# Chinese Norms of McNamara's Cephalometric Analysis

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**ABSTRACT**

**Objective:** To establish cephalometric norms of McNamara's analysis in young Chinese and compare them to those of a matched young Caucasian sample.

**Materials and Methods:** The material comprised lateral cephalometric radiographs of a random sample of 200 male and 205 female 12-year-old southern Chinese children, and an additional sample of 43 male and 43 female 12-year-old British Caucasian children in Hong Kong. The radiographs were digitized twice with the CASSOS program.

**Results:** The results showed that there were statistically significant gender differences for six out of the 11 cephalometric variables in the Chinese, but for only one variable in the Caucasians. The size of the statistically significant gender differences varied from −0.3 to 0.4 on SD scores. There were statistically significant ethnic differences for eight variables in males and seven variables in females. The size of the observed statistically significant ethnic differences varied from −1.8 to 1.6 on SD scores.

**Conclusion:** The use of specific standards for Chinese, separate for gender, for McNamara's cephalometric analysis seems to be justified.

**KEY WORDS:** Cephalometrics; Diagnosis

## INTRODUCTION

Since its introduction in 1931 by Broadbent[1] and Hofrath[2] in the United States and Germany, respectively, radiographic cephalometry has become one of the most important tools of clinical and research orthodontics.[3] In a contemporary comprehensive textbook on cephalometry, a list of the most well-known and popular cephalometric analyses included no fewer than 23 analyses introduced between 1946 and 1985.[4] One of the more recent additions is the McNamara analysis.[5] The vast majority of the 23 analyses used reference values obtained from selected, often small, samples of Caucasians, and some of these methods[6,7] made no distinction for age or gender. One method[8] included reference values based a small sample, separate for gender, over a 15-year age range, whereas for a few methods[9,10] the references were based on larger samples separate for gender and age groups.

In principle, McNamara's analysis[5] combines the anterior reference plane (a plane perpendicular to the Frankfurt horizontal through the nasion) described by Burstone et al[8] and a description of the length of the jaws and their relationship as given by Harvold.[10] This specific innovative cephalometric analysis was introduced because "a need had arisen for a method of cephalometric analysis that is sensitive not only to the position of teeth within a given bone, but also to the relationship of jaw elements and cranial base structures one to another."[5] This approach makes the actual analysis most suitable for diagnosis, treatment planning, and treatment evaluation, not only of conventional orthodontic patients, but also for patients with skeletal discrepancies who are candidates for dentofacial orthopedics and orthognathic surgery.

However, for the appropriate application of any cephalometric analysis, it must be used with norms derived from populations similar to the orthodontic patients with regard to ethnic group, gender, and age.[3,11] Because orthodontic patients nowadays range from juveniles to senior citizens and come from various ethnic groups, a wide range of representative norms would be ideal. Nevertheless, patients most commonly un-

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**Table 1.** Demographic Data of the Study Samples[a]

| | n | Age | | | Range | |
|---|---|---|---|---|---|---|
| | | Mean | SD | Median | Minimum | Maximum |
| Chinese | | | | | | |
| Male | 200 | 12.4 | 0.70 | 12.5 | 11.0 | 13.0 |
| Female | 205 | 12.5 | 0.38 | 12.6 | 11.9 | 13.0 |
| Difference | | −0.1 | | −0.1 | −0.9 | 0.0 |
| Caucasian | | | | | | |
| Male | 43 | 12.4 | 0.20 | 12.4 | 12.1 | 12.7 |
| Female | 43 | 12.5 | 0.32 | 12.3 | 12.1 | 13.0 |
| Difference | | −0.1 | | 0.1 | 0.0 | −0.3 |

[a] None of the differences between the samples were statistically significant.

**Table 2.** Landmarks and Reference Lines for McNamara Analysis[3]

| | | |
|---|---|---|
| Maxilla to cranial base | | |
| 1. NA-P perpendicular | Nasion perpendicular to point A | A vertical line is constructed perpendicular to the Frankfort horizontal and extended inferiorly from the nasion. The perpendicular distance is measured from point A to the nasion perpendicular. |
| 2. SNA | | The angle between the SN and NA lines. |
| Mandible to Maxilla | | |
| 3. Co-Gn | Effective mandibular length | A line is measured from the condylion to the anatomic gnathion. |
| 4. Co-A | Effective midface length | A line is measured from the condylion to point A. |
| 5. MxMD-DF | Maxillomandibular differences | Effective mandibular length minus effective midface length. |
| 6. ANS-Me | Lower anterior face height | A line is measured from the anterior nasal spine to the menton. |
| 7. MD-P | Mandibular plane angle | The angle between the anatomic Frankfort plane and the mandibular plane, gonion-menton. |
| 8. FA-A | Facial axis angle | A line is constructed from the basion to the nasion (NBa). A second line (the facial axis) is constructed from the posterosuperior aspect of the pterygomaxillary fissure (PTM) to the constructed gnathion (the intersection of the facial plane and the mandibular plane). The facial axis angle is the angle between the NBa and the facial axis. |
| Mandible to cranial base | | |
| 9. Pg-N | Pogonion to nasion perpendicular | The perpendicular distance is measured from the pogonion to the nasion perpendicular. |
| Dentition | | |
| 10. Ui-A | Upper incisor to point A | A point A perpendicular is constructed parallel to the nasion perpendicular through point A. The perpendicular distance is measured from the most anterior surface of the upper incisor to the point A perpendicular. |
| 11. Li-APg | Lower incisor to A-Po line | The distance is measured form the facial surface of the lower incisor to the A-pogonion line. |

dergo orthodontic treatment at around 10–14 years of age, and priority should be given to obtaining solid norms for this age group. At present, there is no published Chinese norm for the McNamara analysis.[5] The aim for this study is therefore to establish norms for young Chinese children.

## MATERIALS AND METHODS

Two hundred male and 207 female 12-year-old southern Chinese schoolchildren were selected by a partially stratified random sampling method from 10 schools in Hong Kong.[12] Two females with previous and current orthodontic treatment were excluded, and the final sample consisted of 200 males and 205 females (Table 1). In addition a sample was drawn from two expatriate schools that agreed to participate in the study, consisting of 47 male and 43 female 12-year-old Caucasian school children living in Hong Kong whose parents originated from the United Kingdom. This sample was used for ethnic comparison. Four British males were excluded from the initial sample because of previous or current orthodontic treatment, and the final sample consisted of 43 males and 43 females.[11] Ethical approval was obtained from the Ethics Committee, Faculty of Dentistry, The University of Hong Kong in 1983.

### Radiographic Technique

All the lateral cephalometric radiographs were taken in natural head posture as originally defined by Molhave[13] and later adopted and modified by others.[14,15] The x-ray machine used for both Chinese and Caucasian samples was a General Electric GE1000 (Milwaukee, WI). Magnification was 8.8% for the midsagittal structure, ear-rods were used, and the subjects looked into a mirror 200 cm ahead after first tilting the head forward and backward with decreasing amplitude until a comfortable position of natural balance was found.[15] The lips were in light contact. Intensifying screens were used to minimize the exposure level. Free comprehensive dental treatment, including orthodontic treatment, was offered to all subjects, and copies of the original radiographs were later used for diagnosis.

### Cephalometric Method

The landmarks and reference lines for McNamara analysis[3] are summarized in Table 2 and Figure 1. Initially, the radiographs were traced manually and then rechecked by digitization and application of the program CASSOS (Soft Enable Technology Limited, Hong Kong, PRC).

### Statistical Analysis

Both skewness and kurtosis were within 2 standard errors and the mean and median were close. Hence, the sample measurements around the mean were considered evenly distributed. A *t*-test for independent samples was used, and the levels of statistical significance were $P < .05$, $P < .01$, and $P < .001$. The gender differences and the ethnic differences were also presented in standard deviation score[16] ie, for a certain variable A:

SD score of gender difference of variable A
= (mean of gender difference of A)
÷ [(SD of A for males
+ SD of A for females)/2] (1)

SD score of ethnic difference of variable A
= (mean of ethnic difference of A)
÷ [(SD of A for Chinese males
+ SD of A for Caucasian males)/2] (2)

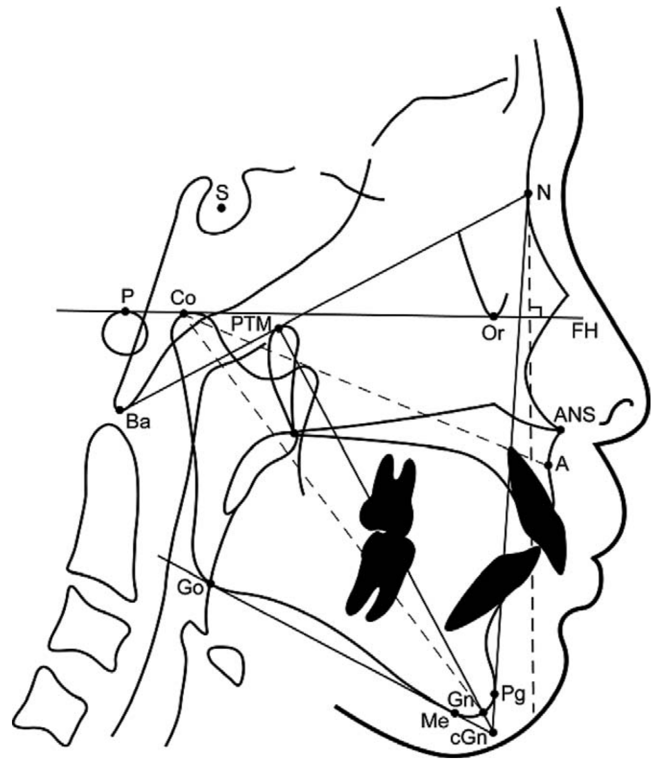


**Figure 1.** The cephalometric landmarks and definitions (McNamara[5]). S indicates sella (the center of sella turcica); N, nasion (the most anterior limit of suture nasofrontalis); Ba, basion (the posterior inferior point on the occipital bone at the anterior margin of the foramen magnum); ANS, anterior nasion spine (the apex of the anterior nasal spine); A, subspinale (the most posterior point on the concave anterior border of the maxillary alveolar process); Po, pogonion (the most anterior point on the mandibular symphysis); Gn, anatomical gnathion (the most anteroinferior point of the mandibular symphysis); cGn, contructed gnathion (the intersection of the facial plane and the mandibular plane; facial plane is the line from the nasion to the pogonion); Me, menton (the lowermost point on the shadow of the mandibular symphysis); Go, gonion (the most outward point on the angle formed by the junction of the ramus and body of the mandible on its posterior, inferior aspect); Co, condylion (the most posterior point on the outline of the mandibular condyle); P, porion (the superior aspect of the external auditory meatus); Or, orbite (the lower border of the orbit of the eye); PTM, pterygomaxillary fissure (the most posterosuperior aspect of the pterygomaxillary fissure)

### Method Error

There was no statistically significant difference between the method error of the tracing by manual and digitizer. Finally, all the radiographs were digitized twice with the program CASSOS. The data were averaged and analyzed by SPSS.

Method errors were calculated by Dahlberg's formula,[17] $ME = \sqrt{\Sigma d^2/2n}$, where $\Sigma d^2$ is the sum of the squared differences between the two mean values, and n is the number of double measurements. The method errors for linear and angular measurement were not statistically significant, and did not exceed 0.5 mm and 0.7° respectively for any variables.

## RESULTS

There was no statistically significant difference between the age groups of the samples (Table 1). The cephalometric norms of McNamara analysis[5] for 12-year-old southern Chinese and 12-year-old British Caucasian subjects are summarized in Table 3 and Table 4 respectively. The interethnic differences for males and females are summarized in Table 5. There was a large individual variation for all variables for both ethnic groups and both genders.

### Gender Differences

There were no statistically significant gender differences among the Chinese subjects for the variables relating the maxilla to cranial base and dentition, but five of the six variables related to the mandible and maxilla, and the variable related to mandible to cranial base, showed statistically significant differences. Three variables among the Chinese subjects were significantly larger in males: effective midface length (2.0 mm; SD score 0.4), lower face height (1.8 mm; SD score 0.4), and mandibular plane angle (1.7°; SD score 0.3). Three variables were significantly larger in females: maxillomandibular difference (−1.3 mm; SD score −0.3), facial axis angle (−1.7°; SD score −0.4), and pogonion to nasion perpendicular (−2.6 mm; SD score −0.4).

Among the Caucasian subjects, a statistically significant gender difference was noted for one parameter only, lower anterior face height, which was larger (2.5 mm; SD score 0.5) in males than in females (Table 4).

### Ethnic Differences

Among the male subjects, statistically significant differences were noted for all three variables related to the dentition and mandible to cranial base, one of the two variables related to the maxilla to cranial base, and four of the six variables related to mandible to maxilla. Five of the variables were larger in the Chinese subjects, two angular measurements, SNA (1.5°; SD score 0.5), mandibular plane angle (4.8°; SD score 1.0), and three linear measurements, maxillomandibular difference (2.1 mm; SD score 0.5), upper incisor to point A vertical (1.5 mm; SD score 0.6) and lower incisor to A-Po line (3.2 mm; SD score 1.4), whereas three variables were larger in the Caucasian subjects, ie, effective midface length (−2.9 mm; SD score −0.7), facial axis angle (−6.7°; SD score −1.8), and pogonion to nasion perpendicular (−2.7 mm; SD score −0.4).

In females, there was no statistically significant difference for maxilla to cranial base and mandible to cranial base, whereas 5 out of 6 variables of mandible to maxilla, and the two variables related to dentition, differed significantly. Five variables were statistically significantly larger in Chinese females: three for mandible to maxilla, maxillomandibular difference (4.7 mm; SD score 1.4), lower anterior face height (1.8 mm; SD score 0.4), and mandibular plane angle (3.9 mm; SD score 0.8), and the two variables related to dentition, upper incisor to point A vertical (2.6 mm; SD score 1.0) and lower incisor to A-Po line (3.7 mm; SD score 1.6). Two variables related to maxilla to mandible were larger in Caucasian females: effective midface length (−4.5 mm; SD score −1.1) and facial axis angle (−5.3°; SD score −1.4).

## DISCUSSION

This study established norms for McNamara analysis[5] in southern Chinese, separate for gender (Table 3). The study was based on a large sample of 12-year-old children that was representative of its original population.[12] In the study, the cephalograms were measured twice and averaged figures were used. These repeated measurements reduced the error of landmark identification, and duplicate measurements were sufficient for a comparison of the two groups.[18] Consequently, the means and standard deviations of the 11 cephalometric variables investigated in this study should be considered as representative for 12-year-old Chinese.

Besides a conventional statistical *t*-test of the differences between variables for the two genders and the two ethnic groups, standard deviation scores were also used. The statistically significant gender differences among the Chinese subjects and the ethnic differences between Chinese and Caucasians (Tables 3, 4 and 5) were also expressed in standard deviation scores.[16] In other words, the differences were expressed not only in degrees and millimeters, but also in relation to their variation around the mean of the actual parameter (Tables 3, 4 and 5). The use of standard deviation scores to describe the extent to which a certain patient deviated for specific cephalometric variables can also be done in clinical situations.

In McNamara's[5] original study, the standards separate for gender were based on 73 untreated female and 38 male adults with well-balanced faces and good occlusion. In addition, composite normative standards were obtained from the same adult sample and two other samples. One was a small sample of boys and girls followed from 6 to 18 years of age, and the other a medium-sized sample of boys and girls followed from 6 to 20 years, in which jaw measurements and

**Table 3.** Cephalometric Norms of McNamara Analysis[3] in Chinese[a]

| Variables | Abbreviations | Male | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Range | | 95% Confidence Interval of the Mean | |
| | | Mean | SD | Median | Min | Max | Lower | Upper |
| Maxilla to cranial base | | | | | | | | |
| 1. Nasion perpendicular to point A (mm) | NA-0P | −0.75 | 3.60 | −0.95 | −10.5 | 7.9 | −1.3 | −0.3 |
| 2. SNA (°) | SNA | 81.78 | 3.65 | 81.85 | 72.3 | 92.5 | 81.3 | 82.3 |
| Mandible to maxilla | | | | | | | | |
| 3. Effective mandibular length (mm) | Co-GN | 113.95 | 5.73 | 113.93 | 102.5 | 130.3 | 113.2 | 114.7 |
| 4. Effective midface length (mm) | Co-A | 87.90 | 4.71 | 88.23 | 74.8 | 100.6 | 87.2 | 88.5 |
| 5. Maxillomandibular difference (mm) | MXMD-DF | 26.06 | 4.26 | 26.15 | 15.8 | 37.9 | 25.5 | 26.6 |
| 6. Lower anterior face height (mm) | ANS-Me | 66.14 | 4.68 | 65.88 | 56.0 | 77.7 | 65.5 | 66.8 |
| 7. Mandibular plane angle (°) | MD-P | 27.81 | 5.19 | 27.83 | 15.0 | 41.1 | 27.1 | 28.5 |
| 8. Facial axis angle (°) | FA-A | −5.51 | 3.94 | −5.53 | −17.7 | 5.3 | −6.1 | −5.0 |
| Mandible to cranial base | | | | | | | | |
| 9. Pogonion to nasion perpendicular (mm) | Pg-N | −7.45 | 6.93 | −7.55 | −34.2 | 6.9 | −8.4 | −6.5 |
| Dentition | | | | | | | | |
| 10. Upper incisor to point A vertical (mm) | Ui-A | 7.34 | 2.82 | 7.48 | −0.3 | 15.6 | 6.9 | 7.7 |
| 11. Lower incisor to A-Po line (mm) | Li-APg | 6.35 | 2.43 | 6.48 | −0.8 | 13.0 | 6.0 | 6.7 |

[a] Min indicates minimum; Max, maximum. * $P < .05$; *** $P < .001$.

**Table 4.** Cephalometric Norms of McNamara Analysis[3] in Caucasian Subjects[a]

| Variables | Abbreviations | Male | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Range | | 95% Confidence Interval of the Mean | |
| | | Mean | SD | Median | Min | Max | Lower | Upper |
| Maxilla to cranial base | | | | | | | | |
| 1. Nasion perpendicular to point A (mm) | NA-P | −1.14 | 3.28 | −1.60 | −8.8 | 7.3 | −2.1 | −0.2 |
| 2. SNA (°) | SNA | 80.26 | 2.72 | 80.65 | 73.5 | 87.0 | 79.4 | 81.1 |
| Mandible to maxilla | | | | | | | | |
| 3. Effective mandibular length (mm) | Co-GN | 114.77 | 4.65 | 115.70 | 104.2 | 123.6 | 113.4 | 116.2 |
| 4. Effective midface length (mm) | Co-A | 90.76 | 3.61 | 91.70 | 79.8 | 98.5 | 89.7 | 91.8 |
| 5. Maxillomandibular difference (mm) | MXMD-DF | 24.01 | 3.77 | 24.05 | 14.8 | 31.1 | 22.9 | 25.1 |
| 6. Lower anterior face height (mm) | ANS-Me | 65.04 | 4.82 | 64.10 | 55.4 | 79.1 | 63.6 | 66.5 |
| 7. Mandibular plane angle (°) | MD-P | 23.01 | 4.48 | 22.95 | 14.9 | 33.6 | 21.7 | 24.3 |
| 8. Facial axis angle (°) | FA-A | 1.17 | 3.34 | 1.20 | −7.1 | 9.3 | 0.2 | 2.2 |
| Mandible to cranial base | | | | | | | | |
| 9. Pogonion to nasion perpendicular (mm) | Pg-N | −4.72 | 5.77 | −5.15 | −19.2 | 5.7 | −6.4 | −3.0 |
| Dentition | | | | | | | | |
| 10. Upper incisor to point A vertical (mm) | Ui-A | 5.82 | 2.36 | 6.10 | −0.1 | 9.6 | 5.1 | 6.5 |
| 11. Lower incisor to A-Po line (mm) | Li-APg | 3.13 | 2.28 | 3.10 | −0.5 | 9.4 | 2.4 | 3.8 |

[a] Min indicates minimum; Max, maximum. * $P < .05$.

lower face height measurements were also given specifically for various ages.

## Ethnic Differences

A direct ethnic comparison was possible only between the 12-year-old Chinese and 12-year-old Caucasian samples obtained in the present study (Table 5), but a close comparison of some variables was possible with the two samples of 12-year-old Caucasians included in the original study (Table 6).

This study showed marked ethnic differences for seven of the 11 variables of each gender between the Chinese and Caucasian samples (Table 5). The statistically significant ethnic differences expressed in standard deviation scores[16] ranged from −1.8 to 1.4 in males and −1.4 to 1.6 in females for McNamara's

**Table 3.** Extended

| | Female | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Range | | 95% Confidence Interval of the Mean | | | |
| Variables | Mean | SD | Median | Min | Max | Lower | Upper | Gender Difference | SD Score |
| Maxilla to cranial base | | | | | | | | | |
| 1. NA-P | −0.53 | 3.48 | −0.45 | −14.5 | 10.4 | −1.0 | −0.1 | −0.22 | −0.1 |
| 2. SNA | 81.97 | 3.50 | 82.10 | 72.6 | 91.1 | 81.5 | 82.4 | −0.18 | −0.1 |
| Mandible to maxilla | | | | | | | | | |
| 3. Co-GN | 113.32 | 5.43 | 113.25 | 100.6 | 126.6 | 112.6 | 114.1 | 0.63 | 0.1 |
| 4. Co-A | 85.93 | 4.41 | 86.10 | 75.7 | 95.7 | 85.3 | 86.5 | 1.97*** | 0.4 |
| 5. MXMD-DF | 27.39 | 3.68 | 27.55 | 14.4 | 37.7 | 26.9 | 27.9 | −1.34* | −0.3 |
| 6. ANS-Me | 64.39 | 4.34 | 64.45 | 53.5 | 75.6 | 63.8 | 65.0 | 1.75*** | 0.4 |
| 7. MID-P | 26.10 | 5.07 | 26.20 | 10.6 | 41.5 | 25.4 | 26.8 | 1.71* | 0.3 |
| 8. FA-A | −3.83 | 3.71 | −3.60 | −14.6 | 7.3 | −4.3 | −3.3 | −1.68*** | −0.4 |
| Mandible to cranial base | | | | | | | | | |
| 9. Pg-N | −4.88 | 6.51 | −5.10 | −23.7 | 13.8 | −5.8 | −4.0 | −2.57*** | −0.4 |
| Dentition | | | | | | | | | |
| 10. Ui-A | 7.86 | 2.60 | 8.10 | −1.3 | 14.3 | 7.5 | 8.2 | −0.52 | −0.2 |
| 11. Li-APg | 6.26 | 2.25 | 6.20 | −0.1 | 12.6 | 6.0 | 6.6 | 0.09 | 0.0 |

**Table 4.** Extended

| | Female | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Range | | 95% Confidence Interval of the Mean | | | |
| Variables | Mean | SD | Median | Min | Max | Lower | Upper | Gender Difference | SD Score |
| Maxilla to cranial base | | | | | | | | | |
| 1. NA-P | −0.04 | 3.34 | 0.45 | −7.9 | 8.2 | −1.0 | 1.0 | −1.09 | −0.3 |
| 2. SNA | 80.87 | 3.49 | 80.85 | 72.1 | 89.8 | 79.8 | 81.9 | −0.62 | −0.2 |
| Mandible to maxilla | | | | | | | | | |
| 3. Co-GN | 113.16 | 4.88 | 112.60 | 102.5 | 122.3 | 111.7 | 114.6 | 1.61 | 0.3 |
| 4. Co-A | 90.43 | 3.72 | 90.00 | 82.2 | 99.1 | 89.3 | 91.5 | 0.33 | 0.1 |
| 5. MXMD-DF | 22.72 | 3.18 | 22.40 | 14.5 | 30.4 | 21.8 | 23.7 | 1.29 | 0.4 |
| 6. ANS-Me | 62.57 | 4.80 | 62.15 | 53.1 | 76.7 | 61.1 | 64.0 | 2.47* | 0.5 |
| 7. MD-P | 22.19 | 5.11 | 22.90 | 11.6 | 34.1 | 20.7 | 23.7 | 0.82 | 0.2 |
| 8. FA-A | 1.46 | 4.09 | 1.70 | −9.1 | 8.7 | 0.2 | 2.7 | −0.29 | −0.1 |
| Mandible to cranial base | | | | | | | | | |
| 9. Pg-N | −4.12 | 5.62 | −4.15 | −18.5 | 6.5 | −5.8 | −2.4 | −0.60 | −0.1 |
| Dentition | | | | | | | | | |
| 10. Ui-A | 5.26 | 2.52 | 5.40 | 0.1 | 10.2 | 4.5 | 6.0 | 0.56 | 0.2 |
| 11. Li-APg | 2.53 | 2.36 | 2.50 | −3.4 | 7.5 | 1.8 | 3.2 | 0.60 | 0.3 |

analysis in this study. This degree of difference would appear to justify separate cephalometric standards for Chinese and Caucasian children. Such ethnic differences were to be expected, because a similar ethnic pattern was noticed from comparison of those samples when adopting conventional cephalometrics.[11,12] Ethnic differences in conventional cephalometric methods have also been reported for Chinese versus Indians and Malays respectively.[19] Ethnic differences have also been reported for cephalometric comparison of Chinese and Caucasian samples with malocclusions.[20,21]

The reference values obtained in this study for Chinese were compared with reference values for the samples of 12-year-old patients from the Bolton and Burlington growth study, and some parameters not af-

**Table 5.** Cephalometric Norms of McNamara Analysis[3] for Interethnic Differences (Chinese vs Caucasian)

| Variables | | Male | SD Score | Female | SD Score |
|---|---|---|---|---|---|
| Maxilla to cranial base | | | | | |
| 1. Nasion perpendicular to point A (mm) | NA-P | 0.39 | 0.1 | −0.49 | −0.1 |
| 2. SNA (°) | (SNA) | 1.53* | 0.5 | 1.10 | 0.3 |
| Mandible to maxilla | | | | | |
| 3. Effective mandibular length (mm) | Co-GN | −0.82 | −0.2 | 0.16 | 0.0 |
| 4. Effective midface length (mm) | Co-A | −2.86*** | −0.7 | −4.51*** | −1.1 |
| 5. Maxillomandibular difference (mm) | MXMD-DF | 2.05* | 0.5 | 4.67*** | 1.4 |
| 6. Lower anterior face height (mm) | ANS-Me | 1.10 | 0.2 | 1.82* | 0.4 |
| 7. Mandibular plane angle (°) | MD-P | 4.80*** | 1.0 | 3.91*** | 0.8 |
| 8. Facial axis angle (°) | FA-A | −6.68*** | −1.8 | −5.29*** | −1.4 |
| Mandible to cranial base | | | | | |
| 9. Pogonion to nasion perpendicular (mm) | Pg-N | −2.72* | −0.4 | −0.76 | −0.1 |
| Dentition | | | | | |
| 10. Upper incisor to point A vertical (mm) | Ui-A | 1.52* | 0.6 | 2.60*** | 1.0 |
| 11. Lower incisor to A-Po line (mm) | Li-APg | 3.22*** | 1.4 | 3.73*** | 1.6 |

* $P < .05$; *** $P < .001$.

fected by growth from the Ann Arbor sample of adults (Table 6) as given by McNamara.[5] The ethnic differences were in general confirmed.

However, for the two variables of dentition in both genders (Table 6), the 12-year-old Caucasian sample of the present study differed significantly from the 12-year-old Bolton standards, but not from the 12-year-old Burlington standards. There were also similar differences between the smaller sample of 12-year-olds from the Bolton standards and the larger sample from the Burlington standards (Table 6), which might reflect unspecified differences in selection criteria between the two samples. The effective mandibular and midface lengths were significantly longer in the 12-year-old Caucasian females in this study than in those of the Burlington sample only, and there was no significant difference in maxillomandibular difference (Table 6).

## Gender Difference

In this study there was a statistically significant difference between male and female Chinese subjects for six of the seven variables related to the mandible (the exception was effective mandibular length; Table 3). Expressed in SD scores[16] these gender differences were 0.3 to 0.4. Although there was no significant difference in the length of the mandible between the genders, the mandible was significantly more retrognathic, the mandibular plane and facial axis angle were steeper, and lower face height was larger in males. Because effective maxillary length was larger, maxillomandibular length was also longer in males than in females. However, for the maxilla to cranial base and dentition variables, there was no statistically significant difference between the genders. Previous cephalometric studies have indicated that there were some gender differences in the conventional cephalometric parameters among Chinese populations.[12,22–24]

In the Caucasian sample used in this study, there was no similar pattern in gender differences of the cephalometric parameters, because the only significant difference was lower face height (Table 4). This is consistent with a report that both angular and linear measurements in both genders in Caucasians were in general agreement.[11,25]

A similar gender difference in lower face height was also found in the other 12-year-old Caucasian samples, but reached a statistically significant level in the Burlington sample only. However, for the Burlington 12-year-olds, there were also statistically significant gender differences for effective midface and mandibular length in three of the four listed variables.[5] For the adult original sample calculations revealed that there were gender differences for six of the 11 dentoskeletal variables, the variables being identical to those with significant gender differences in the Chinese 12-year-old sample used in this study (Table 3). This finding indicates that there probably were statistically significant differences for those variables in representative samples, and that separate standards should be used for each gender.

## CONCLUSIONS

- It would be preferable to use specific Chinese norms, separate for gender, because a comparison has revealed statistically significant differences in most variables between males and females and between Chinese and Caucasians.

**Table 6.** Significant Differences Between Certain Parameters of McNamara Analysis Obtained in the Present Study and Samples From the Mcnamara[5] Study[a]

| Variables/Study | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | Bolton | Burlington | Ann Arbor | Bolton | Burlington | Ann Arbor |
| 1. Effective mandibular length | | | | | | |
| Present study | | | | | | |
| Chinese | ns | ns | | ns | *** | |
| British Caucasian | ns | ns | | ns | * | |
| McNamara 1984 | | | | | | |
| Bolton sample | NA | ns | | NA | ns | |
| 2. Effective midface length | | | | | | |
| Present study | | | | | | |
| Chinese | *** | *** | | ** | * | |
| British Caucasian | ns | ns | | ns | *** | |
| McNamara 1984 | | | | | | |
| Bolton sample | NA | ns | | NA | ns | |
| 3. Maxillomandibular difference | | | | | | |
| Present study | | | | | | |
| Chinese | *** | *** | | *** | *** | |
| British Caucasian | ns | ns | | ns | ns | |
| McNamara 1984 | | | | | | |
| Bolton sample | NA | ns | | NA | ns | |
| 4. Lower incisor to A-Po line | | | | | | |
| Present study | | | | | | |
| Chinese | *** | *** | | *** | *** | |
| British Caucasian | ** | ns | | * | ns | |
| McNamara 1984 | | | | | | |
| Bolton sample | NA | ns | | NA | ** | |
| 5. Upper incisor to point A | | | | | | |
| Present study | | | | | | |
| Chinese | *** | *** | | *** | *** | |
| British Caucasian | ** | ns | | ** | ns | |
| McNamara 1984 | | | | | | |
| Bolton sample | NA | ** | | NA | *** | |
| 6. Lower anterior face height | | | | | | |
| Present study | | | | | | |
| Chinese | ns | ns | | ns | ns | |
| British Caucasian | ns | ns | | ns | ns | |
| McNamara 1984 | | | | | | |
| Bolton sample | NA | ns | | NA | ns | |
| 7. Facial axis angle[b] | | | | | | |
| Present study | | | | | | |
| Chinese | | | *** | | | *** |
| British Caucasian | | | ns | | | ns |

[a] The present study includes 12-year-old Chinese males (n = 200), 12-year-old Chinese females (n = 205), 12-year-old British Caucasian males (n = 43), and 12-year-old British Caucasian females (n = 43). Samples from the McNamara study include 12-year-old Bolton males (n = 16), 12-year-old Bolton females (n = 16), 12-year-old Burlington males (n = 50), 12-year-old Burlington females (n = 56), and young adult Ann Arbor males and females (n = 111). NA indicates not applicable; ns, not significant.

[b] Compared with Ann Arbor adult sample because facial axial angle does not change with growth.

* $P < .05$; ** $P < .01$; *** $P < .001$.

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