The Online
ANGLE ORTHODONTIST
An International Journal of Orthodontics and Dentofacial Orthopedics
78th Anniversary 1930-2008

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The Angle Orthodontist: **Vol. 72, No. 4, pp. 324–330.**

Comparison of Linear Cephalometric Dimensions in Americans of European Descent (Ann Arbor, Cleveland, Philadelphia) and Americans of African Descent (Nashville)

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ABSTRACT

Eleven dimensions, extracted from four commercially available cephalometric atlases were compared. Three populations were American of European descent and one was American of African descent. The source data were carefully corrected for linear enlargement. The confounding effect of linear radiographic enlargement is exemplified by depicting the often-used distance, sella-nasion, before and after correction. Total face height was smallest in the Cleveland population and largest in the Nashville population. The difference was fully accounted for by differences in lower face height and that was the most variable of all dimensions studied. Upper face height was almost identical in all four populations. Posterior face height was largest in the Nashville population. The mandible in the Nashville population had an average ramus height, but a longer corpus. Mandibular dimensions were equal in the three other populations. The maxilla was clearly shortest in the Cleveland population and almost of equal length in the three others.

KEY WORDS: Radiographic enlargement, Cephalometry, Ethnic differences.

Accepted: February 2002. Submitted: August 2001

INTRODUCTION Return to TOC

Comparison of cephalometric data from different sources is common in the orthodontic literature. However, craniofacial structures are enlarged uniquely in each and every study as the result of differences in cephalostat specifications. Therefore, data not corrected for enlargement or data corrected to a so-called standardized enlargement contain significant bias when compared on a value-to-value basis. It has been shown that differing enlargement factors, resulting from the use of different cephalostats, are responsible for considerable errors when linear data from different studies are compared[1]. Linear measures from different studies can only be compared with each other when they are corrected to natural size. Since there is such a wealth of data contained in four much used American longitudinal lateral cephalometric atlases, and because these data are incomparable in the form as they are printed, it was decided to make possible such comparisons by applying strict rules for enlargement correction. Because one of the atlases contains a unique study on Americans of

African descent, the opportunity presented itself to explore metric similarities and differences between these data and the three atlases on Americans of European descent.

MATERIALS AND METHODS Return to TOC

The data were obtained from "*An Atlas of Craniofacial Growth,*" Ann Arbor, Mich,[2] "*Bolton Standards of Dentofacial Developmental Growth,*" Cleveland, Ohio,[3] "*Clinical Atlas of Roentgencephalometry in Norma Lateralis,*" Philadelphia, Penn,[4] and "*Atlas of Craniofacial Growth in Americans of African Descent.*"[5] Nashville, Tenn.

Enlargement correction of the Ann Arbor data (Michigan atlas)

The longitudinal Ann Arbor study, collected by the University of Michigan Dental School between 1953 and 1966, represents an average school population with the regional mix of Class I, Class II and Class III individuals. The Ann Arbor atlas documents a selection of 83 individuals, 47 men and 36 women, from six to 16 years of age. The data are presented in tables with averages computed from digitized tracings and are not corrected for linear enlargement.[2,6]

Enlargement of the cephalograms originally was not mentioned. After scrutinizing University of Michigan Master's Theses for the period 1960–1975, an enlargement factor of 12.9% for the Ann Arbor data was accepted.[7] Thus, the linear dimensions in the tables have been converted into natural size by multiplication with 1/1.129 = 0.886.

Enlargement correction of the Cleveland data (Bolton Standards)

From the Bolton data, collected between 1931 and 1959 at Case Western Reserve School of Dentistry in Cleveland, Ohio, the Bolton faces were selected by excellence of static occlusion and aesthetically favorable faces. The accompanying tables run from one to 18 years of age and are sex specific. They represent averages computed from the original tracings digitized with the Walker program and the data in the atlas are not in natural size.[3,8]

For the present report we infer that the templates and tables on average show a 6% enlargement[3,9,10]; thus, the linear dimensions in the tables have been converted into natural size by multiplication with 1/1.06 = 0.943.

Enlargement correction of the Philadelphia data (Pennsylvania atlas)

The mixed-longitudinal Philadelphia Center for Research in Child Growth Study was conducted between 1948 and 1968 and participants were selected from European ancestry with good medical and dental health. It contains more children of Italian ancestry than any other ethnic group. From the various reports in the literature, conflicting descriptions of the data and methods emerge.[11–13] The study is conducted on subjects from six to 25 years of age. One thousand cephalometric radiographs were traced and digitized by the Walker program, and the data in the atlas are not corrected for linear enlargement.[4,8]

Because a Bolton-Broadbent cephalometer was used, it is assumed that the radiographic enlargement equaled that of the Cleveland data; thus, the linear dimensions in the tables have been converted into natural size by multiplication with 0.943.

Enlargement correction of the Nashville data (Tennessee atlas)

The School of Dentistry, Meharry Medical College in Nashville, Tenn conducted their study between 1965 and 1981. Participants were black American children from African descent from lower to middle class families. The total number of complete longitudinal documentations is 160, but for the atlas a random selection was made of 41 boys and 41 girls. None of the participants received orthodontic treatment. Records were taken semiannually until 14 years of age and annually thereafter. The longitudinal documentation runs from six to 16 years of age. The age classes have been computed from one half year before to one half year after the class value. Documentation was performed on or close to birthdays. The data in the Nashville atlas are averages computed from digitized landmarks, not corrected for linear enlargement.[5]

A Whemer cephalostat was used with a focus-to-midsagittal plane distance of 60 inches and an object-to-film distance of 5.46 inches.[5] Thus, the linear dimensions in the tables have been converted into natural size by multiplication with 60/65.46 = 0.917.

Selection of linear distances

The linear distances had to be available in the Nashville atlas and at least in two other atlases. This limited the number of possible distances to 11: one for the anterior cranial base, three for anterior face height, one for posterior face height, three for mandibular size, one for maxillary size, and two major facial diagonals: sella to gnathion and nasion to articulare.

In order to show the obscuring effect of radiographic enlargement on the raw data, the distance sella to nasion is shown before and after correction in Figure 1. The remainder of the selected longitudinal linear distances is presented in Figures 2 through 11, each curve depicting the data after correction for enlargement. The x-axis represents age and runs from six years to 16 or 18 years, depending on the source data. On the y-axis care has been taken to standardize the vertical step, so that all graphs are directly comparable among each other. No statistical test has been applied, since the curves represent yearly averages and speak for themselves.

RESULTS Return to TOC

Both upper graphs in Figure 1 display the raw data for sella to nasion as they are published, left for men and right for women. This distance seems to differ greatly between the four populations with the Ann Arbor faces showing by far the largest dimension, Philadelphia and Cleveland the smallest, and the Nashville faces falling in between.

Figure 1 (both lower graphs) show that, after correction to natural size, there is considerably less difference between the four populations. Radiographic enlargement apparently obscured the direct value-to-value comparison of the raw data.

Figures 2 through 4 depict three aspects of anterior face height. It shows total face height to be longest in the Nashville population and shortest in the Cleveland population. This difference is also evident for lower face height where the Nashville population clearly has the longest and the Cleveland population the shortest lower face. Upper face height appears to be almost identical in the 4 populations.

Figure 5 depicts posterior face height, being somewhat larger in the Nashville population.

Figures 6 through 8 represent mandibular size. They indicate a larger diagonal and a longer corpus in the Nashville population, but ramus height is comparable in all four populations.

Figure 9 shows that maxillary length in men is shortest in Philadelphia and largest in Nashville, but identical in Ann Arbor and Cleveland. In the women, the maxillary length is shorter in Philadelphia, but the rest are of equal length.

In Figure 10 the diagonal of the face from nasion to articulare is somewhat larger in the Nashville men and clearly larger in the Nashville women.

Figure 11 represent the biggest diagonal, spanning from sella to gnathion. Philadelphia data are lacking. The diagonal is larger in the Nashville population.

DISCUSSION Return to TOC

Cephalometric studies comparing populations of different ethnic background are common in the orthodontic literature.[14–21]

Lavelle[22] studied tooth size in different racial groups and in different occlusal categories. He concludes that, even in patients with good occlusions, tooth size is more highly correlated between maxillary and mandibular dental arches in Negroids as compared with Caucasoids.

Harris et al[23] observed that many dimensions continue to change throughout adulthood and assumed that the amount and direction of these changes were race-specific.

Gould very elegantly showed the dangers inherent to the study of racial differences by demasking Morton's ranking of races by cranial capacity.[24] Obviously selection bias was responsible for the differences found in this outdated but, in its time, extremely influential study.

Bogin[25] in a most interesting monograph analyses all aspects of growth, including ethnic differences. He concludes that differences in body proportion between geographic populations are explained only in terms of a genetic model, though the mechanism is not known.

In a study of weight of bone during the fetal period, Trotter and Peterson[26] report significant race differences but no sex differences for lengths of the long limb bones and with “Negro bones longer than white.”

D'Aloisio et al[27] compared the cranial base of blacks and whites in regard to length, angulation, and flexure, in order to determine what proportion of the differences in facial measurements can be explained by the variability seen in the cranial base. They concluded, “There exists a growth coordinating mechanism between the cranial base and the maxillomandibular complex in blacks.”

Huang et al[20] studied cephalometric norms for Caucasians and African Americans in Birmingham. They conclude that their findings support the hypothesis that cephalometric norms should be based on racial, sex, and age differences.

Richardson,[28] principal investigator of the Nashville data and authority on cephalometric data of Americans of African descent, described racial differences in dimensional traits of the human face. He came to the conclusion that differences in means within ethnic or racial groups are often greater than the differences in means among those groups. He also holds the opinion that those parameters of the face that are closer to the alveolar and dental areas show the greatest differences among ethnic and racial groups. The greatest difference was found in the dentoalveolar area. In a later study, he confirmed that, "the bony facial structures of African Americans and European Americans are similar, with the only major differences to be found in the dentoalveolar area."[29]

Schirmer and Wiltshire[30] proposed a new mixed dentition analysis and probability tables exclusively for black patients of African descent. Trottman and Elsbach[19] compared malocclusion in preschool black and white children and showed that racial differences do exist at a significant level for occlusal relations. Class I molar relation had identical prevalence for black and white children. The prevalence of Class II molar relation was significantly greater in white children, and the prevalence of Class III molar relation and of anterior cross-bite was significantly greater in black children.

Our study compared eleven linear dimensions acquired from four cephalometric atlases. Since linear radiographic enlargement is a major confounding factor in cephalometric studies, the dimensions had to be corrected for enlargement before evaluation. The impact of these corrections is depicted in Figure 1 where the sella-nasion distance shows a huge difference between the four populations before correction but much less so after correction for radiographic enlargement.

Total face height (nasion-menton) appears to differ greatly with Nashville faces being the longest among the four populations, Ann Arbor and Philadelphia being equal and Cleveland having the shortest face height by far. One glance at Figure 3 shows upper face height (nasion-ANS) to be almost identical in all four populations. Figure 4 reveals that the site of the vertical discrepancy is in lower face height (ANS-menton). With the present study we can only register the enormous difference between lower face height in the Nashville and Cleveland studies of 15 to 20 mm on a dimension of 60 mm, as we don't have an explanation.

Posterior face height (sella-gonion) is largest in the Nashville population, but only to a moderate degree and is in no way comparable to the lower face height discrepancy. This suggests a steeper mandibular plane in the Nashville population.

The mandibular diagonal (articulare-pogonion) is clearly longest in the Nashville population. There was no difference in ramus height (gonion-articulare) between the four populations. By contrast, the mandibular corpus (gonion-pogonion Figure 7) in the Nashville population was clearly longer than the other three, in which the mandibular corpus was almost identical. This difference amounts to 10 mm and is constant throughout age.

There was clearly a shorter maxillary base (ANS-PNS) in the Cleveland population. The Nashville men had the largest maxilla, but the difference with the other three was limited to a few millimeters.

The distance from nasion-articulare (Figure 10) was almost identical for the men while in the female populations the Nashville women showed the largest distance and Cleveland the shortest.

The largest dimension in this study, the sella-gnathion (Figure 11), was not available for the Philadelphia study. male populations differed from each other with Nashville being largest. In the women, Nashville showed clearly the largest dimension while Ann Arbor and Cleveland showed no significant difference from each other.

CONCLUSION Return to TOC

Based on the observation in this study that none of the four populations systematically showed larger or smaller dimensions, we assume that the correction for enlargement has been performed correctly. There were clear-cut skeletal differences between the four populations studied, ie, a larger lower face height, a larger corpus length and a larger sella to gnathion dimension in the Nashville population. Yet, the suggestion of Richardson (1980) that "the parameters of the face that are closer to the alveolar and dental areas show the greatest differences among ethnic and racial groups" could hold true.[28]

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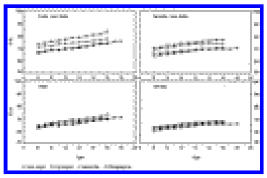
FIGURES Return to TOC



Click on thumbnail for full-sized image.

FIGURE 1. (Four drawings) Sella-nasion distance. Upper row, raw data as they are presented in the atlases. Lower row, dimensions corrected for enlargement to natural size. Note the difference between the upper and lower drawings. Women right, men left

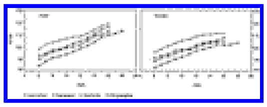


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FIGURE 2. Total face height, nasion-menton. Values corrected for enlargement. Women right, men left

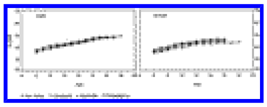

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FIGURE 3. Upper face height, nasion-ANS. Values corrected for enlargement. Women right, men left

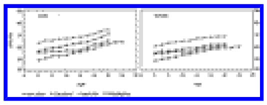

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FIGURE 4. Lower face height, ANS-menton. Values corrected for enlargement. Women right, men left

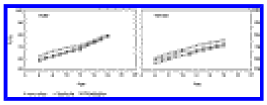

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FIGURE 5. Posterior face height, sella-gonion. Values corrected for enlargement. Data for the Cleveland population are lacking. Women right, men left

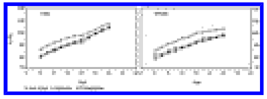

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FIGURE 6. Mandibular diagonal, articulare-pogonion. Values corrected for enlargement. Data for the Cleveland population are lacking. Women right, men left

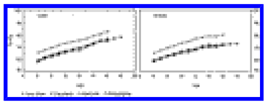

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FIGURE 7. Mandibular corpus length, gonion-pogonion. Values corrected for enlargement. Women right, men left

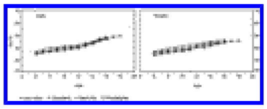

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FIGURE 8. Mandibular ramus height, gonion-articulare. Values corrected for enlargement. Women right, men left

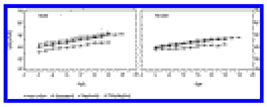

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FIGURE 9. Maxillary length, ANS-PNS. Values corrected for enlargement. Women right, men left

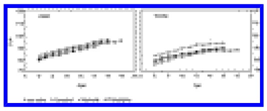

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FIGURE 10. The X-axis, Nasion-articulare. Values corrected for enlargement. Women right, men left

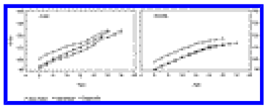

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FIGURE 11. The Y-axis, sella-gnathion. Values corrected for enlargement. Data for the Philadelphia population are lacking. Women right, men left

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