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Quantitative Limb Bone-Morphology at Man Bac

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The aim of this chapter is to: (1) morphometrically describe the Man Bac adult infracranial remains, essentially the major long bones; (2) estimate sex specific stature in the series; and (3) compare the relative level of Man Bac infracranial robusticity with other samples in the region. It is hoped this analysis will contribute to a better understanding of generalised behaviours the Man Bac community may have been engaged in.

MATERIALS AND METHODS

The long bone sample for this study derives from the 2005 and 2007 excavation seasons. Measurements, left side only or right if missing, were taken for the humerus, radius, ulna, femur, tibia, and fibula, following Martin and Saller's (1957) methodology. For incomplete long bones, estimates of maximum length were based on Wright and Vasquez's (2003) methodology.

A range of indices were derived from the measurement suite. For instance, the cross sectional index of a long bone shaft expresses the relative roundness or flatness of the diaphysis in terms of minimum diameter to maximum diameter, or of transverse diameter to sagittal diameter. Upper and lower limb proportions were evaluated by way of the brachial and crural indices. The brachial index is the length ratio of the radius to humerus, while the crural index expresses the proportion of tibial to femoral length. Calculated indices for the Man Bac series were compared to Pietrusewsky and Douglas' (2002) study of the Ban Chiang, Thailand, (4,100BP-1,900 BP) skeletal series, which includes a global infracranial comparative data set.

Due to the lack of an ancient Vietnamese-specific set of stature regression functions, stature was estimated using a range of published methods: Stevenson (1929) derived from a northern Chinese sample; Trotter and Gleser (1958) derived from Asian Americans; Mo (1983) from a southern Chinese series; Fujii (1960) from a Japanese sample; Sangvichien et al. (1985) using a Thai/Chinese sample and Sjøvold's (1990) generic functions. Among these, only Fujii and Sangvichien et al. provided sex specific equations. In order to assess the most suitable stature estimation equations for the Man Bac series, this study compared estimated

statures calculated using different kinds of long bones (humerus, femur and tibia), and assessed discrepancies among the results of the different regression equations. The regression equation set, which provided the smallest discrepancy between estimated stature in the Man Bac series, based on different long bones, was regarded as the most appropriate set.

RESULTS

A summary of limb measurements and indices for individual specimens from Man Bac are given in Tables 6.1 and 6.2. The specimen MB07H1M9 has been excluded from subsequent analyses, including mean limb dimension statistics, due to its pathologically abnormal limb dimensions and morphology (see Oxenham et al. 2009).

The overall size of the long bones will be evaluated in terms of stature comparisons with neighbouring prehistoric samples. In terms of the indices, specific comparisons with Ban Chiang are noted. Unless otherwise stated, all reported measurements are in millimetres. The mid-shaft cross-sectional index of the humerus is greater in the males (82.1) than in the females (70.9), indicating a more rounded humeral shaft for males. The Man Bac values are a little bit greater than the Ban Chiang averages (males 78.7, females 71.7), which were categorised as possessing moderate roundness, so-called 'eurybrachia'.

The mid-shaft indices of the radius are similar for males (71.3) and females (69.6). However, the cross-sectional index of the ulna is greater in the males (91.8) than in the females (82.0), suggesting that the male shaft is flatter than the female diaphysis. These mid-shaft indices were not compared with Ban Chiang due to differences in measurement landmarks.

The mid-shaft cross-sectional index of the femur, 'pilastric index', relates to the degree of development of the linear aspera. Man Bac males (109.5) show greater values than females (102.3), indicating that males have a more robust pilastric form associated with well developed linea aspera. Although the Man Bac values show slight differences when compared to the Ban Chiang samples (males 112, females 102.9), both samples are within the range of medium levels of development globally.

The proximal femoral shaft cross-sectional index, 'platymeric index', reflects the degree of flatness in the upper portion of the femoral diaphysis. There is very little sexual dimorphism difference in the Man Bac series using this index (males 78.9, females 75.0). Man Bac averages are slightly greater than the Ban Chiang males (77.7), which are classified as having moderate flatness in global terms.

The average cross-sectional index of the tibia, which evaluates transverse flatness or sagittal thickness of the tibial shaft at the level of the nutrient foramen, is similar in both the Man Bac (males 66.7, females 67.6) and Ban Chiang (males 68.7, females 67.9) series, suggesting shafts in the moderate range (mesocnemic).

The brachial and crural indices, which evaluate arm and leg length ratios, respectively, are given in Table 6.3. There is little sexual dimorphism in either index (brachial: males 81.6 females 78.1, crural: males 85.5, females 83.9). Figure 6.1 plots these two indices for Man Bac males (open circles) together with comparative population data. Several individuals show relatively very long forearms

Table 6.1 Humerus, radius and ulna measurements (mm) recorded for limb bones of the Man Bac series.

Sample No.	MB05 M9	MB05 M11	MB05 M15	MB05 M16	MB05 M28	MB05 M29	MB05 M31	MB05 M34	MB07 H1M4	MB07 H1M5	MB07 H1M8	MB07 H1M9	MB07 H1M10	MB07 H1M11
Sex	female	male	female	female	female	male	male	female	female	male	male	male	female	female
Humerus	right	right		right	left	right	left	right	right	right	right	right	right	right
1. Max. length	272	288	-	298	-	-	282	295	-	292	307	-	-	269
2. Total length	270	285	-	295	-	-	277	291	-	288	303	-	-	264
4. Bi-epicondylar width	57	63	-	59	-	70	63	57	-	64	62	-	61	60
5. Max. mid-shaft diameter	23	21	-	28	21	27	25	21	24	23	22	16	23	22
6. Min. mid-shaft diameter	15	15	-	17	15	21	21	16	16	17	19	14	18	16
9. Transv. head diameter	40	42	-	41	-	45	46	37	-	43	41	-	-	39
10. Max. sagittal head diameter	37	40	-	42	-	-	40	40	38	44	44	-	-	42
6/5. Mid-shaft cross-section index	64.4	69.0	-	60.7	69.0	77.8	84.0	76.2	66.7	73.9	86.4	87.5	78.3	72.7
9/10. Head cross-section index	109.6	106.3	-	97.6	-	-	115.2	92.5	0.0	97.7	93.2	-	-	92.9
Radius	right	right	-	left	right	right	left	right	right	right	right	right	left	left
1. Max. length	216	239	-	239	-	241	229	216	-	245	241	-	234	207
2. Physiological length	204	229	-	234	-	236	214	212	-	239	237	213	230	202
4. Max. Transv. shaft diameter	14	14	-	16	15	18	19	14	16	15	16	13	15	16
5. Sagittal shaft diameter	11	12	-	11	10	14	13	10	10	10	12	7	11	11
5/4. Mid-shaft cross-section index	77.8	85.2	-	68.8	63.3	77.8	65.8	71.4	62.5	66.7	75.0	53.8	73.3	68.8
Ulna	right	right	right	left	left	right	left	left	left	left	left	right	left	left
1. Max. length	235	264	-	253	-	257	249	234	-	263	262	245	261	227
2. Physiological length	206	234	-	222	-	221	217	205	-	231	232	213	228	199
6. Olecranon breadth	22	23	-	24	-	26	26	23	-	24	25	25	25	23
11. Dorso-ventral shaft diameter	12	12	12	13	11	20	15	14	-	14	14	9	11	12
12. Transv. shaft diameter	16	15	18	16	14	15	16	12	-	16	15	12	16	17
11/12. Shaft cross-section index	71.9	79.3	65.7	81.3	81.5	133.3	90.6	116.7	-	87.5	93.3	75.0	68.8	70.6

For a definition of the measurements see Martin R and Saller K. 1957

Table 6.1 (continued).

Sample No.	MB07 H1M13a	MB07 H2M1	MB07 H2M10	MB07 H2M12	MB07 H2M19	MB07 H2M24	MB07 H2M27	MB07 H2M30	MB07 H2M32	Man Bac Average					
Sex	unknown	male	male	female	male	female	male	male	male		males			females	
Humerus	left	left	left	left	right	right	left	left	left	n	Mean	SD	n	Mean	SD
1. Max. length	-	313	327	281	300	-	282	351	322	10	306.4	22.3	5	283.0	13.1
2. Total length	-	309	321	281	296	-	278	343	315	10	301.5	21.0	5	280.2	13.3
4. Bi-epicondylar width	-	66	74	58	65	59	62	65	66	11	65.4	3.7	7	58.7	1.6
5. Max. mid-shaft diameter	22	22	24	19	27	22	22	28	27	12	23.7	3.4	9	22.5	2.5
6. Min. mid-shaft diameter	15	18	19	14	20	17	21	25	23	12	19.4	3.3	9	15.8	1.3
9. Transv. head diameter	-	43	45	39	46	-	38	-	44	10	43.2	2.3	5	39.2	1.5
10. Max. sagittal head diameter	-	45	48	39	49	-	42	49	47	10	44.7	3.6	6	39.6	2.2
6/5. Mid-shaft cross-section index	68.2	81.8	79.2	73.7	72.6	76.1	95.3	89.5	87.6	12	82.1	7.8	9	70.9	6.0
9/10. Head cross-section index	-	95.6	93.8	100.0	92.8	-	92.2	0.0	92.5	10	87.9	31.8	6	82.1	40.7
Radius	right	left	right	-	left	right	right	right	left	n	Mean	SD	n	Mean	SD
1. Max. length	-	255	278	227	249	227	229	273	261	11	249.1	16.3	7	223.7	11.3
2. Physiological length	-	251	273	222	245	220	223	269	256	12	240.4	19.5	7	217.7	12.3
4. Max. Transv. shaft diameter	14	16	20	15	18	15	15	19	18	12	16.7	2.3	9	15.1	0.9
5. Sagittal shaft diameter	11	12	14	10	14	11	12	13	12	12	11.9	1.9	9	10.5	0.6
5/4. Mid-shaft cross-section index	78.6	75.0	70.0	66.7	75.2	73.5	76.2	68.1	66.3	12	71.3	7.9	9	69.6	5.0
Ulna	left	left	right	left	left	right	right	left	left	n	Mean	SD	n	Mean	SD
1. Max. length	-	279	299	246	265	245	250	-	283	11	265.1	16.2	7	243.0	11.8
2. Physiological length	-	244	268	213	230	215	215	-	249	11	232.2	16.5	7	212.6	10.1
6. Olecranon breadth	-	27	31	22	27	23	26	27	27	12	26.1	2.0	7	23.0	1.2
11. Dorso-ventral shaft diameter	12	15	17	12	14	13	14	14	14	12	14.3	2.6	9	12.1	1.1
12. Transv. shaft diameter	15	12	16	15	18	13	16	20	19	12	15.8	2.5	9	15.1	1.9
11/12. Shaft cross-section index	80.0	125.0	106.3	80.0	79.1	101.6	92.2	67.6	72.8	12	91.8	20.5	9	82.0	16.8

Table 6.2 Femur, tibia and fibula measurements (mm) recorded for limb bones of the Man Bac series.

Sample No.	MB05 M9	MB05 M11	MB05 M15	MB05 M16	MB05 M28	MB05 M29	MB05 M31	MB05 M34	MB07 H1M4	MB07 H1M5	MB07 H1M8	MB07 H1M9	MB07 H1M10	MB07 H1M11
Sex	female	male	female	female	female	male	male	female	male	male	male	male	female	female
Femur	right	right	right	left	left	right	right	right	left	left	left	left	right	left
1. Max. length	377	401	-	420	-	394	407	400	-	398	421	-	(406)	399
2. Physiological length	376	398	-	415	-	391	402	398	-	396	419	-	-	397
6. Sagittal mid-shaft diameter	24	26	28	25	24	27	27	25	24	25	27	14	27	27
7. Transv. mid-shaft diameter	25	21	24	27	24	26	25	24	26	27	25	16	25	29
9. Sagittal proximal shaft diameter	25	23	22	23	-	24	25	22	21	23	23	14	24	24
10. Transv. proximal shaft diameter	27	23	28	31	-	33	30	29	34	29	31	20	31	33
18. Vertical head diameter	42	43	44	46	-	46	49	41	45	46	46	-	45	46
19. Sagittal head diameter	41	42	43	45	-	46	48	41	-	47	46	-	45	46
21. Bicondylar width	69	74	-	77	-	81	80	71	-	82	77	-	-	78
6/7. Mid-shaft cross-section index (Pilastric)	94.0	124.4	119.1	92.6	102.1	103.8	108.0	104.2	92.3	92.6	108.0	87.5	108.0	93.1
9/10. Prox. shaft cross-section index (Platymeric)	108.0	100.0	78.6	134.8	-	137.5	120.0	131.8	161.9	126.1	134.8	142.9	129.2	137.5
19/18. Head cross-section index	98.8	97.7	97.7	97.8	-	100.0	99.0	100.0	0.0	102.2	100.0	-	100.0	100.0
Tibia	right	-	right	-	-	left	left	right	right	left	left	left	right	right
1. Total length	326	-	-	-	-	(334)	340	320	-	342	357	-	(337)	326
1a. Max. length	329	-	-	-	-	(337)	343	323	-	335	360	-	-	328
3. Epicondylar breadth	-	-	-	-	-	79	-	66	-	77	75	-	-	73
8. Max. sagittal mid-shaft diameter	28	-	29	-	-	31	33	26	27	29	30	19	28	30
9'. Transv. mid-shaft diameter	18	-	20	-	-	24	20	18	-	19	21	13	19	18
8a. Max. sagit. diam. at nutrient foramen	34	-	32	-	-	36	36	28	19	35	33	22	35	34
9a'. Transv. diameter at nutrient foramen	21	-	22	-	-	27	22	20	-	20	23	-	25	21
9'/8. Mid-shaft cross-section index	65.5	-	70.2	-	-	77.4	60.6	69.2	-	65.5	70.0	68.4	67.9	60.0
9a'/8a. Shaft cross-section index	62.7	-	67.2	-	-	75.0	61.1	71.4	-	57.1	69.7	-	71.4	61.8
Fibula	right	-	right	-	right	right	right	-	-	left	left	left	right	right
1. Max. length	323	-	-	-	-	341	334	-	-	339	-	-	-	-
2. Max. mid-shaft diameter	15	-	16	-	15	17	17	-	-	14	15	9	17	18
3. Min. mid-shaft diameter	11	-	10	-	10	12	12	-	-	11	10	8	10	8
3/2. Mid-shaft cross-section index	70	-	63	-	69	71	68	-	-	79	67	89	59	44

Parenthesis values estimated via formulae from Wright and Vasquez (2003), (05MB29: T1-T7=322mm; 07MB H1-10: F0-F5=375mm, T1-T6=305mm)

Table 6.2 (continued).

Sample No.	MB07 H1M13a	MB07 H2M1	MB07 H2M10	MB07 H2M12	MB07 H2M19	MB07 H2M24	MB07 H2M27	MB07 H2M30	MB07 H2M32	Man Bac Average					
Sex	female	male	male	female	male	female	male	male	male		males			females	
Femur	right	right	right	left	right	left	left	right	left	n	Mean	SD	n	Mean	SD
1. Max. length	420	445	470	407	400	416	390	482	452	11	423.6	32.9	8	405.6	14.2
2. Physiological length	418	443	467	403	398	412	388	481	450	11	421.2	33.3	7	402.7	14.4
6. Sagittal mid-shaft diameter	27	29	33	24	27	25	29	36	31	12	27.5	5.3	11	25.4	1.6
7. Transv. mid-shaft diameter	24	26	26	23	27	24	25	28	29	12	25.0	3.5	11	24.9	1.8
9. Sagittal proximal shaft diameter	21	24	25	21	25	23	24	29	24	12	23.5	3.4	10	22.6	1.4
10. Transv. proximal shaft diameter	32	30	34	29	31	29	30	33	35	12	29.9	4.4	10	30.3	2.3
18. Vertical head diameter	44	47	47	41	47	43	43	50	47	11	46.3	2.1	10	43.6	2.0
19. Sagittal head diameter	44	47	46	41	47	43	42	50	48	11	46.2	2.3	9	43.2	1.9
21. Bicondylar width	-	78	85	72	79	71	78	85	82	11	80.2	3.3	6	73.0	3.6
6/7. Mid-shaft cross-section index (Pilastric)	112.5	111.5	126.9	104.3	102.8	103.3	113.5	125.9	108.5	12	109.5	12.3	11	102.3	8.8
9/10. Prox. shaft cross-section index (Platymeric)	152.4	125.0	136.0	138.1	125.1	126.7	126.9	115.7	144.9	12	78.9	8.5	10	75.0	8.3
19/18. Head cross-section index	100.0	100.0	97.9	100.0	98.9	99.3	99.4	100.8	102.1	11	99.8	1.5	10	89.4	31.4
Tibia	right	left	right	left	right	right	right	left	right	n	Mean	SD	n	Mean	SD
1. Total length	350	384	409	337	346	333	332	412	381	10	363.7	30.5	7	332.7	9.9
1a. Max. length	357	386	415	342	350	-	330	409	378	10	364.3	31.1	5	335.8	13.8
3. Epicondylar breadth	72	-	81	67	77	-	-	78	75	7	77.5	2.1	4	69.5	3.5
8. Max. sagittal mid-shaft diameter	30	31	32	26	32	26	28	38	31	11	30.4	4.6	9	27.7	1.6
9'. Transv. mid-shaft diameter	21	20	22	18	19	18	18	23	22	11	20.2	3.0	8	18.8	1.2
8a. Max. sagit. diam. at nutrient foramen	32	35	37	32	38	34	32	41	35	11	34.6	4.7	9	31.1	5.0
9a'. Transv. diameter at nutrient foramen	21	22	34	20	21	24	21	24	24	10	23.7	4.1	8	21.7	1.9
9'/8. Mid-shaft cross-section index	70.0	64.5	68.8	69.2	60.7	69.0	66.0	60.6	71.0	11	66.7	5.2	8	67.6	3.4
9a'/8a. Shaft cross-section index (Tibial thickness)	65.6	62.9	91.9	62.5	55.6	70.6	64.2	57.8	67.5	10	66.3	10.8	8	66.7	4.1
Fibula	left	left	left	left	right	left	left	left	left	n	Mean	SD	n	Mean	SD
1. Max. length	-	-	-	-	357	323	324	-	373	6	344.7	17.6	2	323.0	0.0
2. Max. mid-shaft diameter	15	17	18	15	18	15	16	18	19	11	16.1	2.8	8	15.7	1.2
3. Min. mid-shaft diameter	11	11	10	9	13	10	13	13	11	11	11.2	1.5	8	9.9	0.9
3/2. Mid-shaft cross-section index	73	65	56	60	71	69	86	69	59	11	70.7	10.3	8	63.4	9.3

Table 6.3 Indices of limb bone proportions and estimated statures (cm) of the Man Bac series.

Sample No.	MB05 M9	MB05 M11	MB05 M16	MB05 M29	MB05 M31	MB05 M34	MB07 H1M5	MB07 H1M8	MB07 H1M10	MB07 H1M11	MB07 H1M13a	MB07 H2M1
Sex	female	male	female	male	male	female	male	male	female	female	female	male
Limb length proportion												
Brachial index (Rad.1/Hum.1)	79.4	83.0	80.2		81.2	73.2	83.9	78.5		77.0		81.5
Crural index (Tib.1a/Fem.1)	87.3			85.0	84.3	80.8	84.2	85.5		82.2	85.0	86.7
Stature estimation												
Stevenson (1929): northern Chinese (femur)	153.6	159.5	164.1	157.8	160.9	159.2	158.7	164.4	160.7	159.0	164.1	170.2
Stevenson (1929): northern Chinese (tibia)	157.9			160.3	162.1	156.1	162.7	167.3		157.9	165.1	175.4
Stevenson (1929): northern Chinese (humerus)	158.0	162.5	165.3		160.8	164.5	163.7	167.9		157.2		169.6
Trotter & Gleser (1958): USA Asians (femur)	153.6	158.8	162.9	157.3	160.1	158.6	158.1	163.1	160.1	158.4	162.9	168.2
Trotter & Gleser (1958): USA Asians (tibia)	160.1			162.0	163.4	158.6	161.5	167.5		159.8	166.8	173.7
Mo (1983): southern Chinese (femur)	149.0	154.4	158.7	152.8	155.8	154.2	153.7	158.9	155.6	154.0	158.7	164.4
Mo (1983): southern Chinese (tibia)	153.2			155.6	157.4	151.4	155.0	162.5		152.9	161.6	170.3
Fujii (1960): Japanese (femur)	145.5	153.9	155.7	152.2	156.2	150.6	153.2	158.9	152.0	150.8	155.1	164.8
Fujii (1960): Japanese (tibia)	150.3			157.2	158.7	148.9	156.7	162.9		150.0	162.2	169.3
Fujii (1960): Japanese (humerus)	146.0	153.6	152.2		151.9	151.5	154.7	158.9		145.7		160.6
Sangvichien et al. (1985): Thai/Chinese (femur)	**146.6**	**157.5**	**157.7**	**156.3**	**158.5**	**152.5**	**156.9**	**160.9**	**154.1**	**152.2**	**157.7**	**165.1**
Sangvichien et al. (1985): Thai/Chinese (tibia)	149.4			155.8	157.5	147.6	155.3	162.2		148.5	157.7	169.4
Sjovold (1990): nonspecific populations (femur)	148.0	154.5	159.7	152.6	156.2	154.3	153.7	160.0	155.9	154.0	159.7	166.5
Sjovold (1990): nonspecific populations (tibia)	155.6			158.2	160.2	153.6	157.6	165.8		155.3	164.8	174.3
Sjovold (1990): nonspecific populations (humerus)	144.7	152.1	156.7		149.3	155.3	153.9	160.8		143.3		163.6
Difference of stature estimation based on comparisons between humeral and femoral lengths												
Stevenson (1929)	4.4	3.1	1.2		0.1	5.3	4.9	3.5		1.8		0.6
Fujii (1960)	0.5	0.4	3.5		4.3	0.9	1.5	0.0		5.1		4.2
Sjovold (1990)	3.4	2.5	3.0		6.9	1.0	0.2	0.9		10.7		2.8
Difference of stature estimation based on comparisons between femoral and tibial lengths												
Stevenson (1929)	4.3			2.5	1.2	-3.1	4.0	2.9		-1.1	1.0	5.2
Trotter & Gleser (1958)	6.5			4.7	3.4	0.1	3.4	4.4		1.5	3.9	5.5
Mo (1983)	4.2			2.8	1.6	-2.8	1.2	3.5		-1.1	2.9	5.9
Fujii (1960)	4.8			5.0	2.5	-1.7	3.5	4.0		-0.8	7.1	4.5
Sangvichien et al. (1985)	2.8			-0.4	-1.0	-4.9	-1.7	1.3		-3.7	0.0	4.3
Sjovold (1990)	7.6			5.6	4.0	-0.7	3.8	5.8		1.3	5.1	7.9

bold: stature estimation regarded as most suitable for the Man Bac series.

Table 6.3 (continued).

Sample No.	MB07 H2M10	MB07 H2M12	MB07 H2M19	MB07 H2M24	MB07 H2M27	MB07 H2M30	MB07 H2M32	Man Bac Average					
								males			females		
Sex	male	female	male	female	male	male	male	n	Mean	SD	n	Mean	SD
Limb length proportion													
Brachial index (Rad.1/Hum.1)	85.0	80.8	83.0		81.2	77.8	81.1	10	81.6	2.3	5	78.1	3.1
Crural index (Tib.1a/Fem.1)	88.3	84.0	87.5		84.6	84.9	83.6	10	85.5	1.5	5	83.9	2.5
Stature estimation													
Stevenson (1929): northern Chinese (femur)	176.3	160.9	159.2	163.1	156.8	179.2	171.9	11	165.0	8.0	8	160.6	3.5
Stevenson (1929): northern Chinese (tibia)	183.0	161.2	163.9	160.0	159.7	183.9	174.5	10	169.3	9.2	6	159.7	3.2
Stevenson (1929): northern Chinese (humerus)	173.5	160.6	165.9		160.8	180.3	172.1	10	167.7	6.3	5	161.1	3.7
Trotter & Gleser (1958): USA Asians (femur)	173.6	160.1	158.6	162.0	156.4	176.2	169.8	11	163.7	7.1	8	159.8	3.1
Trotter & Gleser (1958): USA Asians (tibia)	180.6	163.2	165.1		160.3	179.2	171.8	10	168.5	7.4	5	161.7	3.3
Mo (1983): southern Chinese (femur)	170.0	155.8	154.2	157.8	151.9	172.7	166.0	11	159.5	7.4	8	155.5	3.2
Mo (1983): southern Chinese (tibia)	179.0	157.1	159.5		153.5	177.2	167.9	10	163.8	9.3	5	155.2	4.1
Fujii (1960): Japanese (femur)	171.0	152.2	153.7	154.2	151.2	174.0	166.5	11	159.6	8.1	8	152.0	3.3
Fujii (1960): Japanese (tibia)	176.5	153.1	160.4		155.5	175.0	167.4	10	164.0	7.7	5	152.9	5.4
Fujii (1960): Japanese (humerus)	164.5	148.2	156.9		151.9	171.2	163.1	10	158.7	6.2	5	148.7	3.0
Sangvichien et al. (1985): Thai/Chinese (femur)	**169.4**	**154.3**	**157.3**	**156.6**	**155.6**	**171.5**	**166.3**	**11**	**161.4**	**5.7**	**8**	**154.0**	**3.7**
Sangvichien et al. (1985): Thai/Chinese (tibia)	177.4	153.2	159.4		153.9	175.7	167.2	10	163.4	8.6	5	151.3	4.2
Sjovold (1990): nonspecific populations (femur)	173.2	156.2	154.3	158.6	151.6	176.5	168.4	11	160.7	8.9	8	155.8	3.9
Sjovold (1990): nonspecific populations (tibia)	183.9	159.9	162.5		155.9	181.9	171.7	10	167.2	10.2	5	157.8	4.5
Sjovold (1990): nonspecific populations (humerus)	170.1	148.8	157.6		149.3	181.2	167.8	10	160.6	10.3	5	149.7	6.1
Difference of stature estimation based on comparisons between humeral and femoral lengths								Mean stature difference (humerus - femur)					
Stevenson (1929)	2.8	0.4	6.7		4.0	1.0	0.2			2.7			
Fujii (1960)	6.5	4.0	3.2		0.7	2.8	3.5			2.7			
Sjovold (1990)	3.2	7.3	3.3		2.3	4.7	0.6			3.5			
Difference of stature estimation based oncomparisons between femoral and tibial lengths								Mean stature difference (humerus - femur)					
Stevenson (1929)	6.7	0.3	4.7		2.9	4.7	2.6			2.6			
Trotter & Gleser (1958)	7.0	3.1	6.5		3.9	3.0	2.0			3.9			
Mo (1983)	9.0	1.3	5.3		1.5	4.5	2.0			2.8			
Fujii (1960)	5.5	0.9	6.7		4.3	1.1	0.8			3.2			
Sangvichien et al. (1985)	8.0	-1.1	2.1		-1.7	4.3	0.9			0.6			
Sjovold (1990)	10.6	3.7	8.2		4.4	5.4	3.3			5.1			

and lower legs, while the Man Bac mean is close to the Ban Chiang mean (Pietrusewsky and Douglas, 2002). In general, Man Bac individuals are dispersed around a range of population means including: Dayak (Yokoh, 1940), Jomon (Takigawa, 2005) and Tasmanians (Roth, 1899). A single specimen shows a close affinity with Chinese (Olivier, 1969) and Iron Age Yayoi Japanese (Wakebe, 2002). Australian aborigines, Hawaiians (Olivier, 1969), Japanese (Takigawa, 2005), Han Chinese and Weidun Neolithic southern Chinese (Wakebe, 2002) are somewhat distant from the Man Bac sample. The Man Bac series, as well as the Ban Chiang sample, are characterised as possessing proportionally longer forearms and lower limbs in comparison with modern Chinese and Japanese.

The results of stature estimation, using several sets of regression equations, are given in Table 6.3. As expected, estimated stature varied by formulae and the specific lone bone employed, with some of this variation caused by sample-specific limb ratio differences (see above). In order to assess the most suitable set of equations for Man Bac, the consistency of estimated statures were compared between the sets of regression formulae. Table 6.3 gives the difference in stature estimation based on comparisons between humeral and femoral lengths, and that based on comparisons between femoral and tibial lengths. In terms of humeral-femoral comparisons Stevenson (1929) and Fijii's (1960) formulae show the smallest differences. Examining estimates based on femoral and tibial lengths, Sangvichien et al.'s (1985) equations provide the smallest differences, more so even than the humeral-femoral comparisons, and are deemed the most appropriate functions for estimating Man Bac stature from the tibia and femur.

Accordingly, average estimated stature for the Man Bac series is 161.4cm (males) and 154.0cm (females). These values can be compared to prehistoric samples from Thailand (Domett, 2001; Pietrusewsky and Douglas, 2002) also based on

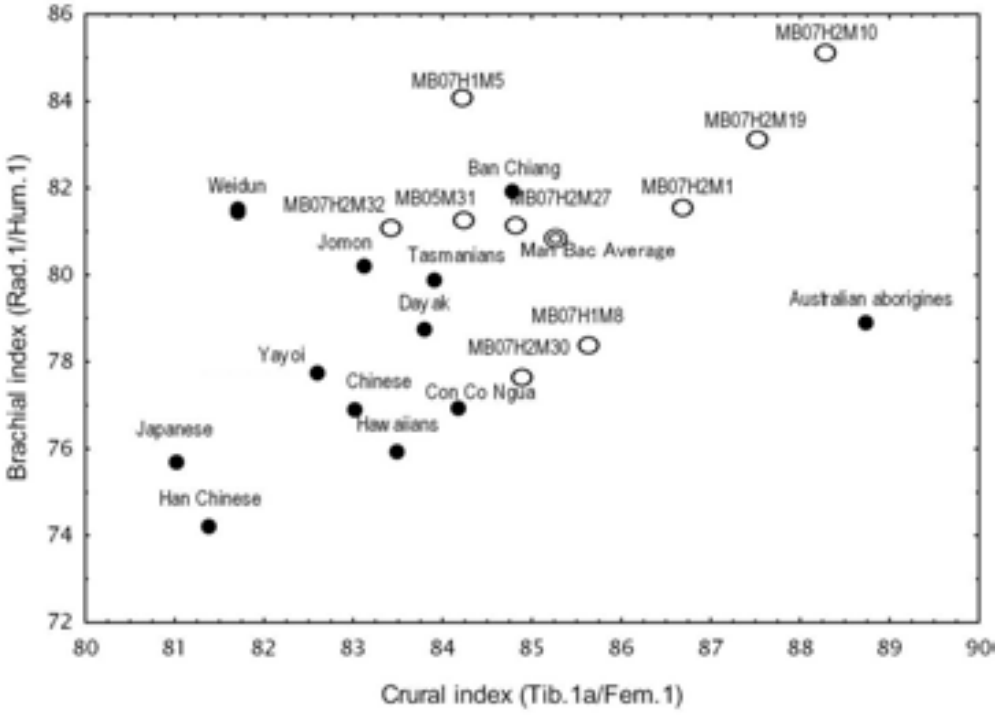

Figure 6.1 Crural and brachial indices for the Man Bac and comparative samples.

Sangvichien et al.'s (1985) equations: Ban Chiang males 166.2 cm, females 154.4 cm; Khok Phanom Di males 162.2, females, 154.3 cm; Bronze Age Nong Nor males 167.2 cm, females 156.1 cm; Bronze Age Ban Lum Khao males 164.7 cm, females 154.7 cm; Bronze-Iron Age Ban Na Di males 168.0 cm, females 155.9 cm. In terms of stature, at least, Mac Bac is closest to the near contemporaneous series from Khok Phanom Di.

DISCUSSION

Man Bac cross-sectional indices, expressing relative roundness of limb diaphyses, are, for the most part, consistent with neighbouring neolithic, Bronze and Iron Age samples and indicate an intermediate position between gracility and robusticity.

The brachial and crural indices are considered useful in evaluating ancestral features with respect to body proportions. Low values, reflecting shorter forearms or lower legs, are associated with cold climate adaptation. The Man Bac series, along with Ban Chiang, is characterised by relatively long forearms and lower limbs.

Stature estimation was carried out using several different sets of regression equations, with Sangvichien et al.'s (1985) functions derived from modern Thai and Chinese cadavers determined to be the most appropriate for the Man Bac series. Male and female Man Bac stature falls within the range of neighbouring prehistoric Thai samples, falling closest to the contemporaneous Khok Phanom Di series.

While the analysis of long bone morphometrics in this chapter is preliminary, the findings and reported data will contribute to more extensive studies addressing questions of physical activity, health, nutrition conditions and genetic relationships in comparison with other populations.

SUMMARY

This chapter has examined limb bone morphometrics of the Man Bac series in comparison with neighbouring assemblages. Relative to neolithic, Bronze and Iron Age samples from Thailand, Man Bac limb bones are neither particularly robust nor gracile. The limb length proportions represented by radial-humeral and tibial-femoral indices also fall in the global intermediate range. Regarding stature estimations, Sangvichien et al.'s (1985) formulae based on the lower limbs was determined to be the most appropriate for the Man Bac assemblage, providing mean stature estimates of 161.4 cm for males and 154.0 cm for females. These values are consistent with those seen in the near contemporaneous Khok Phanom Di series from Thailand.

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