

CRANIOFACIAL MORPHOLOGY OF PREHISTORIC POLYNESIANS AND THAIS

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*This study compares metrical data for craniofacial morphology in prehistoric populations from Polynesia and Thailand. We measured 71 skulls (35 Polynesian and 36 Thai) and 87 mandibles (36 Polynesian and 51 Thai) directly. Lateral X-rays of 61 of the skulls were used for analysing the shape of the cranial base and nasopharyngeal airways. Xerox photocopies of the superior outline of the mandibular condyle were used to assess the condylar angulation. The statistical significance of intergroup and intersex differences was tested with Student's *t*-test for unpaired observations.*

All distances, except nasal width, nasopharyngeal length and intermaxillary dental relationship, were significantly smaller in females than in males. The most significant intergroup differences were found in the skull and upper face. The Polynesian head, nose, and maxillae were narrower than in the Thais.

The intergroup difference in the width of the nasal aperture is in agreement with the hypothesis that nose shape reflects adaptation to climate. Using a different definition of cranial base shape from that of earlier studies we were able to speculate on the concepts of the Polynesian cranial base form.

INTRODUCTION

The distinctive gross anatomy of Polynesian people has been a focus of interest, particularly as a model for the adaptive significance of the human body form (Houghton 1990, 1991a, 1991b). Some of the most characteristic features of the Polynesians are within their craniofacial frame (Houghton 1978; Kean and Houghton 1982). By contrast there is limited information on the craniofacial morphology of Southeast Asian people (Pietrusewsky 1978; 1981). As Pacific people are believed to derive from ancestral Southeast Asian populations some underlying similarities in craniofacial form may be hypothesized. The aim of this work is to make a morphometric comparative study on the complete craniofacial complex in Polynesians and Thais.

Materials and Methods

A total of 71 skulls and 87 mandibles of prehistoric Polynesians and Thais were used for macroscopical and radiographical analyses. All of the Polynesian skeletons were from

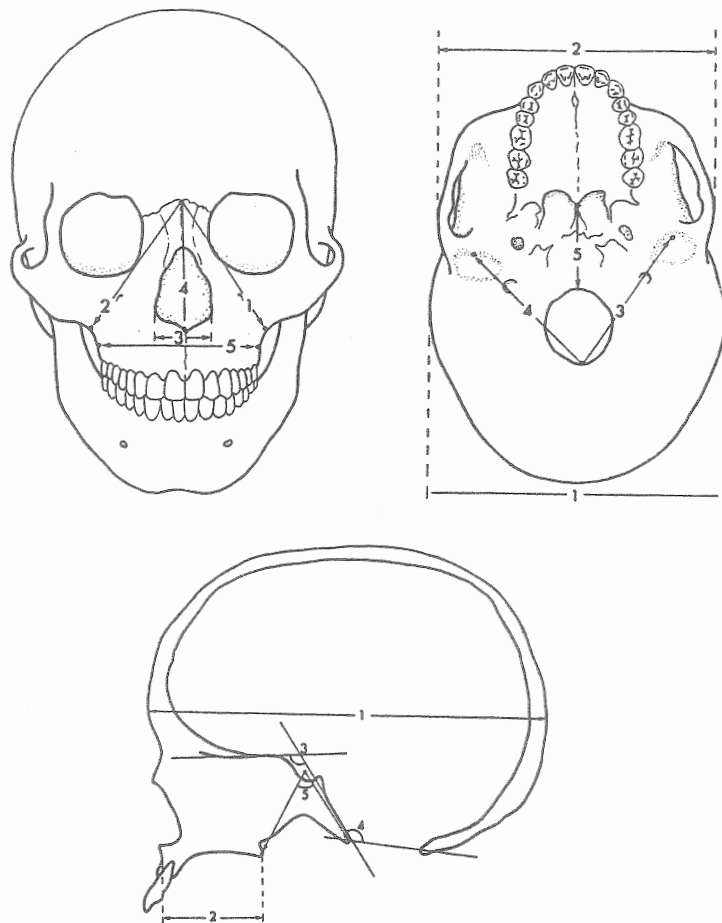


FIGURE 1: MEASUREMENTS MADE ON DRY SKULLS AND ANGLES MEASURED ON X-RAYS

Top left. 1,2: maxillary height (shortest distances between nasion and the zygomaticomaxillary notches); 3: nasal width (maximal breadth of the nasal aperture); 4: nasal height (distance between nasion and anterior nasal spine); 5: maxillary width, (distance between most lateral points of processus alveolaris).

Top right. 1: cranial width (maximal width of the skull); 2: bizygomatic width (maximal bizygomatic width); 3,4: location of fossa glenoidalis (distances between opisthion and midanterior wall of the glenoid fossae); 5: nasopharyngeal length (distance between basion and posterior nasal spine).

Lower: 1: cranial length (maximal length of the skull); 2: maxillary length (distance between subspinale and posterior nasal spine); 3: planum sphenoidale/clival tangent line (Sph/Cliv) (anterior cranial base angle - angle between the tangents to the sphenoidal and clival planes); 4: clival tangent line/foraminal plane (Cliv/For) (posterior cranial base angle - angle between the tangents to the clival plane and a line connecting opisthion and basion (foraminal plane)); 5: nasopharyngeal angle (Pm-S-Ba) (angle between the sella-posterior nasal spine and sella-basion lines).

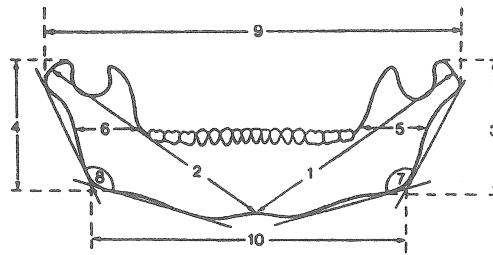


FIGURE 2: DISTANCES AND ANGLES MEASURED ON DRY MANDIBLES

1,2: mandibular length (maximal distances from superior most point on the condyles to the pogonion); 3,4: ramal height (maximal height from the superiormost point of the condyles perpendicular to the lower border of the mandibular corpus); 5,6: ramal width (maximal width of the mandibular rami measured parallel to the occlusal plane); 7,8: gonial angle (the angles between tangents to the lower borders of the mandible and posterior outline of the condyloramal complex); 9: bicondylar distance (distance between the most lateral points on the heads of the mandibular condyles); 10: bigonial distance (distance between the most lateral points on the angles of the mandible).

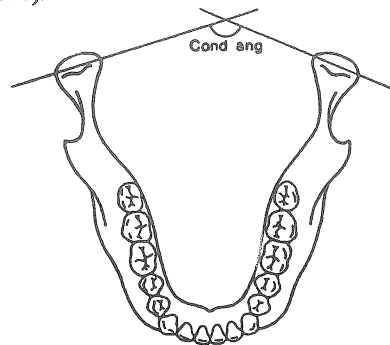


FIGURE 3: MEASUREMENT MADE ON PHOTOCOPIES

Condylar angulation (Cond ang); angle between the superior midlongitudinal axis of the mandibular condyles.



FIGURE 4: THE SAGITTAL DENTAL OCCLUSION

Measured bilaterally (occl sin and occl dex) as the distances between the mesial surfaces of the first, or in case of missing, the second antagonistic molars.

New Zealand or the Chatham islands and represent the Maori people. They date to within the past 1000 years. The Thai skeletons were excavated in the village of Khok Phanom Di about 20 km from the coast of the Gulf of Thailand, and date to about 2000 BC. Sex classification of the skulls with associated skeletons was done on basis of pelvic morphology, and for single skulls on the basis of skull morphology (Krogman 1962),

Distances and angles depicting characteristics of the skull, the cranial base, the nasomaxillary region, the mandible and the dental occlusion were measured on the dry skulls with a digital sliding calliper or protractor. Angular variables representing the cranial base and nasopharynx were measured on lateral x-rays. The condylar angulation was measured on xerox photocopies from the superior outline of the condyles. For all bilateral structures both sides were measured, and in the statistical analysis the mean values of left and right side were used (Figs 1-4).

In order to test the precision of the measuring procedure, skulls, mandibles and X-rays were measured again after two weeks. The method error was calculated as the error variance in percentage of the total variance for each variable (Table 1). For statistical analysis of intersex and intergroup differences, Student's t-test for unpaired observations was used.

RESULTS

Intersex differences

All linear dimensions, except those depicting nasal width, ramal width, nasopharyngeal length and interocclusal relationship, were significantly ($p < 0.05$) less in females than in males. The gonial angle was larger in females than in males ($p < 0.05$), whereas the posterior cranial base angle (Cliv/For) was larger in Thai females ($p < 0.05$; Table 2).

Intergroup differences

Both males and females in the Thai group had shorter and wider skulls ($p < 0.05$), wider noses ($p < 0.01$) and jaws ($p < 0.001$), but a smaller nasopharyngeal angulation ($p < 0.01$) than the Polynesians. The Thai males had a shorter maxilla ($p < 0.001$) and a steeper posterior cranial base ($p < 0.01$) than Polynesian males. The Thai females had larger bizygomatic width ($p < 0.01$), mandibular length ($p < 0.001$) and maxillary height dimensions ($p < 0.05$), but shorter nasopharyngeal length ($p < 0.05$) than Polynesian females (Table 2).

DISCUSSION

The head and cranial base form in Polynesian people is distinctive, and some of the present findings are merely a verification of known facts. Kean and Houghton (1982) and Houghton and Kean (1987), for instance, point out the high and narrow cranial vault to be a prominent feature of the Polynesian head. They also observed an obtuse cranial base angle in the Polynesian people which was not, however, evident in our findings. This conflicting result is presumably due to the methodological difference in these studies.

Instead of measuring the cranial base shape as the angulation between nasion-sella and sella-basion lines, we used the cranial tangent lines (Sph/Cliv) to the bones of which the cranial base is actually constituted. The standard Na-S-Ba angle mainly reflects the respiratory pathway whereas the Sph/Cliv angle reflects the endocranial outline. Moss and Greenberg (1955) introduced this approach for cephalometric studies and it was later adopted by Koski (1964) and Koskinen and Koski (1965), who stressed also the important fact that nasion is definitively not representative of a cranial base structure (Varjanne and Koski 1982).

As we observed only a slightly longer nasopharynx (Pm-Ba) in the Polynesians than in the Thais, the considerable enlargement of the Pm-S-Ba angle as well as the flatness of Na-S-Ba angle observed in earlier studies (Kean and Houghton 1982), should consequently be explained as caused by a difference in the location of the sella. To illuminate this, the lateral X-rays were separately analysed to assess the location of the sella (Fig. 5). We then found a highly significant difference between the groups, since in

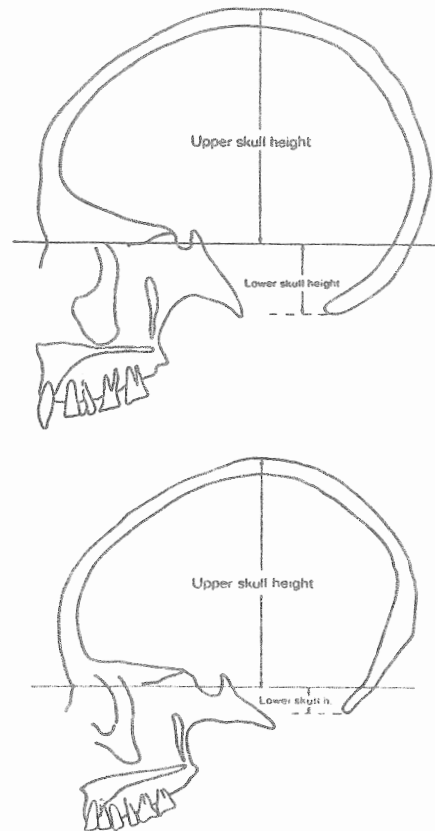


FIGURE 5: MEASUREMENTS MADE TO SHOW THE VERTICAL LOCATION OF THE SELLA IN THAI (UPPER) AND POLYNESIAN (LOWER) PEOPLE



FIGURE 6: FRONT VIEW OF A POLYNESIAN MALE SKULL (LEFT) AND A THAI MALE SKULL (RIGHT).

The difference in the shape of the nasal aperture and interorbital breadth is evident.

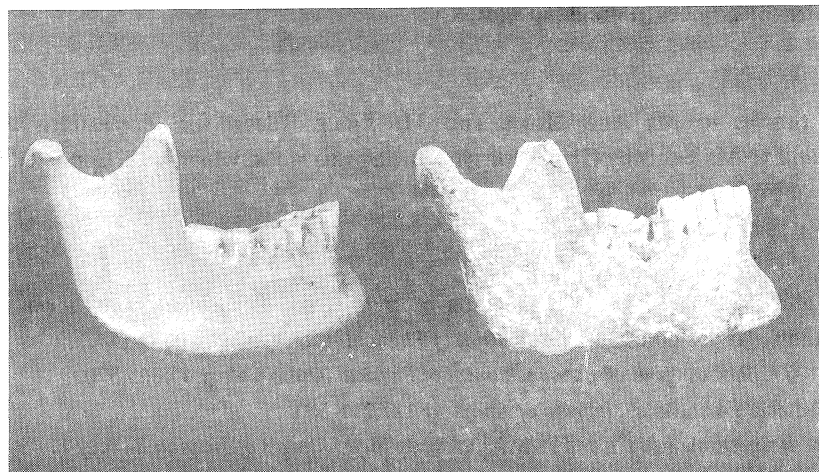


FIGURE 7: LATERAL VIEW OF A POLYNESIAN MALE MANDIBLE (LEFT) AND A THAI MALE MANDIBLE (RIGHT).

The Polynesian mandible is of the typical "rocker form" whereas the Thai mandible shows an antegonial notch.

the Polynesians the upper/lower skull ratio was 5.9, while in the Thais only 3.7. This phenomenon has also been described by Anderson and Popovich (1983) who found an obtuse Na-S-Ba angulation in children with large upper cranial heights (sella-vertex) and small lower cranial heights (sella-Bolton).

The intergroup difference in the nasal width was also obvious, in that Polynesians had a narrower aperture than Thais (Fig. 6). Climate is suggested to be a factor influencing the shape of the nose, people living in a warm environment generally having wider nasal apertures than those living in a cold environment (Thomson and Buxton 1923; Woo and Mourant 1934; Wolpoff 1968). The groups in this study lived in different climates. The maritime environment, to which the Polynesians adapted, was actually one of the coldest of all global climates for neolithic peoples (Houghton 1990, 1991a, 1991b). Also, the larger New Zealand is generally a cool temperate environment. The Thai environment was hot and humid (Maloney 1991). Further, we found the difference in the nasal width to be even more evident in the females. This is in accordance with findings that the nasal aperture of females tends to narrow more than that of the males in a cooler and drier climate (Wolpoff 1968).

The distinct form of the mandible in Polynesians, which has been described as a "rocker jaw" (Houghton 1977, 1988), was not brought out in this study as we did not evaluate those mandibular structures principally contributory to a rocker shaped jaw (mandibular canal curvature and absence of the antegonial notch). However, visual inspection gave us a strong impression of the general difference in the mandibular form between Polynesians and Thais (Fig. 7).

The intergroup differences in maxillary and bicondylar widths may be explained as a reflection of the differences in the head widths.

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	Me ² *	Sd ²	Me %
<u>Skull & Cranial base</u>			
Cranial length	0.13	87.20	0.15
Cranial width	0.13	46.92	0.28
Sph/Cliv	3.13	88.18	3.55
Cliv/För	2.25	56.12	4.00
Fossa glenoidalis sin	2.13	15.88	13.40
Fossa glenoidalis dex	0.13	12.29	1.06
<u>Upper face & Nasopharynx</u>			
Bizygomatic width	0.25	65.24	0.38
Nasal height	0.38	12.29	3.09
Nasal width	0.13	4.14	3.14
Maxillary height sin	0.13	18.34	0.70
Maxillary height dex	0.25	21.26	1.18
Maxillary width	0.63	24.61	2.62
Maxillary length	0.25	19.29	1.30
Nasopharyngeal length	0.13	12.89	1.01
Pm-S-Ba	0.38	45.03	0.84
<u>Mandible</u>			
Bicondylar width	0.50	47.82	1.05
Bigonial width	0.75	56.36	1.33
Mandibular length sin	0.25	35.47	0.70
Mandibular length dex	0.25	33.42	0.75
Ramal height sin	0.75	47.44	1.58
Ramal height dex	0.00	45.22	0.00
Ramal width sin	0.25	8.50	2.94
Ramal width dex	0.25	9.70	2.58
Gonial angle sin	0.00	41.32	0.00
Gonial angle dex	0.63	37.11	1.70
Condylar angle sin	1.50	38.12	3.94
Condylar angle dex	2.63	34.28	7.67
Condylar tot	8.25	112.06	7.36
<u>Dental occlusion</u>			
Interocclusion sin	0.15	5.90	2.54
Interocclusion dex	0.52	9.66	5.38

$$* Me^2 = \sum d^2/2n$$

TABLE 1: METHOD ERROR VARIANCE (ME²) AND ITS PERCENTAGE (ME%) OF TOTAL VARIANCE (SD²) FOR CRANIOFACIAL MEASUREMENTS IN SAMPLES OF PREHISTORIC POLYNESIANS AND THAIS

	POLYNESIAN					THAI		
	Sex	N	\bar{X}	SD	Sign	N	\bar{X}	SD
Cranial length	M	14	185.4	6.96	*	15	180.2	5.20
			***				***	
	F	21	176.1	7.51	***	21	168.3	6.91
Cranial width	M	14	140.9	3.89	***	14	147.6	5.12
			***				***	
	F	21	133.8	5.57	**	21	139.5	6.48
Sph/Cliv	M	14	114.9	11.44	NS	10	109.0	6.55
			NS				NS	
	F	18	116.4	7.17	NS	15	110.9	10.01
Cllv/For	M	14	128.5	7.97	**	11	121.0	5.27
			NS				*	
	F	18	125.1	5.61	NS	17	127.2	7.88
Fossa glenoidalis	M	12	76.3	2.53	NS	9	77.5	3.23
			***				**	
	F	16	71.6	2.31	NS	16	73.3	2.88
Biszygomatical width	M	10	141.6	4.95	NS	12	141.3	9.27
			***				**	
	F	13	127.1	5.81	**	17	133.5	5.70
Nasal height	M	12	53.9	3.70	NS	13	53.5	3.43
			*				***	
	F	17	50.5	3.50	NS	21	49.5	2.04
Nasal width	M	12	24.8	1.75	**	13	27.0	1.96
			NS				NS	
	F	18	23.6	1.79	***	22	26.0	1.46
Maxillary height	M	12	67.3	3.95	NS	12	70.0	3.79
			***				***	
	F	17	62.4	3.07	*	18	64.9	2.94
Maxillary width	M	11	61.8	2.71	***	17	68.2	3.01
			***				***	
	F	18	57.7	2.64	***	23	64.0	3.66
Maxillary length	M	10	55.4	2.80	***	13	50.0	3.16
			***				**	
	F	18	48.8	3.28	NS	20	47.1	2.86

*** P ≤ 0.001
 ** P ≤ 0.01
 * P ≤ 0.05
 t-test

TABLE 2: MEANS, STANDARD DEVIATIONS AND SIGNIFICANCES OF INTERSEX AND INTERGROUP DIFFERENCES IN CRANIOFACIAL MORPHOLOGY OF PREHISTORIC POLYNESIANS AND THAIS

	POLYNESIAN					THAI		
	Sex	N	\bar{X}	SD	Sign	N	\bar{X}	SD
Nasopharyngeal length	M	10	45.2	4.10	NS	7	43.0	3.74
	F	16	43.9	1.98	*	16	41.6	3.16
Pm-S-Ba	M	12	71.2	5.47	**	9	62.3	5.81
	F	17	69.9	4.78	***	14	62.8	5.21
Bicondylar width	M	14	124.3	7.08	*	17	129.8	6.78
	F	12	117.4	7.90	**	23	123.2	5.14
Bigonial width	M	17	106.9	5.73	NS	22	105.8	6.79
	F	18	96.3	5.09	NS	28	96.0	4.40
Mandibular length	M	16	129.8	5.30	NS	19	130.8	5.36
	F	14	119.2	5.27	***	27	124.2	3.81
Ramal height	M	15	62.6	5.35	NS	20	62.5	6.91
	F	14	54.5	8.24	NS	27	56.5	6.18
Ramal width	M	18	37.1	2.50	NS	20	36.9	3.08
	F	17	34.6	3.84	NS	29	35.4	2.92
Gonial angle	M	16	113.0	6.20	NS	22	115.6	3.98
	F	16	118.8	7.70	NS	28	118.7	5.57
Condylar angle	M	14	149.6	6.15	NS	20	150.0	11.65
	F	14	152.5	18.48	NS	27	152.4	10.35
Interocclusal relationship	M	10	0.6	2.75	NS	16	1.3	3.08
	F	10	1.0	1.80	NS	15	2.0	1.24

TABLE 2: (CONTINUED)