Craniofacial Variations, Sex Differences and the Nature of Prognathism in Chinese Subjects

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Introduction

In a previous paper[1] the craniofacial profile of the Chinese subjects was studied with particular reference to some of the factors influencing prognathism. In order to elucidate the nature of the variations in prognathism, other craniofacial structures such as facial height, depth and length of the jaw bases, etc., would have to be considered.

Björk[2,3] placed much emphasis on the variations of the cranial base on the degree of prognathism in individuals within a population group and suggested that the length of the jaw bases were only secondary considerations. The results of this investigation, however, indicated only a minor association between the lengths of the cranial base and prognathism. It appears, therefore, that the part played by the length of the jaw bases may assume a more important role in individual variations in prognathism than suggested by Björk.

It should be indicated, however, that the relationship between cranial base and facial prognathism is probably much more complex than suggested by the results of correlation analysis and no precise association could be conclusively determined. Furthermore, various craniofacial structures combine in different ways to influence prognathism and the general morphology of the face.

This investigation therefore analyzes the relationship between the angles of prognathism and other craniofacial variables and, in particular, the sizes and orientation of the jaw bases.

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Methods and Materials

The sample studied consisted of eighty-four male and twenty-three female adult Chinese subjects. The sample and the roentgenographic cephalometric techniques have been described.[1]

The variables selected for study are classified into the following groups:

(1) Facial heights.
- Morphological face height (n-gn)
- Maxillary upper face height (n-sp)
- Maxillary lower face height (sp-pr)
- Maxillary alveolar length (ss-pr)
- Maxillary face height (n-ss)
- Mandibular lower face height (id-gn)
- Posterior upper face height (s-pm-V)
- Mandibular ramus height (ar-tgo)

(2) Facial depth and mandibular angular measurements.
- Maxillary jaw base length (ss-pm)
- Maxillary protrusion (s-pm-H)
- Total mandibular base length (pg-ar)
- Mandibular corpus length (pg-tgo)
- Projected mandibular body length (tgo-tgn)
- Chin angle (CL/ML)[4]
- Gonial angle (ar-tgo-gn)

(3) Incisal inclination measurements.
- Upper incisor inclination (ILs/NL)[4]
- Lower incisor inclination (ILi/ML)[4]
- Interincisal angle (ILs/ILi)[4]
- Overbite
- Overjet

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(4) Inclination of the jaw bases.
NSL/NL
NSL/ML
NL/ML
ML/FH
NL/OL
NL/ESL

Unless otherwise stated, the cephalometric reference points and lines follow those described by Lindegard[5] and reported previously by Wei.[1]

Results

The arithmetic means and the standard deviations were calculated for each variable. The sex differences were tested statistically using the Students "t-test" with 105 degrees of freedom and the results are listed in Tables 1 to 3. The values of "t" and the probability levels of the significant sex differences are shown.

The relationships between the maxillary and mandibular jaw bases and with the cranial and facial reference lines were investigated by obtaining angular measurements; the results are shown in Table 5.

Facial polygons, based on the mean values of the above variables, were constructed in order to compare the essential sex differences between the male and female subjects studied. These are shown in Figure 1.

To investigate the relationship between the various components of facial height and depth, correlation analyses were performed with the results shown in Tables 6, 7, and 8. In addition, the correlations between the angulation of the jaw bases and other facial measurements were calculated and summarized in Table 9. The correlations between the maxillary and mandibular angles of prognathism and other craniofacial variables are shown in Tables 10 and 11, respectively.

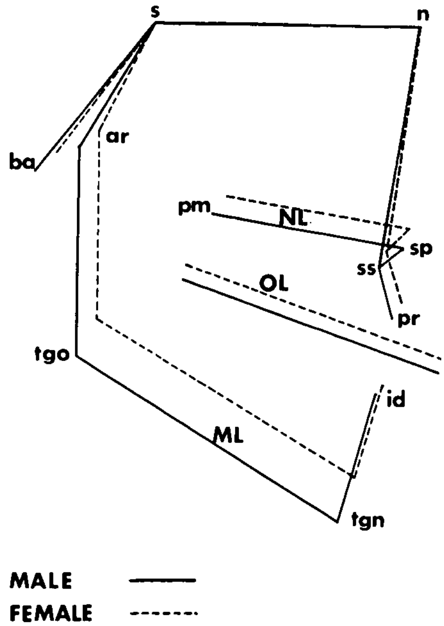

Fig. 1 Comparison of mean facial outlines of male and female subjects.

Discussion

Tables 1 and 2 show that most linear measurements were significantly greater in the male than in the female Chinese subjects. This was in agreement with most previous studies and in accord with the explanation that male subjects generally have a longer period of active growth compared to the females.[6]

The angular measurements (Tables 2, 3, 5), however, did not reveal any marked differences between the sexes. This result confirmed the general conclusions of previous investigations[6-8] which showed that, despite sex differences in linear dimensions, the facial shape and proportions of male and female subjects within an ethnic group were remarkably similar.

In addition, judging from the range of variations, the standard deviations, and the coefficients of variation which were calculated but not included in the tables, the males were generally more variable than the females. This lesser degree of variability in the females

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Facial height dimensions are recorded in mm for 84 male and 23 female Chinese subjects. Values of 't' and the probability levels of the significant sex differences are shown.

VARIABLE	SEX	MEANS	s	RANGE	't'	P
n - gn	M F	122.2 113.7	6.0 4.7	106.3-139.8 106.3-121.7	6.24	<0.001
n - sp	M F	54.7 49.5	2.6 2.5	47.5- 61.5 45.6- 54.0	8.58	<0.001
sp - pr	M F	15.7 15.9	2.7 1.9	7.4- 21.9 12.5- 18.6	0.35	n.s.
id - gn	M F	32.1 29.2	3.0 2.2	25.1- 40.5 24.7- 33.5	4.50	<0.001
s - pm - V	M F	46.1 42.0	2.7 2.1	41.0- 55.9 38.2- 44.7	6.87	<0.001
ar - tgo	M F	51.0 46.0	5.2 5.0	38.7- 67.1 34.5- 53.6	4.17	<0.001
n - ss	M F	60.4 55.6	2.7 2.3	53.1- 66.2 51.2- 60.1	7.82	<0.001
ss - pr	M F	11.2 11.1	2.2 1.7	6.0- 17.7 8.3- 14.4	0.24	n.s.

n.s. - not significant

Table 1

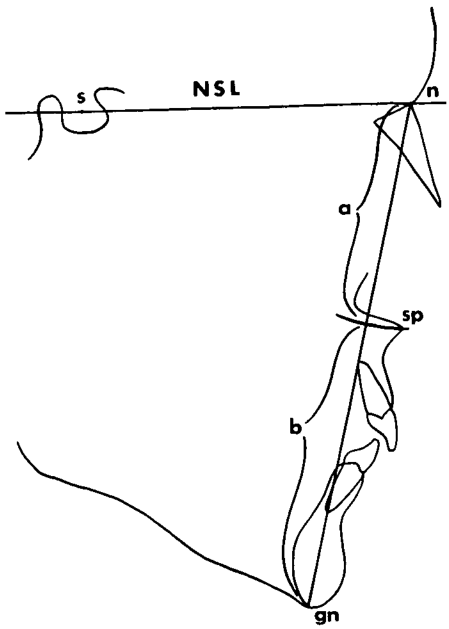

Fig. 2 Facial Height Proportions.

could be related to the earlier onset of puberty and earlier attainment of skeletal maturity compared with the males.

Each group of craniofacial variables is discussed in more detail in the following sections.

Facial height measurements (Table 1).

All but two facial height measurements showed decisively greater mean values in the males than in the females, the difference being statistically significant at the $p<.001$ level. This applied to both maxillary and mandibular components of the total facial height. However, the variables sp-pr and ss-pr showed no sex difference in mean values.

The proportions of facial height dimension have been studied by a number of investigators (Fig. 2). The general conclusion was that the proportion of upper face height (n-sp) to the morphological face height (n-gn) remained relatively stable from 43 to 45 per cent regardless of age, sex, ethnic groups[7,9,10] or tooth attrition.[11] This was not confirmed by Meredith *et al.*[12] who used different measurements. Hixon[13] suggested the adoption of an index a to b rather than a to a+b (see Fig. 2). He found that this index changed with age. Recently, Brown and Barrett[8] also questioned the validity of this concept but reported that, while the mean values of the female Australian aborigines fell within the specified range at 43.6%, the mean value of the male ratio was lower (41.4%).

In the Chinese, the proportion of upper face height to total face height using the mean values of n-sp and n-gn for the male and female subjects were 44.76% and 43.44%, respectively, for the total sample. The ratios were almost identical to the mean values of 44.2% and 43.5% in the male and female crania in North American Indian skulls reported by Sarnas.[7] This result therefore confirmed the stability of the range of variation of the n-sp/n-gn ratio in different populations.

Facial depth measurements (Table 2).

The sex differences in total mandibu-

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Facial depth dimensions and mandibular angles are recorded in mm and degrees respectively for 84 males and 23 females. Values of 't' and the probability levels of the significant sex differences are shown.

VARIABLE	SEX	MEAN	s	RANGE	't'	P
ss - pm	M F	44.2 42.6	2.6 2.6	37.3- 50.3 38.7- 47.5	2.58	<0.01
s-pm-H	M F	12.9 12.7	3.7 3.3	2.7- 20.9 6.9- 18.1	0.29	n.s.
pg - ar	M F	106.1 100.3	5.4 5.0	93.2-117.5 91.8-108.6	4.59	<0.001
pg - tgo	M F	73.9 72.4	5.1 4.5	55.9- 85.3 65.2- 80.2	1.27	n.s.
tgo - tgn	M F	75.4 74.0	5.7 4.6	49.4- 88.1 66.2- 82.0	1.08	n.s.
Mandibular angles CL/ML	M F	75.9 75.9	4.9 4.8	60.0- 85.0 68.0- 88.5	0.10	n.s.
ar-tgo-gn	M F	120.7 120.4	7.4 6.6	97.0-139.5 108.0-131.5	0.19	n.s.

n.s. - not significant

Table 2

lar length and mandibular ramus height in the Chinese subjects were greater than the sex differences in upper facial dimensions of maxillary base length and posterior upper face height. It was surprising, however, to find that there was no significant sex difference between the mandibular corpus length as shown by both measurements pg-tgo and tgn-tgo. Nevertheless, the mean values of the male group exceeded the females by about 1.5 mm in both the above distances.

The conclusions, therefore, were that there was a general tendency for the males to show a greater lower face development than the females especially in the vertical and diagonal directions. The sex difference in the mandibular corpus length, that is horizontal direction, was much smaller.

A possible explanation for these findings lies in the mechanisms of mandibular growth. The active growth of the mandible by surface apposition along its entire posterior border and the coronoid process usually ceases at an earlier age than condylar growth, which accounts for the main increase in length of the mandibular body and the height of the ramus.[14-17] The earlier onset of puberty and subsequent earlier cessation of skeletal and condylar growth in the female would partly explain the reported sex differences in mandibular dimensions.

Incisal inclination measurements are recorded in degrees for 84 male and 23 female Chinese subjects. Values of 't' showed that none of the sex differences are statistically significant.

VARIABLE	SEX	MEAN	s	RANGE	't'
ILs/NL	M F	118.8 118.7	7.5 4.7	102.0 - 135.0 109.5 - 127.5	0.07
ILi/ML	M F	93.5 94.9	7.3 7.3	78.5 - 118.5 83.0 - 113.5	0.79
ILi/ILs	M F	124.1 122.5	11.4 8.0	96.5 - 157.0 111.0 - 138.0	0.60
Overbite	M F	1.8 1.4	1.9 0.9	-5.1 - 6.0 0.5 - 2.7	0.75
Overjet	M F	2.4 2.6	2.2 1.2	-4.1 - 8.3 0.5 - 5.5	0.28

Table 3

The mean values for both the chin angle and the mandibular gonial angle were almost identical in males and females. This confirmed the sex similarity in lower facial shape.

Incisal inclination measurements (Table 3).

None of the sex differences in incisal inclinations were statistically significant indicating a close similarity in profile denture patterns in the males and females. The angle of upper incisor inclination was almost the same in both sexes but the lower incisors were slightly more proclined in the females than in the males.

The interincisal angle measured the procumbency of the incisor teeth. The more prognathic tendency in the female was probably partly related to the smaller interincisal inclination angles (ILs/ILi) in the females (122.5°) compared to the males (124.1°).

The results of the present study were similar to those reported by Hong[18] who

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also compared the procumbency of incisors in the Japanese and Caucasians by using the Downs analysis. Other population groups including Swedes and Australian aborigines are listed in Table 4 for comparison. It can be seen that the proclination of the lower incisors to the mandibular line was least in the American whites, followed by the Chinese, Japanese and Australian aborigines in that order. The prominent proclination of the lower incisors in the Australian aborigines was obviously related to the marked bimaxillary alveolar prognathism of that group.

The mean interincisal inclination angles were largest in the Caucasians reported by both Björk[2] and Downs.[19] A large interincisal angle meant a relatively upright incisor profile. The Chinese possessed the next largest angle followed by the Japanese and Australian aborigines. The female Australian aborigines had the most acute angle at 114.3° and 114.5° as reported by Craven[20] and Brown,[6] respectively. The marked alveolar prognathism associated with a convex denture profile was clearly seen in the Australian aborigines.

The intragroup variations as judged by the standard deviations and coefficients of variations were great for each of the ethnic groups compared regardless of sample size. This indicated clearly that the denture arch pattern was subject to great intragroup variations.

Inclination of jaw bases and reference lines (Table 5).

From Table 5 it can be seen that the male and female mean values for the inclination of NSL or ESL to NL were almost identical. All the other mean values, including the mandibular and nasal line inclinations, showed higher mean values in the females than in the males. The sex difference was greatest in the angular relationship between ML and NL at 2°. This indicated a slightly more angular profile in the females; however, none of the differences between the sexes were statistically significant. This result confirmed the observation that, although the males exceeded the females in linear dimensions, the two sexes showed a marked similarity in shape and facial profile (see Fig. 1) due to the relative genetic homogeneity within the same ethnic group.

Correlation analyses

The various facial height and depth measurements were relatively poorly correlated. From the combined results in Tables 6, 7, and 8, none of the significant correlations could be considered to be at a "high" level.* Fourteen pairs of variables were "moderately" correlated and seventeen were in the "low" category. The number of nonsignificant coefficients far outnumbered the significant ones and totalled 79, while another 10 were in the probably significant class ($p=0.05$). This result confirmed the concept of the independence of facial components as previously suggested by Abbie.[21,22] Other workers[23-25] have investigated this problem and emphasized that component bones which make up the craniofacial complex show great individual variation. The recent study of correlation of facial measurements in the Australian aborigines[8] gave further supporting evidence to this concept. The results of this study are also confirmatory.

The maxillary (ss-pm) and mandibular jaw base lengths (pg-tgo) were not related to any of the facial height measurements (Table 7). Furthermore, the maxillary and mandibular jaw base lengths appeared largely to vary inde-

*According to Garn (1958), significant correlation coefficients were arbitrarily classified, regardless of sign, as:

"high"	-	$r>0.80$
"moderate"	-	$0.80>r>0.40$
"low"	-	$0.40>r$

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AUTHOR	Population and Material		ILi/ML M	ILi/ML s	ILs/ILi M	ILs/ILi s	CL/ML M	CL/ML s
Present Study	CHINESE	84M	93.5	7.3	124.1	11.4	75.9	4.9
		23F	94.9	7.3	122.5	8.0	75.9	4.8
		107M + F	93.8	7.3	123.7	10.8	75.9	4.8
HONG (1960)	CHINESE	30M	-	-	-	-	69.4	5.5
		12F	-	-	-	-	70.8	5.0
		30M + 12F	93.3	5.5	123.0	8.8	-	-
KAYUKAWA (1957)	JAPANESE Adolescents	39M + F	95.3	7.4	120.8	8.1	-	-
BJORK (1947)	SWEDES	281M	-	-	137.4	11.8	64.2	6.4
DOWNS (1948)	CAUCASIANS	10M + 10F	91.4	3.8	135.4	5.8	-	-
CRAVEN (1958)	AUSTRALIAN ABORIGINES	21M	101.6	5.1	117.0	7.9	86.6	4.4
		35F	104.0	6.5	114.3	8.6	87.9	5.8
		56M + F	103:1	6.1	115.3	8.4	-	-
BROWN (1962)	AUSTRALIAN ABORIGINES	31M	-	-	124.6	9.2	85.0	4.8
		27F	-	-	114.5	8.3	86.0	5.6

Table 4 Comparison of incisal procumbency and chin angle of several population groups.

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Inclination of jaw bases to each other and to craniofacial reference lines measured in degrees. Values of 't' showed that none of the sex differences are statistically significant.

VARIABLE	SEX	MEAN	s	RANGE	't'
NSL/NL	M F	9.6 9.2	3.2 2.8	2.0 - 17.0 3.0 - 13.5	0.47
NSL/ML	M F	33.7 34.4	7.6 6.4	13.0 - 54.5 22.5 - 46.5	0.37
ML/NL	M F	24.1 26.0	7.0 5.6	9.0 - 43.0 17.0 - 40.0	1.19
ML/FH	M F	26.2 27.9	7.0 7.0	11.0 - 41.5 17.0 - 47.0	1.01
NL/OL	M F	7.4 8.7	4.0 4.0	0.5 - 17.5 2.5 - 17.5	1.42
ESL/NL	M F	6.4 6.3	4.3 2.6	0.0 - 16.5 1.5 - 10.5	0.08

Table 5

pendently of each other (Table 7), a finding also reported by Brown and Barrett.[8]

The chin angle and the mandibular gonial angle were both correlated with mandibular ramus height. A negative correlation for gonial angle indicated some interesting covariations between these three variables. Thus, the shorter the mandibular ramus height, the more obtuse the gonial angle which tended to be accompanied by a smaller chin angle.

The gonial angle was also significantly correlated with the lower face height and the total morphological face height. It appeared that both the upper

Correlation between facial height measurements for 84 male Chinese adults. The levels of significance of correlation coefficients are shown.

VARIABLE	n - sp	n - ss	sp - pr	ss - pr	id - gn	s-pm-V	ar-tgo
n - gn	+0.58**	+0.50**	+0.59**	+0.47**	+0.78**	+0.34**	-0.06
n - sp		+0.67**	+0.09	+0.04	+0.23	+0.32**	-0.05
n - ss			+0.22*	+0.18	+0.17	+0.08	-0.23*
sp - pr				+0.71**	+0.47**	+0.14	-0.17
ss - pr					+0.39**	+0.20	-0.03
id - gn						+0.23*	-0.01
s-pm-V							+0.19

** - Significant at the 1 percent level

* - Significant at the 5 percent level

Table 6

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Correlation between facial depth and mandibular angular measurements. The significant (**) and probably significant (*) correlation coefficients are shown.

VARIABLE	s-pm-H	pg - ar	pg - tgo	tgo - tgn	CL/ML	ar-tgo-gn	n - na
ss - pm	+0.02	+0.34**	+0.28*	+0.19	+0.04	-0.06	+0.09
s-pm-H		+0.37**	+0.19	+0.10	+0.15	-0.04	-0.39**
pg - ar			+0.60**	+0.37**	-0.06	+0.06	-0.10
pg - tgo				+0.55**	-0.15	-0.40**	-0.11
tgo - tgn					-0.28*	-0.24*	-0.04
CL/ML						-0.21	+0.01
ar-tgo-gn							+0.16

Table 7

Correlation between measurement of the face for 84 male Chinese adults. The levels of significance of correlation coefficients are shown.

VARIABLE	ss - pm	s-pm-H	pg - ar	pg - tgo	tgo-tgn	CL/ML	ar-tgo-gn	n - na
n - gn	+0.10	-0.04	+0.37**	+0.18	+0.20	-0.04	+0.33**	+0.34**
n - sp	+0.27*	-0.29**	+0.09	+0.08	+0.08	-0.06	+0.09	+0.65**
n - ss	+0.15	-0.21	-0.04	+0.07	+0.15	-0.07	+0.10	+0.39**
sp - pr	+0.08	-0.06	+0.11	+0.07	+0.19	+0.06	+0.22	+0.08
ss - pr	-0.15	+0.05	+0.14	+0.17	+0.18	+0.21	+0.07	+0.05
id - gn	+0.01	+0.05	+0.39**	+0.15	+0.09	+0.05	+0.35**	+0.09
s-pm-V	+0.14	+0.22*	+0.31**	+0.18	+0.09	-0.04	+0.09	+0.17
ar - tgo	+0.17	+0.33**	+0.52**	+0.26*	+0.11	+0.32**	-0.54**	-0.13

** Significant at the 1 percent level
* Significant at the 5 percent level

Table 8

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Correlation between inclination of jaw bases and some selected measurements of the face for 84 male Chinese adults.

VARIABLE	NSL/NL	NSL/ML	ML/NL	ML/FH	NL/OL
n - gn	+0.19	+0.53**	+0.49**	+0.48**	+0.16
n - sp	+0.55**	+0.31**	+0.07	+0.23	+0.19
sp - pr	-0.04	+0.40**	+0.46**	+0.34**	+0.27
id - gn	-0.03	+0.43**	+0.46**	+0.42**	-0.04
s-pm-V	-0.58**	-0.12	+0.16	+0.05	-0.17
ss - pm	+0.02	-0.18	-0.21	-0.16	-0.11
s-pm-H	-0.38**	-0.39**	-0.23	-0.21	-0.26
pg - ar	-0.20	-0.26	-0.18	-0.24	-0.54**
pg - tgo	-0.08	-0.33**	-0.31	-0.42**	-0.24
ar-tgo-gn	-0.03	+0.71**	+0.78**	+0.79**	+0.14

** Correlation coefficients significant at the 1% level probability.

Table 9

and lower anterior face height bore a direct relationship to the gonial angle in the production of facial patterns. A long anterior face height tended to be associated with a relatively more obtuse gonial angle which often coexisted with a short mandibular ramus and a short mandibular jaw base length.

Correlation of facial measurements and angular measurements between reference lines and jaw bases. (Table 9).

The angle between NL and NSL was significantly correlated with the anterior and posterior maxillary face heights at a moderate level.

The inclination of the mandibular line to the nasion-sella line was significantly correlated with all anterior facial height variables and the gonial angle (ar-tgo-gn) in a positive direction. However, the angle ML/NSL showed negative associations with the posterior face height (s-pm-V) and other facial depth variables; two of these coefficients were statistically significant. This finding suggested that a long face tended to be associated with a more angular profile with an obtuse gonial angle, shorter jaw base lengths and perhaps a shallower face.

The significant correlations between the inclination of the mandibular line to the nasal line and facial variables confirmed the above pattern. Again, very similar patterns of significant correlations existed between facial variables and the inclination of the mandibular line to the Frankfort Horizontal.

The above pattern was consistent with the clinical appearance of subjects possessing an angular profile with a long shallow face and an anterior open bite.[26] On the other hand, a squarish facial shape tended to be associated with more parallel jaw bases, short anterior face heights and an acute gonial angle together with a more solidly built mandible.

Prognathism and other craniofacial variables. (Tables 10 and 11).

Table 10 presents the probably significant and significant correlation coefficients between the maxillary angles of prognathism and other craniofacial variables, which have been subdivided broadly into facial heights, depths and jaw bases inclination measurements. Table 11 shows the corresponding results for the mandibular angles of prognathism.

Prognathism and facial heights.

Anteriorly, the upper face height (n-sp) showed a significant negative corre-

Correlations between maxillary angles of prognathism and other craniofacial variables.

VARIABLE	s-n-ss		s-n-pr	
Facial Heights	n-gn s-pm-V sp-pr ar-tgo n-ss-pg n-na n-ss	-0.22** +0.37** -0.24* +0.26* -0.30** -0.28* -0.22*	n-sp s-pm-V ar-tgo n-na n-ss	-0.28* +0.41** +0.30** -0.33** -0.29**
Facial Depths	ss-pm s-pm-H pg-ar ba-pr	+0.41** +0.61** +0.24* +0.40**	ss-pm s-pm-H pg-ar Overjet ILs/NL ba-pr	+0.36** +0.67** +0.33** +0.22* +0.30** +0.49**
Inclination of jaw bases	ML NSL NSL/NL ESL NL NL OL	-0.40** -0.50** -0.42** -0.29**	ML NSL NSL NL ESL NL NL OL	-0.41** -0.59** -0.46** -0.37**

* Significant at the 5% level probability
** Significant at the 1% level probability

Table 10

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Correlations between mandibular angles of prognathism and other craniofacial variables.

VARIABLE	s-n-id		s-n-sm	
Facial Heights	n-sp	-0.29**	n-gn	-0.27*
	s-pm-V	+0.37**	n-sp	-0.31**
	sp-pr	-0.26*	s-pm-V	+0.36**
	ar-tgo	+0.35**	sp-pr	-0.32**
	n-ss	-0.35**	n-ss	-0.39**
	n-na	-0.30**	ar-tgo	+0.39**
			n-ss-pg	-0.23*
			n-na	-0.33**
Facial Depths	ss-pm	+0.24*	ss-pm	+0.24*
	s-pm-H	+0.61**	s-pm-H	+0.58**
	pg-ar	+0.47**	pg-ar	+0.48**
	ILs/NL	+0.40**	pg-tgo	+0.22*
	ba-pr	+0.37**	ILs/NL	+0.37**
			ba-pr	+0.32**
Inclination of jaw bases	ML/NSL	-0.44**	ML/NL	-0.29**
	ML/FH	-0.23*	ML/NSL	-0.53**
	NSL/NL	-0.57**	ML/FH	-0.32**
	ESL/NL	-0.44**	NSL/NL	-0.58**
	NL/OL	-0.48**	ESL/NL	-0.44**
			NL/OL	-0.50**

* Significant at the 5% level probability.
** Significant at the 1% level probability.

Table 11

lation with the angles of alveolar prognathism (s-n-pr, s-n-id). Probably significant negative correlations existed between s-n-ss and s-n-sm and the total morphological face height (n-gn) as well as with sp-pr length. These negative correlations indicated that a prognathic build was associated with a tendency for short anterior face heights. A classic example of this could be found in the Australian aborigines.[6]

The posterior face height was measured by the distance s-pm-V in the maxilla whereas in the mandible it was represented by the mandibular ramus height. Both the angles of prognathism in the maxilla and mandible showed low to moderate significant correlations with s-pm-V and ar-tgo, with one exception. This clearly indicated that a prognathic face is related to longer posterior upper and lower face heights.

Prognathism and facial depth.

The significant correlation coefficients between the maxillary jaw base length and the maxillary angles of prognathism are worthy of note, because they showed that the jaw base length in the maxilla played a significant part in determining maxillary prognathism.

An even more interesting finding was the moderately significant correlations between maxillary protrusions (s-pm-H) and the angles of prognathism. The values of r between s-pm-H and s-n-ss, s-n-pr, s-n-id and s-n-sm were among the highest significant coefficients obtained from the whole series and were at +0.61, +0.67, +0.61 and +0.58, respectively. This meant that the position of the maxillary jaw base in relation to the sella perpendicular or in relation to the cranial base had a significant bearing on the degree of prognathism of the face, and in particular on the alveolar prognathism.

On the other hand, the mandibular corpus length (pg-tgo) did not appear to be related to the degree of maxillary prognathism. The total mandibular length (pg-ar), however, was significantly correlated with s-n-pr, s-n-id and s-n-sm to a moderate degree. Therefore it seemed that the overall size of the mandible (in contrast to its corpus length) could influence mandibular prognathism. The greater pg-ar length might be related to a longer ramus height in more prognathic faces.

The results of this investigation appeared to be in contrast to Björk's thesis on the nature of prognathism in one respect. He postulated[3] that within a population group, the variations in prognathism were more dependent on the size and shape of the cranial base and not intimately connected with the size of the jaws. It seemed that in the Chinese male subjects studied in this investigation, the jaw base lengths were important factors in influencing the degree of prognathism. A possible explanation might be offered in that slightly different landmarks were used in the two studies. Björk selected s-n-sp and s-n-pg to represent maxillary and mandibular basal prognathism, whereas the landmarks which showed a greater variation between ethnic groups, s-n-ss and

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s-n-sm, were used in the present study. Similarly, Brown[6] obtained a significant correlation between s-n-ss and ss-pm, the value of r being +0.46. That the maxillary jaw base length was an important factor in determining the degree of prognathism within a population group received further support from the investigation of Knowles[27] who studied the influence of cranial base morphology on the orientation of the middle third of the face.

It was of further interest to investigate the correlation between the cranial base length, angulation and the maxillary protrusion. The results of these correlation coefficients are as follows:

s-pm-H with n-s (+.35), with n-s-ba (—.50), and with n-s-ar (—.39).

The negative significant correlation coefficient between n-s-ba and s-pm-H appeared to suggest that the deflection of the cranial base and the subsequent reduction in the cranial base angulation might produce a maxillary protrusion resulting in a forward displacement of the maxillary jaw base which in turn was related to a higher angle of prognathism.

Inclination of Incisors and Jaw Bases

The significant correlation between ILi/NL with s-n-pr could easily be visualized. It was more interesting, however, to note the significant correlations of ILi/NL with the mandibular angles of prognathism. It might be postulated that some kind of compensating mechanism in the mandibular alveolus probably operated in company with the procumbent maxillary incisors so that the greater maxillary alveolar prognathism was compensated by a greater alveolar development in the mandible so that a more harmonious sagittal anterior bite relationship could be established.

The angles of prognathism were significantly correlated in the negative direction with nearly all the jaw base inclinations to each other and to the craniofacial reference lines. The general negative trends indicated that a prognathic face was related to more parallel jaw bases angulations which would result in more square craniofacial outlines.

Conclusions

1. Males were significantly greater than females in nearly all linear dimensions.
2. No significant sex difference was found in angular measurements indicating a close resemblance of craniofacial shape in male and female Chinese subjects, as in other population groups.
3. The ratios of upper face height/morphological face height of male and female Chinese subjects conformed to a constant of between 43 to 45%.
4. Males exhibited a slightly greater lower face development than females.
5. The denture patterns in the Chinese, as in other populations, appeared to be subject to great intragroup variations.
6. Correlation analyses confirmed the independent character of craniofacial components.
7. It was shown that the size of the maxillary jaw base and the degree of maxillary protrusion were important factors in influencing prognathism within the Chinese males. This result did not confirm Björk's suggestion that the sizes of the jaw bases were not important factors in determining intragroup variations in prognathism.
8. The influence of cranial base deflection on prognathism was probably closely related to the degree of maxillary protrusion produced.

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9. Total correlation tests revealed that a prognathic face tended to be associated with a combination of the following factors:
   Short anterior upper and total face height
   Long posterior face height and long ramus height
   Long maxillary jaw base length
   More pronounced maxillary protrusion
   More parallel jaw bases and reference lines
   More square craniofacial outline.
10. Further research using multivariate analyses would help to clarify the above findings and provide a more comprehensive understanding of the relative importance of various factors in the complex interaction of craniofacial variables and their contribution to morphology.

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