Variations Of The Craniofacial Skeleton In Postadolescent Males And Females

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Normal sex differences in the size and relationship of facial components tend to increase with age. Most often it is with the onset of puberty (Stern) that male-female variations in general body growth and proportions, as well as in the relative growth of specific parts of the craniofacial skeleton, begin to develop most noticeably. These secondary sex differences are of particular diagnostic interest to the orthodontist, whose therapeutic efforts are usually carried out during late childhood or early adolescence, and are thus completed long before mature facial contours have been achieved.

In order to more fully investigate the extent of sex differences in the adult, several dimensions of the face and skull were measured in a group of postadolescent male and female subjects in whom growth was essentially complete.

Method and Materials

Data for depth, height and angular relations of the skeleton were obtained from lateral cephalometric tracings of 100 males and 100 females. Criteria for selection of a subject in this study were: (1) Caucasian, age 20-30, (2) Class I dental occlusion with good alignment of teeth, (3) no prior orthodontic treatment, (4) excellence of the x-ray film*. Measurements to the nearest 0.5 mm or one-half degree were taken of the following 7 linear and 3 angular dimensions: (Figure 1)

1. Nasion-sella (n-s): the anterior cranial base.
2. Nasion-gnathion (n-gn): total face height.
3. Nasion-Ans': upper face height. Ans' is the point of intersection of a perpendicular from anterior nasal spine to the line n-gn.
4. Ans'-gnathion: lower face height.
5. Chin length: the distance between the point of intersection of a perpendicular dropped from Downs' B point to the mandibu-

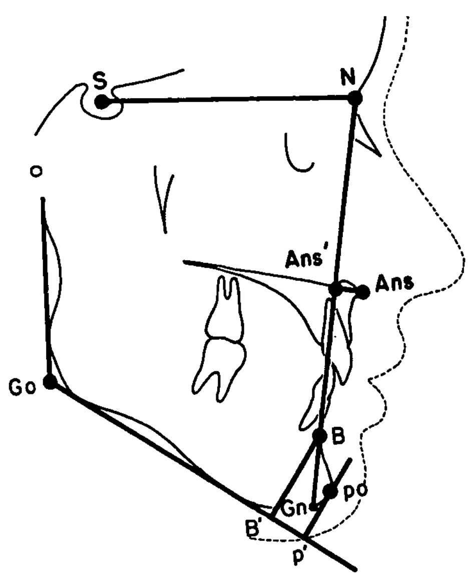

Figure 1. Reference points used.

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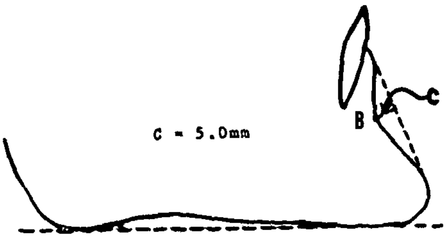
* The head plates were selected from a large number of films accumulated as part of a continuing study which has been in progress for several years in the Division of Orthodontics, School of Dental and Oral Surgery, Columbia University under the supervision of Dr. Clifford L. Whitman.



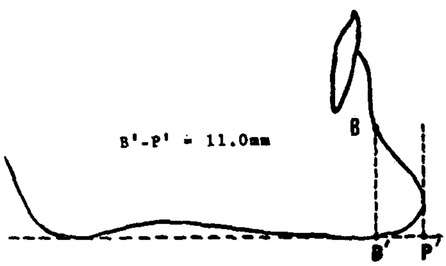


Figure 2a. Measurement ("C") proposed by Meredith (1957) for the "Anterior concavity of the mandible".

Figure 2b. The linear dimension B'-p' is the complement of "C".

lar plane (B'), and the point of intersection of a perpendicular tangent to the most anterior point on the chin with the mandibular plane (p').

This dimension (B'-p') is the complement of a measurement proposed by Meredith (1957) for the "anterior concavity of the mandible" (Fig. 2a). The B'-p' diameter is larger and somewhat easier to measure than the anterior concavity and this tends to minimize the impact of measurement error (Fig. 2b).

6. Gonion-B': mandibular length (minus the c h i n dimension). Gonion is the point of intersection of a line tangent to the posterior border of the ascending ramus and the mandibular plane.
7. Overbite: measured as the difference between n-incisal tip of $\underline{1}$ and n-incisal tip of $\overline{1}$.
8. Angle s-n-pogonion.
9. Angle s-n-B'.
10. Gonial angle: formed by the mandibular plane and a line tangent to the posterior border of the mandible.

Except as noted below, differences between the mean values observed for each of the measurements in the 100 males and the corresponding values for the 100 females were tested for statistical significance with a Normal Curve Test; the F ratio was used to test the variability of each measurement in relation to sex; correlation coefficients were computed for several pairs of measurements. In all instances the confidence interval for determining statistical significance was 95%.

Results

On the basis of generally larger stature it is expected that male values would exceed those of females and this proved to be so in most cases. The gonial angle is an exception, as the female mean value is 2.7 degrees larger than that of the males. These data confirm earlier reports on sex variation in the gonial angle (Hrdlicka, Izard, and Hellman, reviewed by Jensen and Palling, 1954) (Braun and Schmidt, 1956).

Differences in male-female mean values for all of the other dimensions studied are statistically significant (Table I) except for overbite and angle s-n-po. It will be recalled that when comparisons are made between mean values there is an assumption that the measurement series, when grouped, will be similar to a normal distribution curve. Nine of the dimensions studied approached normality in distribution pattern. Measurements of the tenth (the bony chin dimension B'-p') were not normally distributed, however, and are discussed separately below.

Although there is a tendency in both

TABLE I

The ranges, means, differences between means, standard deviations and F ratios.

Measurement	Range Males	Range Females	Mean Males	Mean Females	Difference Between Means	S.D. Males	S.D. Females	F Ratio
s-n	70-90	63-83	79.2	73.2	6.0*	4.10	3.60	1.29
n-gn	116-151	104-141	136.0	125.6	10.4*	7.08	6.24	1.29
n-ans'	52-68	46-66	59.4	55.2	4.2*	3.42	3.14	1.19
ans'-gn	57-90	58-85	76.5	70.5	6.0*	5.67	5.16	1.19
go-B'	68-96	60-83	79.8	72.9	6.9*	5.88	4.86	1.46*
Angle s-n-po	74-90	70-94	82.2	81.4	.8	3.52	4.12	1.37
Angle s-n-B'	67-83	66-87	76.2	74.8	1.4*	3.46	3.90	1.27
Gonial Angle	106-140	112-136	122.2	124.9	2.7*	6.90	5.91	1.36
Overbite	1-6	1-6	3.8	3.7	.1	1.31	1.35	1.06

* Signifies P of .05 or less.

sexes for variation in most of the linear dimensions studied (s-n, n-gn, n-ans', ans'-gn, go-B') to increase as the mean measurement increases, only one variance ratio (go-B') was found to be statistically significant at the 5% level. This is partly due to the relatively lower female standard deviation obtained for this dimension and may also be related to the similarly lower female S.D. found in the gonial angle measurement.

Values for angles s-n-po and s-n-B' were of interest in that female variability exceeded that of males. Although males showed slightly larger mean measurements in both angles, the male-female difference was significant only for s-n-B'. Differences in mandibular position plus the compensating effect of sex differences in the bony chin appear to be contributing to this lack of between-sex variation in angle s-n-po.

Total correlation coefficients for the several pairs of variables investigated were calculated and are presented in Table II. While a number of the *r* values obtained differ significantly from zero, none are high enough to warrant special comment. In general, the correlations fall within the limits reported in similar studies of craniofacial morphology.

When ranges of the various series of measurements are considered in relation to sex, some overlapping is to be expected. That is, some females are likely to be smaller than any of the males and some males larger than any females. The lower face height dimension (Ans'-gn) is an exception to this expected pattern as the entire range for the females falls within the male range and no skewing is apparent. The male mean value is significantly greater in this case. An almost reverse situation occurs in the gonial angle measurement, where the entire female range of values falls within the extremes of the male distribution and the female mean is significantly larger than that for the males.

The Bony Chin

The chin process (B'-p') of the mandible plays an important role in facial esthetics. This dimension differs from the others studied in that the ranges for males and females are nearly the same at the lower limit, but quite dif-

TABLE II

Correlation coefficients for measurements of pairs of linear and angular dimensions.

	n-ans'		ans'-gn		B'-p		go-B'		s-n-po		s-n-B'		Gonial		Overbite	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
s-n	.13	.43	–.01	.16	.24	–.13	.22	.27	–.01	–.21	–.05	–.18	–.02	.21	.04	.07
n-gn					.40	.07	.03	.14	–.50	–.26	–.56	–.26	.14	.14	.40	.08
n-ans'			.15	.12	.23	.02	.11	.11	–.35	–.41	–.35	–.41	–.01	.08	–.22	.15
ans'-gn					.36	.19	–.06	.25	–.41	–.23	–.49	–.22	.23	.03	–.34	–.27
B'-p'							–.19	–.10	–.07	.16	–.30	–.03	.21	.23	–.24	.01
go-B'									.37	.33	.39	.37	–.64	–.51	.07	–.11
Angle s-n-po													–.21	–.16	.13	–.23
Angle s-n-B'													–.29	–.33	.20	–.24
Gonial angle															–.17	.00

Since correlations of s-n-B' with s-n-po and n-ans' or ans'-gn with n-gn all represent correlation of part of the structure with the whole and are difficult to interpret, they have been omitted.

In testing the correlation coefficient against 0, the 95% confidence interval includes r values between –.196 and +.196.

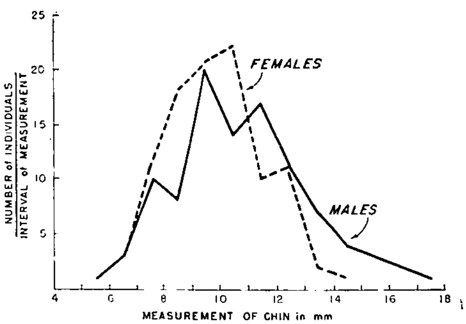


Figure 3. Distribution of measurements of the bony chin (B'-p') taken from the tracings of 100 male and 100 female white adults age 20-30.

ferent at the upper end of the distribution (Fig. 3). The impression gained is that of an irreducible minimum for normal bony chin size regardless of sex. In the population studied, very large chins appear to be characteristically male attributes.

As the frequency distribution of male values (and to a lesser extent the female values) are skewed and do not approximate a normal distribution curve the differences in this case were subjected to a Chi Square Test. This provides a measure of the association between sex and measurements falling above and below the median value for the two groups combined (Table III). Assessment* of the approximation of the observed measurements indicates that the departure from normality is statistically significant (Table IV).

Age variations in chin contour are apparent in an illustration contained in the *Natural History of the Human Teeth* (Fox, 1803), although no mention of this is made in the text (Fig. 4). The illustration is similar to an even older one which appears in John Hunter's classic work (1771) and was probably inspired by the earlier drawing. Bolk (1924) concluded from his studies of the human mandible that the critical period in chin "metamorphosis" from *mesiogeniotisch* (straight chin) to *eugeniotisch* (well developed chin) occurred at the beginning of the second dentition. In a longitudinal study, Meredith (1957) found a measurable increase in the "anterior concavity" of the mandible

* The g1 and g2 statistics (Snedecor) were used to determine skewness and kurtosis.

TABLE III

The range; the median, 1st and 3rd quartile values for measurements of the chin.

	Range	Median	1st Quartile	3rd Quartile
Males	6.0-17.5	10.6	9.20	12.27
Females	5.5-14.0	9.8	9.55	10.95
Males and Females	5.5-17.5	10.14	8.85	12.86

TABLE IV

The distribution of chin measurement values above and below the median of the combined series of male and female values according to sex.

	Males	Females	Total
Below Median	43	57	100
Above Median	57	43	100
Total	100	100	100

Chi Square Value = 3.92 ($P < .05$) 1 d.f.

between 4 and 14 years of age. The contribution of the chin process to the prominence of the lower facial profile thus tends to increase with age.

The lower jaw may be considered as a complex composed of several components (Washburn 1951, Garn 1962). Different regions of the mandible (Figures 5a and 5b), including the chin, appear to vary independently of one another. It has been shown elsewhere (Horowitz, Osborne and De George, 1960; Horowitz, In press) that the length of the adult chin, particularly, is affected by sex-influence as well as specific genetic factors.

Finally, the protrusive chin is a unique human attribute which serves to distinguish man from not only his closest primate relatives but also from most of his hominid ancestors as well. In view of the finding that sex differences in the anterior portion of the mandible are not significant in childhood (Meredith), it appears that the emergence of the chin through remodeling in later adolescence parallels the development of other secondary sex characteristics.

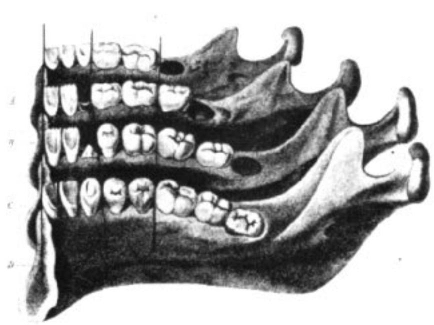
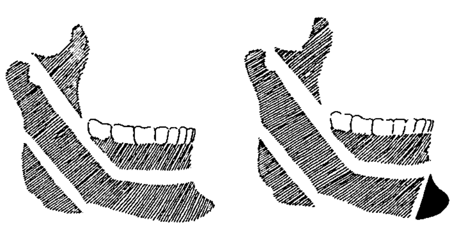


Figure 4. Increase in the prominence of the bony chin from the stage of the deciduous dentition through adulthood. (from Fox, 1803)



A B

Figure 5a. Regions of the lower jaw which vary independently. (after Washburn, 1951)

Figure 5b. The bony chin is also an independently varying component of the mandible.

Summary

1. Mean values obtained from cephalogram tracings of 100 males and 100 females age 20-30 with untreated Class I occlusion are presented.

2. The dimensions obtained for males are generally larger than those for females except for gonial angle size.

3. Correlation coefficients calculated for several pairs of variables are presented.

4. Both the age of the subject and the parameter under study assume importance when investigating sex differences in craniofacial morphology.

5. These data suggest that the chin process varies independently of the tooth bearing portion of the mandible.

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References

Bolk, L. 1924 Die Entstehung des Menschenkinnes, Vehandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam 23: 106.

Braun, M. and Schmidt, W. 1956 A Cephalometric Appraisal of the Curve of Spee in Class I and Class II Division I Occlusions. *A. J. Ortho.* 42: 255.

Fox, Joseph 1803, *Natural History of the Human Teeth,* London, Cox.

Garn, S. M. 1961 Research and Malocclusion *A. J. Ortho.* 47: 661.

Horowitz, S. L., Osborne, R. H. and DeGeorge, F. V. 1960 A Cephalometric Study of Craniofacial Variation in Adult Twins *Angle Ortho.* 30: 1.

Horowitz, S. L. Some Clinical Aspects of Genetic Research in Dentistry *J. D. R.,* 42: supp to No. 6, 1330, 1963.

Hunter, John *The Natural History of the Human Teeth* London, J. Johnson 1771.

Jensen, E. and Palling, M. 1954 The Gonial Angle *A. J. Ortho.* 40: 120.

Meredith, H. V. 1957 Change in the profile of the osseous chin during childhood *A. J. Phys. Anthro.* 15: 247.

Snedecor, G. W. 1956 *Statistical Methods Applied to Experiments in Agriculture and Biology.* 5th Edition Ames, Iowa State College Press.

Stern, C. 1960 *Principles of Human Genetics,* San Francisco, W. H. Freeman.

Washburn, S. 1951 The New Physical Anthropology *Transactions New York Academy of Sciences,* Series II 13: 298.