Studies of Dentofacial Morphology. IV. Profile Changes Among 6,829 White Individuals According to Age and Sex

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Interest in facial development began with investigations such as those of Duhamel[1], Hunter[2] and Brash[3] who were concerned with the mechanism of bone growth rather than the morphological result of growth.

Keith and Campion[4], measuring skulls of infants and normal adults, have, by superimposing on Frankfort plane, determined areas and amounts of bone growth within the human face. They noted an increase of 23 mm. in the linear dimension between nasion and the external auditory meatus between the ages of 5 and 25 years. They reported a forward and upward movement of nasion with respect to the external auditory meatus during this age range.

Hellman's[5] studies on skulls of American Indians and soft tissue measurements of 526 male and 670 female patients in approximately the age range of 5 to 25 years concluded that as the face grew, depth increased the most, height increased less, and width increased least of all. In the course of transformation, the face gradually moved forward and changed in relative position to the cranium. This work emphasized that the greatest changes are found in the depth and vertical dimensions of the face and that the female face becomes "relatively longer and the male face relatively deeper."

A useful tool, the cephalometer, was evolved by Broadbent[6, 7] whereby skeletal growth and development of living individuals could be studied from roentgenograms. Brodie[8], utilizing a series of cephalometric roentgenograms on 21 white male children age 3 months to 8 years, postulated that the facial pattern in the mid-saggital plane is established at about 3 months of age and continues proportionately until 8 years of age. Reporting further on growth changes of 19 individuals (distribution by sex not specified) from the 8th to approximately the 17th year of life he concluded[9] that there was an "orderly development of the various types of faces and . . . adherance to an original proportionality . . .".

Bjork[10], after cephalometric studies on 150 boys examined at age 12 and again at age 20 and drawing from the results of an earlier cross-sectional cephalometric investigation of "12 year old boys and an approximately equal number of adult males" totaling 603 cases, stated that an increased prognathism of both jaws was characteristic of profile changes with age and that the increase is greater in the mandible than the maxillae. Thus the profile of Swedish males becomes straighter as the individual matures.

In a serial cephalometric study of 34 white males with a mean age span from 4.4 to 17.1 years of age, Lande[11]

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reported a very distinct difference between the growth behavior of the maxilla and the mandible in an anteroposterior direction. He deduced that in males the mandible tended to become more prognathic between the ages of 7 to 17 years while the maxilla showed very little change. An increase in mandibular prognathism generally occurred after 7 years of age and usually reduced the convexity of the face.

At this time it appears that two points of view exist regarding males. One holds that while the face continues to grow downward and forward with relation to the cranial base, there is a marked stability and constancy of the individual pattern. The other view holds that with growth the mandible becomes more prognathic than the maxilla and that therefore the concept of a proportionate relationship between vertical dimension and depth of the face is in error.

Within the scope of our studies, facial measurements were available on 3,676 white males, ages 5 to 24 years and 3,153 white females in the same age range. It was decided to evaluate what changes take place, with age and sex, in the mean facial configuration of this population group.

Method

Previous publications[12, 13, 14] have presented a system of obtaining measurements and converting the data to an index of malocclusion. Briefly, an anthropometric instrument was designed to obtain profile point readings in relation to a vertical plane 20 mm. anterior to the point nasion and at right angles to the Frankfort horizontal plane (Fig. 1). The measurements obtained were as follows (Fig. 2):

1. The distance from the plane of reference (20 mm. anterior to nasion, N) to the point on the soft tissue corresponding to subnasion*, Sn. (P-Sn).
2. The distance from the plane of reference to the tip of the upper

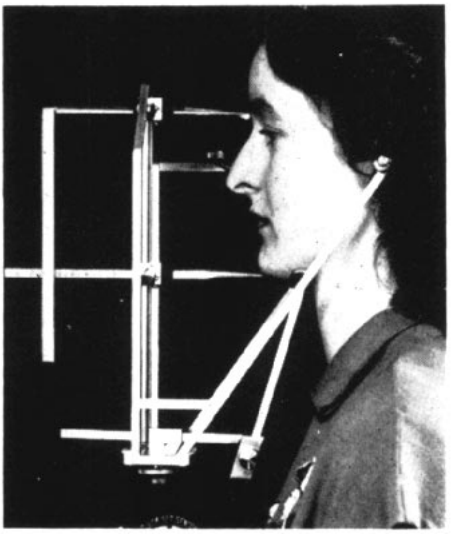


Fig. 1. An adult subject positioned in the orthometer. The subject's head is oriented in the Frankfort horizontal plane.

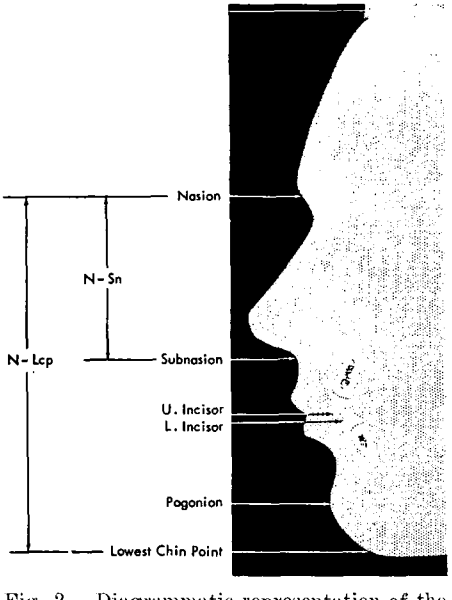


Fig. 2. Diagrammatic representation of the horizontal and vertical measurements utilized in this study.

*In these studies "subnasion" is identical with "subnasale" as used by physical anthropologists.

incisor (at midline), Ui (P-Ui).
3. The distance from the plane of reference to the point on the soft tissue corresponding to pogonion, Pg (P-Pg).
4. The vertical distance from nasion to subnasion (N-Sn).
5. The vertical distance from nasion to the lowest chin point L.C.P. (N-LCP).

The distance N-Sn, although properly referred to as nasal height, was for purposes of this instrumentation referred to as upper face height*.

Figure 2 indicates the horizontal measurements taken at varying intervals along the vertical plane of reference. If plotted, they will reproduce a rough outline of a profile.

In Figure 2, it is seen that a decrease with age in the average value of any horizontal dimension signifies a forward movement of that particular part of the face in relation to nasion. An increase of the average value of any horizontal dimension signifies a progressively greater posterior relationship with respect to nasion.

The averages presented in this study are based upon data obtained from 10 different geographic areas in the United States and include results of observations on 6,829 white individuals of both sexes. The selection of population groups involved was made on the basis of water-borne-fluoride intake for the school-age children. Data on young adults were obtained largely from examinations of male enlisted personnel of the U. S. Coast Guard and female enlisted personnel of the U. S. Navy. The age distribution of individuals studied are indicated in Table I.

Findings

Examination of Figure 3 (graph of Tables I and II) indicates that for both males and females there is a gradual decrease in the dimension P-Sn from ages 6 to 24. The total magnitude of this decrease is 3.38 for males and 3.23 for females. On the average, the point subnasion moves forward about 3 mm. toward the plane of reference with respect to nasion. This indicates an increase in maxillary prognathism with age for both males and females. Furthermore, it was determined that in the mid-saggital plane, subnasion moves downward and away from nasion. During this age period, the upper facial height, as measured from nasion to subnasion, increased from a mean of 47.81 mm. to a mean of 57.21 mm. for males and from 46.8 to 52.5 mm. for females. Thus, it is evident that subnasion in both sexes moves in a downward and forward direction in its spatial relation to nasion. This closely conforms to the findings of other investigators[6, 7, 8] who have demonstrated the same general resultant in the direction of growth of the underlying bony maxilla.

The curve for the dimension P-Pg (Fig. 4) exhibits a very slight decrease in dimension for males (1.36 mm.) and a slightly greater decrease for females (2.93 mm.) from ages 6 through 24. This finding suggests an increase in the prognathism of the lower jaw, in relation to nasion, but one that is not of the same magnitude as the increase in prognathism of the upper jaw (Fig. 3). The increase in mandibular prognathism was found to be considerably greater in the females than in the males.

In evaluating the change in the vertical facial dimension from ages 6 to 24, it is evident that the total facial height increases markedly over this age period. This increase in vertical facial dimension as measured from nasion to the lowest chin point (L.C.P.) was found to be somewhat greater in males than in females. The females reached a plateau in the vertical growth of the face at about age 15 years while males

*Ordinarily upper face height is the distance between nasion and the alveolar point (papilla between upper central incisors).

Figure 3.

AVERAGE VALUES OF ORTHOMETRIC MEASUREMENTS FOR P-Sn AND P-Ui DIMENSIONS

For Males and Females by Single Year of Age

(Based on 6,829 Cases from 10 Study Areas)

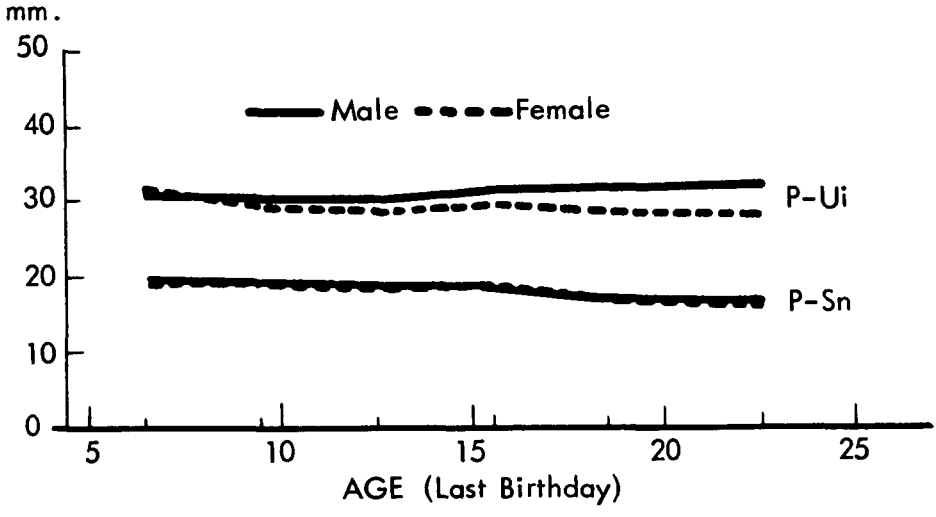
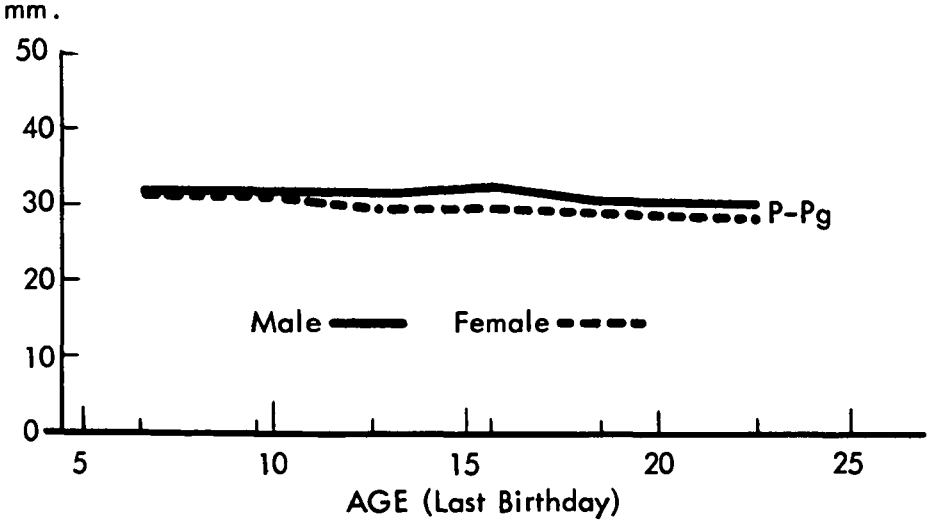


Figure 4.

AVERAGE VALUES OF ORTHOMETRIC MEASUREMENTS FOR P-Pg DIMENSION

For Males and Females by Single Year of Age

(Based on 6,829 Cases from 10 Study Areas)



did not plateau until age 18 years (Fig. 5).

Once again, it may be reasoned that from ages 6 to 20 the anterior aspect of the lower jaw moves downward and forward in its spatial relationship to nasion. This change is strikingly evident in females, whereas the movement, while being of considerable magnitude in the downward direction, was only very slightly forward in males.

In both sexes, with a smaller forward movement of the lower face as compared to the upper face there is not the so-called "straightening" of the facial profile as reported by Lande and Bjork. In the female sex, the degree of convexity of the facial profile increased only slightly (166.5° at age 6 and 165.0° at age 24) while in the male sex the facial profile tended to become more convex with age (166.0° at age 6 and 162.0° at age 24) (Fig. 6).

It is interesting to note that the average proportion of upper face height to total face height remains markedly uniform during this period. Ranging from a mean of 46.0 to 47.1 percent in males and from a mean of 46.1 to 47.6 percent in females (Table II).

For practical purposes there is an overall increase in dimension from the males, of less than 1 mm. and an overall decrease for females of 2.26 mm. from plane of reference to upper incisors, for ages 6 to 24. These observations suggest

TABLE I.

Mean values of orthometric measurements for each of the five dimensions, by age and sex, based on 6,829 cases from 10 study areas.

Age Groups	MALE						FEMALE					
	No. Exam'd.	P-Sn	P-Ui	Li-Ui	P-Pg	Percent Upper Face Height	No. Exam'd.	P-Sn	P-Ui	Li-Ui	P-Pg	Percent Upper Face Height
5- 7	460	19.9	31.2	3.5	31.8	47.0	426	19.5	30.2	3.5	31.0	47.1
8-10	607	19.5	30.1	4.7	31.7	47.0	646	19.1	29.0	4.6	31.0	47.6*
11-13	539	18.6	30.0	4.7	31.3	46.9	636	18.1	28.5	4.3	29.4	47.2
14-16	450	18.2	31.4	4.3	32.2	47.1	525	18.8	29.4	3.8	29.5	47.4
17-19	654	16.9	31.6	3.6	30.6	46.0	628	17.0	28.7	3.7	28.7	46.3
20-24	966	16.5	31.9	3.6	30.4	46.1	292	16.3	28.0	3.6	28.4	46.1
24 and under	3,676	18.0	31.1	4.0	31.2	46.6	3,153	18.2	30.0	4.0	29.7	47.0

*The average is based on 645 cases because the reading for one case was not recorded.

TABLE II.

Average values for upper face and total face height for males and females, by age, (based on 6,829 cases from 10 study areas).

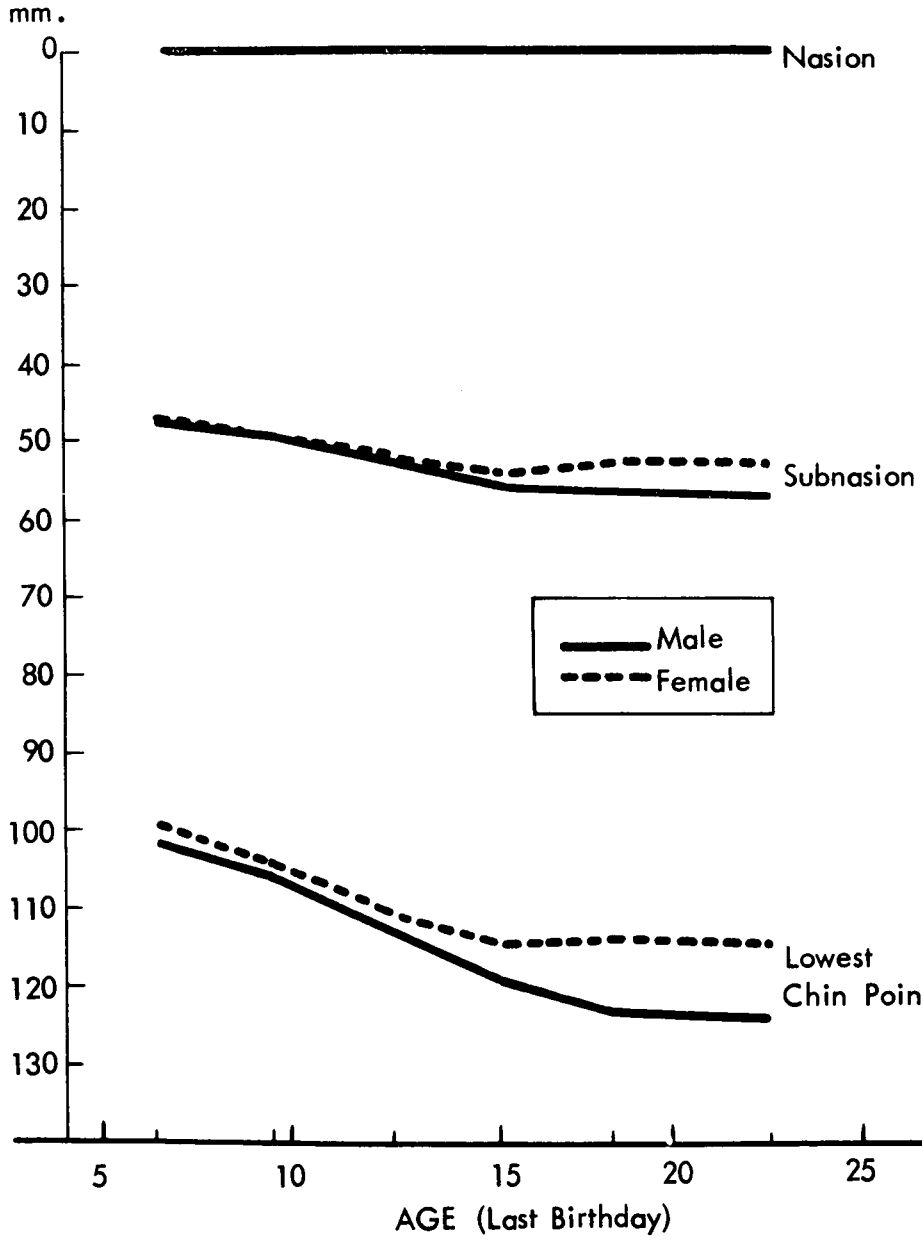
Age Groups	MALE			FEMALE		
	Number Examined	Total Face Height (mm.)	Upper Face Height (mm.)	Number Examined	Total Face Height (mm.)	Upper Face Height (mm.)
5- 7	460	101.5*	47.7	426	99.1	46.7
8-10	607	105.7**	49.7	646	103.9	49.5***
11-13	539	112.5	52.8	636	110.6	52.2
14-16	450	119.1	56.1	525	114.9	54.5
17-19	654	123.2	56.7	628	114.0	52.8
20-24	966	124.0	57.2	292	114.1	52.6

*This average is based on 459 cases.
**This average is based on 608 cases.
***This average is based on 645 cases.

Figure 5.

AVERAGE VALUES FOR UPPER FACE AND TOTAL FACE HEIGHT

For Males and Females - By 3 Year Age Interval
(Based on 6,829 Cases from 10 Study Areas)



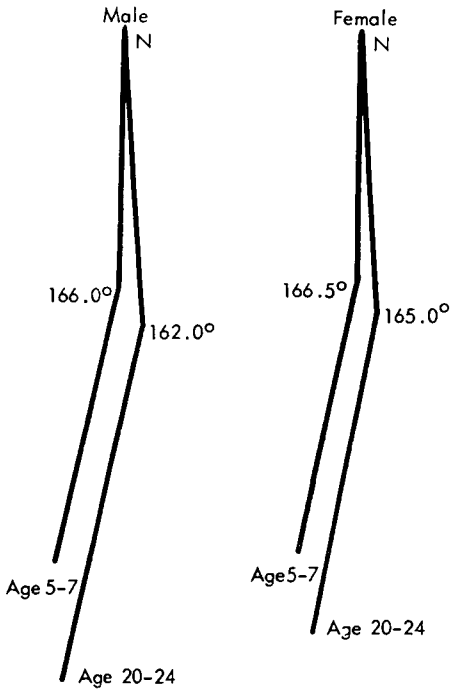


Fig. 6. Illustration of the changes, with age, in the convexity of the facial profile. The angular readings are noted at the position of subnasion (Sn). In the determinations, pogonion (Pg) was arbitrarily plotted at the level of the lowest chin point (LCP).

that in the male the upper incisor falls back an average of 1 mm. in relation to nasion and the facial profile. In females, on the other hand, the upper incisors come forward in relation to nasion but the forward movement is not as great as at the other two facial landmarks. Thus the position of the anterior teeth fails to keep up with the forward movement of the facial profile of females.

Discussion

It appears that two points of view exist concerning facial growth of males. One view holds that while the face grows downward and forward in relation to the cranial base, there is a marked stability and constancy of the individual pattern. The other contends that with growth the mandible becomes more prognathic than the maxilla and therefore the concept of a proportionate relationship between vertical dimension and depth of the face is in error.

Any information which helps to decide which of the two points of view is correct can have great practical value to orthodontics. If the constancy of the pattern viewpoint is correct, one cannot expect much change in facial appearance, without treatment. On the other hand, if the concept of advancing mandibular prognathism is correct, one may expect some facial change without treatment.

From the data presented on nearly 7,000 individuals from ages 5 through 24 years it apears that facial prognathism does increase with maturation. Consistent but slight changes, as shown by the average values, suggest that facial appearance of certain individuals may be favorably or unfavorably influenced by the forward growth of the upper and lower jaws during the time the face is elongating.

The curves for maxillary prognathism exhibited a remarkably close parallelism between males and females. On the other hand, mandibular prognathism showed practically no change for males while females showed a more positive trend toward increase in prognathism with maturation.

It is also of interest to note that at age 6 the mean vertical dimension of the face is similar in males and females but at age 15 the female face ceases to elongate while in males the plateau is not reached until age 18. Thus the female face is relatively shorter than the male's and yet exceeds it slightly in mandibular prognathism suggesting that the mature female face may appear more prognathic than the male face.

The findings in this study do not fully corroborate the findings of any of the previous investigations. Thus it is not

possible to support either of the aforementioned conflicting opinions. With a considerably smaller forward movement of the lower face in both sexes as compared to that of the upper face, there is no evidence to substantiate a stability or constancy of the facial pattern. Furthermore, within this sample, there is no evidence for the reduction, with age, of the convexity of the male facial profile as noted by Bjork and Lande. In fact, just the reverse is exhibited; the convexity of the facial profile of both sexes seems to increase slightly with age. However, it must be noted that Bjork and Lande based their conclusions on measurements taken in reference to skeletal landmarks. The measurements in this investigation were related to soft tissue landmarks overlying the skeletal foundation.

The evidence presented here indicates that the basic facial pattern does change between the ages of 6 and 24. However, it is questionable whether the specific site of the changes can bring about an esthetic improvement in the facial profile. It is commonly accepted in the orthodontic world that a straightening of the facial profile constitutes an aesthetic improvement. The trend, as noted in this investigation, would indicate that, by becoming more convex, the facial profile does not improve with age.

Summary and Conclusions

1. Facial profile measurements of 6,829 subjects have been presented. The sample included 3,676 white males and 3,153 white females in the 5 to 24 years age range.
2. The mean value of these measurements indicates an increase in facial prognathism with advancing age. The increase in mandibular prognathism was greater in females than in males. In both sexes, the increase in prognathism in the lower jaw region was not as great as that noted in the upper jaw region.
3. Thus, judging from mean values, the maxillae and mandible appear to come forward at unequal rates, with respect to nasion. With the maxilla coming forward to a greater degree than the mandible, it is reasoned that the convexity of the facial profile increases with age in both sexes. Furthermore, the average male in this study did not exhibit the reduction in the convexity of the facial profile of the Bjork and Lande samples.
4. If this is true, then it may not be hopeful that the facial profile will straighten with growth. According to these data, this deduction may apply with greater force to the average male than to the average female. This finding suggests that the practicing orthodontist can not hope that the average profile of either sex will improve with age without orthodontic intervention. The great number of other investigations being carried out, at this time, in the field of facial growth and development will probably shed further light on this subject.
5. Other determinations in this study were found to be consistent with the findings reported in the literature.

Washington, 25

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