample of 320 children was examined (Hamdan, 2001).

The selection criteria for the present study were Class I incisors (BSI-4492 1986), normal overbite, balanced facial profile, and no previous orthodontic treatment.

Ethical approval was obtained from three sources: the Scientific Research Committee at the University of Jordan which provided funding for the study; the Research Ethics Committee at the University of Jordan Hospital, where the radiographs were taken; and the Ministry of Education. Consent was also sought by asking parents to sign a form that explained the nature and purpose of the radiographic examination. Lateral cephalograms of 65 children were taken in centric occlusion with lips in repose and Frankfort Plane horizontal according to natural head position, using a Gendrix (Italy) cephalostat at 70 KV, 9 MA, and 1·25 seconds exposure.

Cephalometric points were digitized using the Gela program (Version GLP 1.27; Gordon and Turner, 1999) in a darkened room in random order. A sheet of thin black cardboard with a rectangular cut-out the size of a cephalogram placed in the centre was used to prevent glare from the light box. Radiographs were oriented so that the lower border was parallel to the edge of the light box. No more than 10 radiographs were digitized at one time to prevent examiner fatigue.

Cephalometric landmarks were digitized directly from radiographs with the exception of gonion (Go), which was constructed on the radiograph prior to digitization (Sandler, 1988). The following points were digitized: nasion (N), sella (S), anterior nasal spine (ANS), and posterior nasal spine (PNS), A point and B point, upper incisor tip (UIT), upper incisor apex (UIA), lower incisor tip (LIT), lower incisor apex (LIA).

The Gela computer program then calculated the following cephalometric values: angle SNA, angle SNB, angle ANB, maxillary-mandibular planes angle (MMPA), upper incisor axis to maxillary plane angle (UI/MX), lower incisor axis to mandibular plane angle (LI/MN), inter-incisal angle (UI/LI), and lower incisor tip to A–Pog line distance (LI/A–Pog)

Statistical analysis

An error analysis exercise was carried out using the radiographs of 25 subjects digitized twice at 3–4 weeks apart. Systematic bias was examined using a paired t-test (Stirrups, 1993) and estimation of random error was carried out using the index of reliability by correlating repeat measurements (Houston, 1983). This analysis revealed there were no significant differences when systematic bias was tested ($P > 0{\cdot}01$) and correlations were found to be greater than 0·95, indicating no random errors.

Further statistical analysis was carried out using the SAS statistical package. An independent sample *t*-test was used

TABLE 1 *Cephalometric standards from previous studies*

Author	Date	SNA	SNB	ANB	UI/MX	LI/MN	UI/LI	MMPA
Bjork	1947	82	78	4	110	91	131	28
Downs	1948	81	78	3	112	91	135	22*
Riedel	1950	82	80	2		93	131	
Steiner	1953	83	80	1		93	130	
Ballard	1956	81	77·5	3·5	109	93	131	27
Riedel	1957			3	107	94	136	23*
Taylor & Hitchcock	1966	81	78	3	110	97	127	26*
Peck & Peck	1970	82	80	2	107·5	95	133·5	24*
Riolo *et al.*	1974	81	78	3	111	94	129	26
Bolton sample	1975	84	81	3	104·5	91	140·5	24*
Bishara	1981	81·5	79	2·5	106·5	97	131	25·5*
Mills	1982	81	78	3	109	93	131	27
McNamara	1988	83·5	81	2·5	113·5	93·5	134	19
MacAllister & Rock	1992	81	78	3	108	91	134	27
Overall Mean		81·8	79	2·8	109	93·3	132·4	24·9
Range Min		81	77·5	2	104·5	91	127	19
Max		84	81	4	113·5	97	140·5	28
SD		0·99	1·27	0·56	0·72	0·54	0·90	0·75

to test for significance among the sexes in addition to comparing between Jordanian cephalometric norms and Eastman Standard values (Ballard, 1956; Mills, 1982)

Results

Mean values for each measurement are illustrated according to gender in Table 2. There were no statistically significant differences between the genders; data were therefore pooled for further analysis.

These pooled means are illustrated in Table 3 as the 'Jordanian Standards' and are compared to the Eastman Standards. There were no significant differences for SNA, SNB, and ANB between Jordanian norms and Eastman Standards, whereas differences in MMPA, UI/MX, LI/MN, and UI/LI were statistically significant ($P < 0{\cdot}05$). In addition, values for LI/A–Pog were compared to those published by MacAllister and Rock (1992) and the difference was found to be statistically significant. The 95% confidence interval values for MMPA, U1/MX, L1/MN, and U1/L1 were relatively large, with ranges of 5·1, 5·3, 6·9, and 7·9 degrees, respectively. Since the value of U1/L1 depends upon variations in the other three measurements this last variation is explicable in the context of the other findings.

In order to test whether or not the number of subjects in the study was sufficient to demonstrate whether clinically relevant differences between the sexes were of statistical significance *post-hoc* power calculations were carried out. If 4 degrees is set as the clinically significant difference, a study with a power of 0·8 would require total sample sizes of 50, 56 and 90 to demonstrate statistically significant differences between males and females as regards MMPA, U1/MX, and L1/MN, respectively (Altman, 1991). These sample sizes indicate that the only value that is not statistically significant but may be clinically significant is L1/MN.

Discussion

When Ballard (1956) published cephalometric standards, he acknowledged that the sample from which they had been derived was not chosen scientifically. However, he was confident that his findings were valid since they agreed closely with those published by Bjork (1947). Similar comfort may be drawn from the overall means calculated for the 14 sets of data listed in Table 1. The overall means published here are not statistically reliable in the manner of a true meta analysis since it was not possible to access original data from previous studies, however they do indicate the uniformity of previous results. All but one of the standard deviations are less that 1 degree and all of the ranges are below 10% of the mean, except for MMPA, which is complicated by the fact that the Frankfort plane was used in six studies. The accuracy of measurements involving the Frankfort plane is highly dependent on correct placement of the ear rods when the radiograph is taken and for this reason it has been superceded by the maxillary plane, known in the United States as the palatal plane.

The present study showed no significant differences between Jordanian males and females for any cephalometric measurement; this was in accordance with previous findings for other ethnic groups (Gianelly, 1970; Chan, 1972; Cooke and Wei, 1988).

The antero-posterior skeletal relationships of the maxilla and mandible to the anterior cranial base were similar for

TABLE 2 *Comparison between Jordanian males and females*

	Males (n = 33)		Females (n = 32)			
Parameter	Mean	SD	Mean	SD	Difference	95% CI
SNA (°)	81·3	3·89	80·4	3·30	0·9	–0·9 to 2·7
SNB (°)	78·3	2·91	77·3	3·22	1·0	–0·5 to 2·5
ANB (°)	3·0	2·32	3·1	1·55	–0·1	–1·1 to 0·9
MMPA (°)	26·5	5·88	24·6	4·18	1·9	–0·6 to 4·5
UI/MX (°)	112·1	5·08	109·9	5·46	2·2	–0·5 to 4·8
LI/MN (°)	95·2	7·89	96·5	5·88	–1·3	–4·7 to 2·2
UI/LI (°)	126·2	8·16	129·1	7·68	–2·9	–6·8 to 1·1
LI/A–Pog (mm)	4·0	1·88	3·3	1·48	0·7	–0·1 to 1·5

TABLE 3 *Comparison of Jordanian and British cephalometric norms*

	Jordanian standards (n = 65)		Eastman standards (n = 250)		Difference
Parameter	Mean	SD	Mean	SD	Mean
SNA (°)	80·7	3·67	81	3	–0·3
SNB (°)	77·7	3·19	78	3	–0·3
ANB (°)	3·0	1·96	3	2	0·0
MMPA (°)	25·5	5·28	27	4	–1·5*
UI/MX (°)	111·1	6·83	109	6	2·1*
LI/MN (°)	95·9	5·06	93	6	2·9*
UI/LI (°)	127·5	7·93	131	6	–3·5*
LI/A–Pog (mm)	3·7	1·96	–0·86†	2·6†	4·56*

*Significant difference at $P < 0{\cdot}05$ (independent sample *t*-test).
†From MacAllister and Rock (1992).

the Jordanian and British populations in that no statistically significant differences were found for SNA, SNB, and ANB values. However, MMPA was lower in the Jordanian population.

The effect of this reduction in lower face height was expressed dentally in the relation of the upper incisors to the maxillary plane (UI/MX), lower incisors to mandibular plane (LI/MN), and upper incisors to lower incisors (UI/LI). Both upper and lower incisors were proclined significantly by 2·1 and 2·9 degrees, respectively, in the Jordanian population, whilst the inter incisal angle was correspondingly reduced.

The increase in the LI/MN angle was associated with the finding that on average the lower incisors in Jordanians were 4·56 mm further forward in relation to the A–Pog line than in other published norms (MacAllister and Rock, 1992).

The same is true of other normative cephalometric values, although the mean values are useful diagnostic aids they should not be used as treatment goals for individual patients. The objective of treatment must be to obtain tooth relationships in harmony with the facial and dental morphology

Conclusions

The present study has produced normative cephalometric data for a Jordanian population that will aid in diagnosis and treatment planning. In comparison with a British sample, Jordanians have a reduction in lower face height, proclined upper and lower incisors in relation to their corresponding dental bases, and a reduction in inter-incisal angle. The lower incisors are also significantly forward of the A–Pog line in relation to the incisors of European populations.

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