CHAPTER 7

RESULTS PART 2:

CORRELATION ANALYSIS

7.1 INTRODUCTION

This chapter reports the results of the correlation and regression analyses carried out on the Australian Aboriginal groups measured by Birdsell.

To assess possible effects of covariation on the ecogeographic correlations, several initial analyses were carried out. These included separate correlation matrices for climatic variables and anthropometric variables. Also included are bivariate correlations between the anthropometric variables and age, using both the sample containing individual cases and the means of the sample groups.

Following this the ecogeographic correlations between the climatic variables and anthropometric measurements are reported. Both parametric (Pearson) and non-parametric (Spearman) correlations are included in the tables below. Any large difference between the two forms of correlation coefficient may indicate that non-normality or non-linearity has effected the size and significance of a correlation.

Australia is a vast continent and west to east exist quite different typographies, vegetation and climate (see Chapter 2). As a result, the sample was partitioned into eastern and western sections in order to elucidate any differences between the populations living in these different environments. The anthropometric variables for each sub-section were then subjected to correlation analysis (parametric only). The disadvantage with this methodology was the further reduction of group sample sizes, particularly for females.

Also included are the results of a multiple stepwise correlation analysis (MSR hereafter). This involved each anthropometric variable being correlated with all climatic variables. The rationale behind this analysis was the identification of a critical stressor: the aspect of climate that is seen to have the strongest effect on particular anthropometric measurement or index. It will also allow a comparison with the results of the stepwise regression analysis conducted by Macho and Freedman (1987) on Abbie's data set.

Finally, partial correlations were calculated to assess the effect that inter-correlation between body variables has had on the associations between body size and shape, and climate.

Although all correlations are reported, only those that are significant and above 0.45 (20% shared variance) will be considered important to the analysis. This cut-off point is arbitrary, however it was felt that correlations between climate and body morphology below this level of shared variance were likely to be meaningless in evolutionary terms. Of course it remains to be proven that correlations between human morphology and climate have any direct evolutionary meaning at all, or simply reflect co-correlated or coincidental processes. When discussing correlations in the text, the term 'very weak' will be used for correlations below 0.45; 'weak' will be used to describe correlations between 0.45 and 0.49; 'moderately strong' will be the term for correlations between 0.50 and 0.69, and 'strong' or 'very strong' for will indicate correlations over 0.70.

In the tables below, significant correlations of 0.45 and above are highlighted in bold type and the significance level is indicated by an asterisk: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$. "r" indicates Pearson's product-moment correlation coefficient, "ρ " (Rho) refers to Spearman's rank order correlation coefficient. "E" refers to the sample groups east of longitude 137° and "W" refers to the sample groups west of this longitude.

As a compromise between clarity and brevity, the climatic variables discussed in the text will be referred to by an abbreviation of the full term (as mentioned in Chapter 4). To recap, these abbreviations, which differ from those in the tables, are:

- Hottest Month (Mean Maximum Temperature of the Hottest Month);
- Coldest Month (Mean Minimum Temperature of the Coldest Month);
- Temperature Range (Annual Variation in Temperature)
- Annual Temperature (Average Annual Temperature)
- Most Humid Month (Relative Humidity of the Most Humid Month)
- Least Humid Month (Relative Humidity of the Least Humid Month)
- Humidity Range (Annual Variation in Relative Humidity)
- Annual Rainfall (Average Annual Rainfall)

Group sample sizes for all variables are: n = 57 (males) and n = 45 (females), except for bi-iliac breadth and relative bi-iliac (pelvic) breadth where n = 28 (males) and n = 17 (females).

7.2 RESULTS OF REGESSION AND CORRELATION PROCEDURES

7.2.1 Associations between climatic variables

The matrix of correlations between climatic variables is reported in Table 7.1. In most cases r and ρ agree in magnitude, direction and significance, with the only large differences occurring with Temperature Range and Annual Rainfall, both of which have very non-normal distributions (Figure 7.1).

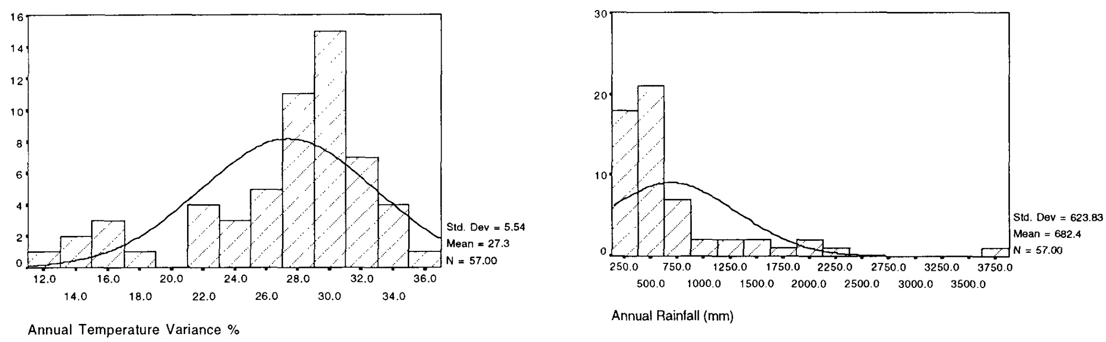

Figure 7.1: Histograms of Annual Temperature Variance and Annual Rainfall

As is seen in Table 7.1, Hottest Month has strong to moderately strong, negative correlations with the moisture variables Least Humid Month, Most Humid Month and Annual Rainfall. It also has moderately strong, positive correlations with Temperature Range and Annual Temperature. Coldest Month, on the other hand, has only a weak, positive correlation with Least Humid Month, a strong, negative correlation with Temperature Range and a moderately strong, positive correlation with Annual Rainfall. This highlights the hotter-drier/cooler-wetter dichotomy of climatic zones in Australia, although, by far, it is hot-dry zones that predominate.

Latitude has a negative association with temperature variables as might be expected, but more so with Coldest Month than Hottest Month. This indicates a greater seasonality in the south as revealed by the positive correlation between latitude and Temperature Range. There is also a north-south decline in average rainfall. The correlations with longitude reveal an east-west incline in temperature and a decline in moisture. The west also has more variation in yearly temperature and moisture than the east. The correlations indicate that winter temperatures are determined mainly by latitude, with colder winters in the south. Summer temperatures, meanwhile, are more closely related to longitude, with hotter summers in the arid west.

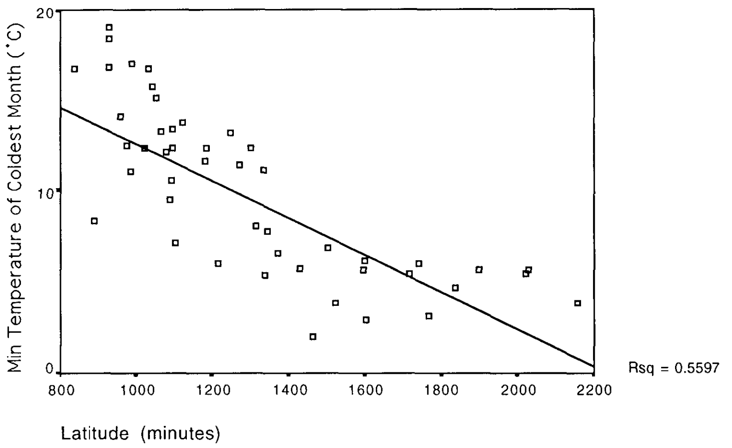

Figure 7.2: Bivariate scatterplot of Minimum Temperature of the Coldest Month vs Latitude

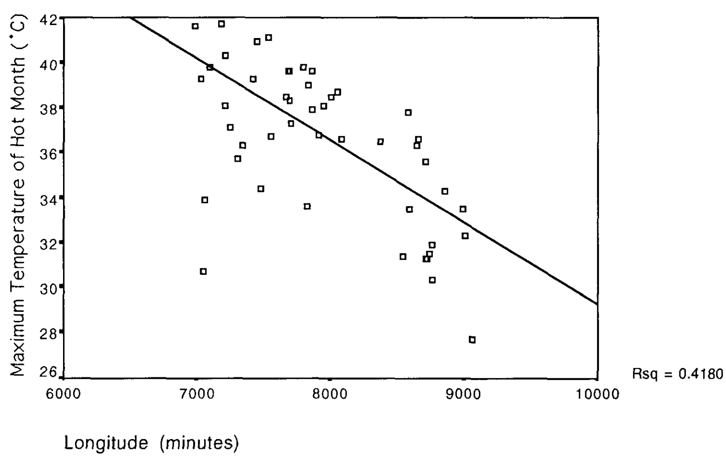

Figure 7.3: Bivariate scatterplot of Maximum Temperature of the Hottest Month vs Longitude

The size and direction of these correlations have important implications for the interpretation of the body/climate correlations presented below. For example, it might be expected that variables with a strong, positive correlation with temperature would also have a negative correlation with moisture variables, or vice versa. This, of course, makes it difficult to determine which selective force is operative on human morphology: heat or moisture, or a combination of both. Further, the failure of concordances in the morphological versus climate and climate versus climate correlations will also be of interest.

Table 7.1: Correlations between climatic variables of sample areas

Variables		Max Hot	Min Cold	RH Dry	RH Wet	Ann Temp Var	Ann RH Var	Av Ann Temp	Ann Rain	Absolute Latitude	Absolute Longitude
Max Hot	r	1.00									
	ρ	1.00									
Min Cold	r	-0.01	1.00								
	ρ	0.06	1.00								
RHWet	r	-0.73***	0.087	1.00							
	ρ	-0.73***	0.027	1.00							
RHDry	r	-0.85***	0.35**	0.75***	1.00						
	ρ	-0.72***	0.26	0.80***	1.00						
Ann Temp Var	r	0.63***	-0.79***	-0.52***	-0.79***	1.00					
	ρ	0.56***	-0.71***	-0.48***	-0.68***	1.00					
Ann RH Var	r	0.30*	-0.40**	0.20	-0.49***	0.50***	1.00				
	ρ	0.19	-0.31*	0.19	-0.27*	0.31*	1.00				
Av Ann Temp	r	0.64***	0.71***	-0.43***	-0.31*	-0.16	-0.12	1.00			
	ρ	0.62***	0.74***	-0.36**	-0.22	-0.22	0.04	1.00			
Ann Rain	r	-0.54***	0.54***	0.51***	0.74***	-0.76***	-0.44***	0.11	1.00		
	ρ	-0.30*	0.61***	0.46***	0.61***	-0.69***	-0.27*	0.33*	1.00		
Abs. Latitude	r	-0.35**	-0.75***	0.13	-0.002	0.37**	0.18	-0.88***	-0.43***	1.00	
	ρ	-0.14	-0.82***	-0.09	-0.17	0.48***	0.07	-0.74***	-0.72***	1.00	
Abs. Longitude	r	-0.65***	0.02	0.48***	0.66***	-0.41***	-0.35**	-0.31*	0.47***	NA	1.00
	ρ	-0.59***	-0.05	0.44***	0.47***	-0.26*	-0.28*	-0.40**	0.40**	NA	1.00

7.2.2 Associations between anthropometric variables

7.2.2.1 Age Correlations

The results of an analysis of secular change in Birdsell's populations were reported in Chapter 6. In order to assess the effect of age variation on the relationships between climate and human morphology, bivariate correlations were calculated between the group means for each variable and average age. The correlations between each individual's anthropometric measurements and age in years are also included to gauge the effect of advancing age on body and cranio-facial morphology. The limitation of this analysis is that the data are cross-sectional and that exact age was unknown for many individuals. With this in mind, the results may be cautiously interpreted as indicating that many anthropometric measurements change with age. In males, correlations between bi-iliac breadth, calf circumference and climate are likely to be affected by age differences between groups, as are the correlations with head breadth, total facial height, upper facial height, nose height, nose depth and mandibular depth. In females the correlations likely to be most affected are those involving weight, tibia length, biacromial and bi-iliac breadths, calf circumference, head breadth, head height, bizygomatic diameter, total facial height, upper facial height, nose depth and mandibular depth.

Table 7.2: Correlations between measurements of the body and face and age

Variable	Male Mean	Male Individual	Female Mean	Female Individual	Trends from Literature #
Weight kg	0.22	0.03	**0.48*** **	**0.14*** **	*Inc, Irr, Dec*
Stature mm	-0.20	**-0.15*** **	-0.16	**-0.18*** **	Irr, Dec
Hum L	-0.10	**-0.06***	-0.18	**-0.10** **	
Rad L	-0.15	**-0.13*** **	-0.27	**-0.18*** **	Irr
Fem L	-0.23	-0.05	-0.20	-0.05	
Tib L	-0.25	**-0.12*** **	**-0.33***	**-0.14*** **	Irr, Dec
Biac	0.15	**-0.15*** **	**0.39** **	**-0.15*** **	Irr, Dec
Bi-iliac	**0.49** **	**0.25*** **	**0.57***	**0.20***	
Sit H	-0.07	**-0.15*** **	0.11	**-0.19*** **	Irr, Dec
Calf C	**0.30***	**-0.07***	**0.59*** **	0.03	
Head L	-0.19	-0.04	0.15	0.04	Inc, Irr, Dec
Head B	**0.46*** **	**0.06***	**0.70*** **	**0.10** **	Inc, Irr, Dec
Head H	0.04	**-0.10*** **	**0.58*** **	-0.02	
Min Front D	-0.06	**-0.09*** **	0.21	**-0.16*** **	Inc, Irr, Dec
Bizyg	-0.08	**0.12*** **	**0.38** **	**0.13*** **	Inc, Irr
Bigon	0.09	**0.10*** **	0.24	**0.12*** **	Inc, Irr
Tot Fac H	**0.59*** **	**0.18*** **	**0.47*** **	**0.14*** **	Inc, Irr, Dec
Upp Fac H	**0.34** **	**0.12*** **	**0.33***	**0.17*** **	Inc, Irr, Dec
Nose H	**0.47*** **	**0.18*** **	0.21	**0.08***	Inc, Irr
Nose B	-0.03	**0.24*** **	0.27	**0.33*** **	Inc
Nose D	**0.42*** **	**0.12*** **	**0.39** **	0.02	
Mand D	**0.40** **	**0.23*** **	**0.35***	**0.30*** **	

(Groups means: male n = 57, female n = 45, except bi-iliac: male n = 28, female n = 17. Individual cases: male n = 1424, female n = 880. These figures represent total sample size: sample sizes for each variable may be lower than these due to missing cases. This is especially pertinent to bi-iliac breadth where male n = 563 and female n = 160. # Results from previous studies indicating change in variable with increasing age: Inc = Increase with age, Dec = decrease with age, Irr = irregular - contradictory trends. Plain type - from Lasker and Evans 1961, in *italics* - from Sinnett *et al.* 1973.)

These results are also compared with those of previous studies, as summarised in Lasker and Evans (1961: 208) and Sinnett *et al.* (1973). Overall, it appears that age changes in Birdsell's samples are similar, or the same, as those found in previous studies.

7.2.2.2 Anthropometric Inter-correlations

The inter-correlations between body measurements for males and females are presented in Tables 7.3 and 7.4. All male body measurements are positively and significantly correlated. In the male sample group weight has moderately strong correlations with linear body measurements such as stature and the limb segment lengths, and strong correlations with calf circumference and breadth and height measurements of the trunk. Stature, meanwhile, is very strongly correlated with all other linear body measurements, but has only moderately strong correlations with breadth and circumference measurements. The limb segment lengths are all highly intercorrelated, but have weaker relationships with breadth and circumference measurements: in particular tibia length has very weak correlations with these variables. Breadth measurements are moderately intercorrelated and sitting height has the most consistent correlations, being associated with both linear and lateral measurements.

Table 7.3: Matrix of correlations between male mean body variables

	Weight	Stature	Hum L	Rad L	Fem L	Tib L	Biac	Bi-iliac	Sit H	Calf C
Weight	1.00									
Stature	0.63***	1.00								
Hum L	0.66***	0.94***	1.00							
Rad L	0.65***	0.94***	0.92***	1.00						
Fem L	0.54***	0.96***	0.91***	0.88***	1.00					
Tib L	0.51***	0.96***	0.90***	0.93***	0.93***	1.00				
Biac	0.82***	0.65***	0.68***	0.64	0.57***	0.53***	1.00			
Bi-iliac	0.81***	0.54**	0.60***	0.54**	0.54**	0.44*	0.78***	1.00		
Sit H	0.72***	0.93***	0.86***	0.87***	0.84***	0.84***	0.75***	0.58***	1.00	
Calf C	0.82***	0.51***	0.54***	0.48***	0.43***	0.36**	0.81***	0.65***	0.66***	1.00

Table 7.4: Matrix of correlations between female mean body variables

	Weight	Stature	Hum L	Rad L	Fem L	Tib L	Biac	Bi-iliac	Sit H	Calf C
Weight	1.00									
Stature	0.19	1.00								
Hum L	0.26	0.93***	1.00							
Rad L	0.15	0.91***	0.90***	1.00						
Fem L	0.18	0.92***	0.90***	0.84***	1.00					
Tib L	0.11	0.95***	0.93***	0.93***	0.91***	1.00				
Biac	0.86***	0.42**	0.47***	0.38**	0.36*	0.31*	1.00			
Bi-iliac	0.72***	0.46	0.54*	0.52*	0.37	0.38	0.73***	1.00		
Sit H	0.35*	0.86***	0.74***	0.74***	0.74***	0.74***	0.54***	0.58*	1.00	
Calf C	0.92***	0.12	0.12	0.03	0.05	-0.02	0.83***	0.77***	0.36*	1.00

In the female sample weight exhibits no significant relationship with stature or limb length and only a weak correlation with sitting height. Calf circumference is also seen to have this pattern. This may reflect, in part, sexually dimorphic differences in human body morphology. These differences have important implications for the results of the ecogeographic correlation analysis to be reported below.

In Tables 7.5 and 7.6 the inter-correlations for cranio-facial variables are presented. Stature has also been included in the matrix as a *de facto* measure of total body size. As seen with the correlations for body variables, the pattern of correlation differs somewhat between the male and female sample groups. In males there are weak to moderately strong significant correlations between stature (body size) and all cranio-facial variables. In females, however, some of the correlations with stature are reduced in size and significance: in particular, those for head length, breadth and height, upper and mid-facial breadth and mandibular breadth. The inter-correlations between cranio-facial variables are broadly similar in both males and female groups. Where differences do occur, they involve the relationship between measurements of the cranium and breadth of upper and mid-face, and measurements of facial and nasal height. Differences also occur in the correlations between nasal measurements.

Table 7.5: Matrix of correlations between male mean cranio-facial variables.

	Stature	Head L	Head B	Head H	Min Front D	Bizyg	Bigon	Tot Fac H	Up Fac H	Nose H	Nose B	Nose D	Mand D
Stature	1.00												
Head L	**0.51*****	1.00											
Head B	0.40**	0.28*	1.00										
Head H	**0.60*****	0.43***	**0.45*****	1.00									
Min Front D	**0.56*****	0.40**	**0.63*****	**0.49*****	1.00								
Bizyg	**0.70*****	**0.55*****	**0.46*****	**0.51*****	**0.65*****	1.00							
Bigon	**0.66*****	0.43***	**0.57*****	**0.52*****	**0.63*****	**0.75*****	1.00						
Tot Fac H	0.43***	0.10	**0.56*****	0.44***	0.24	0.25	0.43***	1.0000					
Up Fac H	**0.62*****	0.23	**0.62*****	**0.54*****	0.37**	0.44***	**0.58*****	**0.87*****	1.00				
Nose H	**0.51*****	0.16	**0.62*****	**0.46*****	0.29*	0.29*	**0.49*****	**0.87*****	**0.93*****	1.00			
Nose B	**0.62*****	0.27*	0.32*	**0.49*****	**0.65*****	**0.66*****	**0.75*****	0.28*	0.43***	0.32*	1.00		
Nose D	0.32*	0.29*	**0.57*****	**0.48*****	0.27*	0.23	0.44***	**0.57*****	**0.55*****	**0.58*****	0.21	1.00	
Mand D	0.44***	0.09	0.43***	**0.48*****	0.37**	**0.47*****	**0.58*****	**0.71*****	**0.71*****	**0.60*****	**0.53*****	**0.47*****	1.00

Table 7.6: Matrix of correlations between female mean cranio-facial variables.

	Stature	Head L	Head B	Head H	Min Front D	Bizyg	Bigon	Tot Fac H	Up Fac H	Nose H	Nose B	Nose D	Mand D
Stature	1.00												
Head L	0.35*	1.00											
Head B	0.17	0.44**	1.00										
Head H	0.19	0.29	**0.59*****	1.00									
Min Front D	0.39**	**0.60*****	**0.58*****	0.38*	1.00								
Bizyg	**0.46****	**0.67*****	**0.73*****	**0.46****	**0.78*****	1.00							
Bigon	**0.50*****	**0.55*****	**0.58*****	0.34*	**0.73*****	**0.80*****	1.00						
Tot Fac H	0.35*	0.40**	**0.60*****	**0.56*****	**0.56*****	**0.59*****	**0.57*****	1.00					
Up Fac H	**0.53*****	**0.46*****	**0.49*****	0.41**	0.44**	**0.57*****	**0.56*****	**0.81*****	1.00				
Nose H	**0.56*****	0.29	0.40**	0.39**	0.39**	0.38**	**0.45****	**0.76*****	**0.88*****	1.00			
Nose B	**0.58*****	0.26	0.39**	0.40**	**0.55*****	**0.53*****	**0.67*****	**0.54*****	**0.54*****	**0.54*****	1.00		
Nose D	0.25	0.37*	**0.62*****	0.44**	**0.47*****	**0.61*****	**0.59*****	**0.62*****	**0.51*****	**0.46****	0.36*	1.00	
Mand D	0.16	0.26	0.42**	**0.51*****	**0.53*****	**0.57*****	**0.46****	**0.71*****	0.43**	0.31*	0.36*	**0.50*****	1.00

Table 7.7: Pearson's and Spearman's correlation coefficients between mean body measurements and climate: males.

		Max Hot	**Min Cold**	**Ann Temp Var**	**Av Ann Temp**	**RH Wet**	**RH Dry**	**Ann RH Var**	**Ann Rain**	**Absolute Latitude**	**Absolute Longitude**
Weight	*r*	0.31*	-0.19	0.34**	0.10	-0.17	-0.40**	0.36**	-0.34**	0.06	-0.27*
	ρ	0.26*	-0.12	0.16	0.18	-0.15	-0.22	0.38**	-0.14	0.08	-0.24
Stature	*r*	**0.59*****	0.08	0.30*	**0.54*****	**-0.46*****	**-0.58*****	0.25	-0.33*	-0.36**	-0.38**
	ρ	**0.58*****	0.21	0.13	**0.64*****	**-0.50*****	**-0.43*****	0.18	0.07	-0.36**	-0.32*
Hum L	*r*	**0.49*****	0.002	0.30*	0.39**	-0.38**	**-0.52*****	0.27*	-0.38**	-0.18	-0.40***
	ρ	**0.48*****	0.17	0.02	**0.57*****	-0.41**	-0.34***	0.19	0.06	-0.25	-0.34**
Rad L	*r*	**0.62*****	0.09	0.31*	**0.53*****	**-0.46*****	**-0.58*****	0.25	-0.37**	-0.31*	-0.43***
	ρ	**0.59*****	0.23	0.13	**0.63*****	**-0.48*****	**-0.44*****	0.20	-0.002	-0.29*	-0.37**
Fem L	*r*	**0.55*****	0.01	0.33*	**0.47*****	**-0.44*****	**-0.55*****	0.24	-0.31*	-0.32*	-0.34*
	ρ	**0.56*****	0.15	0.19	**0.61*****	**-0.50*****	**-0.45*****	0.18	0.07	-0.35**	-0.27*
Tib L	*r*	**0.65*****	0.11	0.32*	**0.59*****	**-0.49*****	**-0.62*****	0.27*	-0.35**	-0.40**	**-0.45*****
	ρ	**0.61*****	0.22	0.16	**0.66*****	**-0.51*****	**-0.48*****	0.23	0.009	-0.37**	-0.40**
Biac	*r*	0.20	-0.11	0.21	0.09	-0.06	-0.26*	0.31*	-0.24	0.05	-0.18
	ρ	0.14	-0.04	-0.02	0.19	-0.03	-0.06	0.29*	0.03	0.001	-0.15
Bi-iliac	*r*	0.08	**-0.64*****	**0.54****	**-0.45***	-0.06	-0.30	0.36	**-0.50****	**0.55****	0.09
	ρ	0.22	**-0.57****	**0.50****	-0.36	-0.19	-0.34	0.32	-0.40*	**0.46***	0.06
Sit H	*r*	**0.51*****	0.17	0.19	**0.55*****	-0.37**	**-0.46*****	0.20	-0.21	-0.39**	-0.28*
	ρ	**0.50*****	0.25	0.02	**0.64*****	-0.39**	-0.33*	0.21	0.16	-0.37**	-0.26*
Calf C	*r*	0.01	0.03	-0.02	0.09	0.15	-0.04	0.26	0.003	-0.06	0.02
	ρ	0.03	0.06	-0.17	0.21	0.13	0.11	0.25	0.29*	-0.12	-0.02

Table 7.7: Pearson's and Spearman's correlation coefficients between mean body measurements and climate: males.

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
Weight	*r*	0.31*	-0.19	0.34**	0.10	-0.17	-0.40**	0.36**	-0.34**	0.06	-0.27*
	ρ	0.26*	-0.12	0.16	0.18	-0.15	-0.22	0.38**	-0.14	0.08	-0.24
Stature	*r*	**0.59*** **	0.08	0.30*	**0.54*** **	**-0.46*** **	**-0.58*** **	0.25	-0.33*	-0.36**	-0.38**
	ρ	**0.58*** **	0.21	0.13	**0.64*** **	**-0.50*** **	**-0.43*** **	0.18	0.07	-0.36**	-0.32*
Hum L	*r*	**0.49*** **	0.002	0.30*	0.39**	-0.38**	**-0.52*** **	0.27*	-0.38**	-0.18	-0.40***
	ρ	**0.48*** **	0.17	0.02	**0.57*** **	-0.41**	-0.34***	0.19	0.06	-0.25	-0.34**
Rad L	*r*	**0.62*** **	0.09	0.31*	**0.53*** **	**-0.46*** **	**-0.58*** **	0.25	-0.37**	-0.31*	-0.43***
	ρ	**0.59*** **	0.23	0.13	**0.63*** **	**-0.48*** **	**-0.44*** **	0.20	-0.002	-0.29*	-0.37**
Fem L	*r*	**0.55*** **	0.01	0.33*	**0.47*** **	**-0.44*** **	**-0.55*** **	0.24	-0.31*	-0.32*	-0.34*
	ρ	**0.56*** **	0.15	0.19	**0.61*** **	**-0.50*** **	**-0.45*** **	0.18	0.07	-0.35**	-0.27*
Tib L	*r*	**0.65*** **	0.11	0.32*	**0.59*** **	**-0.49*** **	**-0.62*** **	0.27*	-0.35**	-0.40**	**-0.45*** **
	ρ	**0.61*** **	0.22	0.16	**0.66*** **	**-0.51*** **	**-0.48*** **	0.23	0.009	-0.37**	-0.40**
Biac	*r*	0.20	-0.11	0.21	0.09	-0.06	-0.26*	0.31*	-0.24	0.05	-0.18
	ρ	0.14	-0.04	-0.02	0.19	-0.03	-0.06	0.29*	0.03	0.001	-0.15
Bi-iliac	*r*	0.08	**-0.64*** **	**0.54** **	**-0.45* **	-0.06	-0.30	0.36	**-0.50** **	**0.55** **	0.09
	ρ	0.22	**-0.57** **	**0.50** **	-0.36	-0.19	-0.34	0.32	-0.40*	**0.46* **	0.06
Sit H	*r*	**0.51*** **	0.17	0.19	**0.55*** **	-0.37**	**-0.46*** **	0.20	-0.21	-0.39**	-0.28*
	ρ	**0.50*** **	0.25	0.02	**0.64*** **	-0.39**	-0.33*	0.21	0.16	-0.37**	-0.26*
Calf C	*r*	0.01	0.03	-0.02	0.09	0.15	-0.04	0.26	0.003	-0.06	0.02
	ρ	0.03	0.06	-0.17	0.21	0.13	0.11	0.25	0.29*	-0.12	-0.02

Table 7.8: Pearson's and Spearman's correlation coefficients between mean body measurements and climate: females.

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
Weight	*r*	-0.07	-0.28	0.18	-0.25	0.12	-0.10	0.30*	-0.30*	0.38**	-0.05
	ρ	-0.03	-0.25	0.002	-0.10	0.11	-0.07	0.36*	-0.21	0.36*	-0.14
Stature	*r*	**0.51*****	0.18	0.19	**0.51*****	-0.31*	**-0.51*****	0.28	-0.15	-0.42**	-0.42**
	ρ	0.42**	**0.45****	-0.06	**0.66*****	-0.25	-0.25	0.22	0.27	**-0.53*****	-0.24
Hum L	*r*	**0.52*****	0.05	0.30*	0.40**	-0.33*	**-0.58*****	0.35*	-0.35*	-0.24	**-0.50*****
	ρ	**0.47*****	0.38**	0.01	**0.64*****	-0.23	-0.30*	0.32*	0.21	**-0.47*****	-0.24
Rad L	*r*	**0.59*****	0.17	0.25	**0.54*****	-0.43**	**-0.61*****	0.25	-0.22	-0.41**	**-0.49*****
	ρ	**0.49*****	**0.50*****	-0.04	**0.67*****	-0.38**	-0.35*	0.13	0.13	**-0.50*****	-0.34*
Fem L	*r*	**0.55*****	0.09	0.29	**0.49*****	-0.33*	**-0.57*****	0.34*	-0.22	-0.40**	-0.38**
	ρ	0.40**	0.31*	0.04	**0.59*****	-0.22	-0.30*	0.28	0.28	**-0.54*****	-0.04
Tib L	*r*	**0.66*****	0.12	0.34*	**0.56*****	-0.48***	**-0.67*****	0.27	-0.27	-0.44**	**-0.54*****
	ρ	**0.54*****	0.39**	0.07	**0.68*****	-0.39**	-0.37*	0.18	0.21	**-0.53*****	-0.26
Biac	*r*	0.002	-0.24	0.19	-0.16	0.12	-0.14	0.36*	-0.27	0.28	-0.13
	ρ	0.04	-0.16	-0.06	0.02	0.16	-0.01	0.37*	0.01	0.20	-0.16
Bi-iliac	*r*	-0.12	-0.30	0.16	-0.24	0.04	-0.07	0.16	-0.23	0.37	0.18
	ρ	0.06	-0.21	0.14	-0.17	-0.06	-0.09	0.19	-0.09	0.33	0.09
Sit H	*r*	0.32*	0.25	0.01	**0.46*****	-0.09	-0.28	0.27	0.04	-0.42**	-0.20
	ρ	0.30*	0.38*	-0.18	**0.58*****	-0.10	-0.10	0.27	0.35*	-0.44**	-0.18
Calf C	*r*	-0.26	-0.21	-0.01	-0.31*	0.26	0.12	0.20	-0.09	0.38**	0.15
	ρ	-0.10	-0.17	-0.13	-0.07	0.20	0.04	0.34*	-0.03	0.25	-0.10

Table 7.9: Pearson's correlation coefficients between mean body measurements and climate and location: male eastern and western sub-samples. (E: n = 16; W: n = 41, except bi-iliac n = 12).

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Abs Latitude
Weight	E	0.30	-0.68**	0.71**	-0.45	-0.48	-0.58*	0.41	-0.71**	0.57*
	W	0.13	0.25	-0.16	0.27	0.12	-0.06	0.21	0.40**	-0.30
Stature	E	0.52*	-0.51*	0.66**	-0.14	-0.57*	-0.62**	0.37	-0.69**	0.29
	W	0.36*	0.62***	-0.38*	0.75***	-0.21	-0.21	-0.12	0.59***	-0.81***
Hum L	E	0.35	-0.57*	0.64**	-0.27	-0.45	-0.52*	0.34	-0.61*	0.40
	W	0.20	0.67***	-0.53***	0.65***	-0.07	-0.004	-0.10	0.52***	-0.68***
Rad L	E	0.57*	-0.43	0.62*	-0.04	-0.60*	-0.60*	0.32	-0.61*	0.20
	W	0.40**	0.63***	-0.36*	0.72***	-0.19	-0.20	-0.10	0.45**	-0.70***
Fem L	E	0.49	-0.46	0.60*	-0.10	-0.56*	-0.57*	0.30	-0.60*	0.24
	W	0.29	0.47**	-0.28	0.63***	-0.17	-0.16	-0.10	0.57***	-0.74***
Tib L	E	0.63*	-0.35	0.57*	0.06	-0.56*	-0.59*	0.34	-0.59*	0.11
	W	0.37*	0.62***	-0.37*	0.76***	-0.21	-0.21	-0.12	0.53***	-0.81***
Biac	E	0.09	-0.68**	0.63**	-0.59*	-0.30	-0.50*	0.46	-0.66**	0.69**
	W	0.14	0.37*	-0.27	0.37*	0.14	0.04	0.16	0.45**	-0.40**
Bi-iliac	E	0.002	-0.75***	0.64**	-0.72**	-0.14	-0.42	0.49	-0.63**	0.79***
	W	0.33	-0.37	0.72**	0.40	0.06	-0.28	0.09	-0.25	0.07
Sit H	E	0.40	-0.62*	0.70**	-0.32	-0.52*	-0.59*	0.38	-0.72**	0.44
	W	0.43**	0.67***	-0.39*	0.79***	-0.19	-0.23	-0.07	0.60***	-0.82***
Calf C	E	0.17	-0.72**	0.69**	-0.49	-0.47	-0.54*	0.35	-0.71**	0.62*
	W	0.03	0.39*	-0.36*	0.31*	0.29	0.12	0.31*	0.60***	-0.39*

Table 7.10: Pearson's correlation coefficients between mean body measurements and climate: eastern and western female sub-samples. (East: n = 8; West: n = 37, except bi-iliac n = 9).

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Abs Latitude
Weight	E	-0.18	-0.72*	0.59	-0.68	-0.15	-0.51	0.37	-0.70*	0.71*
	W	-0.05	0.004	-0.03	-0.09	0.20	-0.06	0.35*	-0.12	0.18
Stature	E	0.08	-0.26	0.26	-0.16	-0.25	-0.20	0.02	-0.42	0.18
	W	0.24	0.57***	-0.38*	0.61***	-0.02	-0.12	0.09	0.61***	-0.73***
Hum L	E	-0.21	-0.32	0.21	-0.37	0.01	-0.15	0.14	-0.42	0.40
	W	0.25	0.49**	-0.30	0.53**	-0.01	-0.11	0.09	0.40*	-0.61***
Rad L	E	-0.11	-0.22	0.17	-0.21	-0.09	-0.08	0.02	-0.34	0.24
	W	0.42**	0.56***	-0.25	0.68***	-0.22	-0.34*	-0.01	0.48**	-0.74***
Fem L	E	0.06	-0.24	0.24	-0.17	-0.20	-0.18	0.04	-0.40	0.19
	W	0.29	0.41*	-0.19	0.57***	-0.03	-0.22	0.16	0.49**	-0.70***
Tib L	E	0.14	-0.23	0.26	-0.10	-0.33	-0.20	-0.03	-0.39	0.13
	W	0.42**	0.53***	-0.23	0.71***	-0.22	-0.33*	-0.02	0.57***	-0.82***
Biac	E	-0.15	-0.75*	0.63	-0.69	-0.15	-0.53	0.39	-0.75*	0.73*
	W	-0.02	0.13	-0.14	0.01	0.28	0.04	0.37*	0.10	0.003
Bi-iliac	E	-0.52	-0.54	0.31	-0.70*	0.18	-0.25	0.35	-0.52	0.74*
	W	0.62	0.47	0.44	0.56	-0.22	-0.37	0.16	0.01	-0.55
Sit H	E	0.05	-0.46	0.44	-0.33	-0.32	-0.34	0.11	-0.55	0.41
	W	0.22	0.61***	-0.44**	0.62***	0.09	-0.04	0.17	0.63***	-0.72***
Calf C	E	-0.26	-0.74*	0.58	-0.73*	-0.13	-0.50	0.38	-0.68	0.76*
	W	-0.08	0.12	-0.16	-0.03	0.25	0.03	0.34*	0.05	0.08

(Range for bi-iliac in western tribes is confined to southern half of continent only.)

Table 7.11: Multiple stepwise regression analysis on male body measurements.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
	Percent Shared Variance									
Weight	.	.	.	.	.	15.79**	.	.	0.40	0.16**
Stature	34.98***	.	.	.	.	.	.	.	0.59	0.35***
Hum L	.	.	.	5.84*	.	26.79***	.	.	0.57	0.33***
Rad L	38.07***	.	.	.	.	.	.	.	0.62	0.38***
Fem L	30.53***	.	.	.	.	.	.	.	0.55	0.31***
Tib L	42.56***	.	.	5.05*	.	9.60**	.	.	0.76	0.57***
Biac	.	.	.	.	.	.	9.41*	.	0.31	0.09*
Bi-iliac	.	40.72***	.	.	.	.	.	.	0.64	0.41***
Sit H	.	9.85**	.	30.48***	.	.	.	.	0.64	0.40***
Calf C	.	.	.	.	.	.	.	.	.	.

Table 7.12: Multiple stepwise regression analysis on female body measurements.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
	Percent Shared Variance									
Weight	.	.	.	.	.	.	9.25*	.	0.30	0.09*
Stature	.	.	.	11.46**	.	26.29***	.	.	0.61	0.38***
Hum L	.	.	.	.	.	34.14***	.	.	0.58	0.34***
Rad L	.	11.25**	.	.	.	36.99***	.	.	0.69	0.48***
Fem L	.	.	.	8.30*	.	32.75***	6.40*	.	0.69	0.47***
Tib L	.	.	.	10.30*	.	45.36***	.	.	0.75	0.56***
Biac	.	.	.	.	.	.	12.83*	.	0.36	0.13*
Bi-iliac	.	.	.	.	.	.	.	.	.	
Sit H	.	.	.	21.19**	.	.	11.62**	.	0.57	0.33***
Calf C	.	.	.	9.55*	.	.	.	.	0.31	0.10*

Table 7.13: Complete and partial correlations between mean body measurements and climate: males.

Variables	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
Weight	0.31*	-0.19	0.34**	0.10	-0.17	-0.40**	0.36**	-0.34**
age	**0.49*** **	-0.20	0.44***	0.18	-0.33*	**-0.56*** **	0.37**	-0.42***
stature	-0.09	-0.31*	0.21	-0.36**	0.17	0.05	0.27*	-0.18
Stature	**0.59*** **	0.08	0.30*	**0.54*** **	**-0.46*** **	**-0.58*** **	0.25	-0.33*
age	**0.58*** **	0.08	0.26	**0.51*** **	-0.43***	**-0.56*** **	0.26	-0.30*
Hum L	**0.49*** **	0.003	0.30*	0.39**	-0.38**	**-0.52*** **	0.27*	-0.38**
age	**0.50*** **	0.004	0.28*	0.38**	-0.38**	**-0.53*** **	0.28*	-0.37**
weight	0.39**	0.18	0.10	0.43***	-0.35**	-0.37**	0.05	-0.22
stature	-0.24	-0.21	0.04	-0.41**	0.20	0.10	0.12	-0.23
Rad L	**0.62*** **	0.09	0.31*	**0.53*** **	**-0.46*** **	**-0.58*** **	0.25	-0.36**
age	**0.63*** **	0.09	0.28*	**0.51*** **	**-0.45*** **	**-0.57*** **	0.25	-0.34**
weight	**0.57*** **	0.28*	0.13	**0.62*** **	**-0.46*** **	**-0.46*** **	0.02	-0.20
stature	0.22	0.04	0.09	0.08	-0.08	-0.12	0.05	-0.17
Fem L	**0.55*** **	0.01	0.33*	**0.47*** **	-0.44***	**-0.55*** **	0.24	-0.31*
age	**0.52*** **	0.01	0.28*	0.44***	-0.38**	**-0.52*** **	0.25	-0.27*
weight	**0.48*** **	0.13	0.19	**0.50*** **	-0.41**	-0.44***	0.07	-0.16
stature	-0.06	-0.23	0.16	-0.17	0.03	0.01	0.02	0.01
Tib L	**0.65*** **	0.11	0.32*	**0.59*** **	**-0.49*** **	**-0.62*** **	0.27*	-0.35**
age	**0.63*** **	0.12	0.26*	**0.56*** **	-0.43***	**-0.59*** **	0.28*	-0.31*
weight	**0.60*** **	0.24	0.18	**0.63*** **	**-0.47*** **	**-0.53*** **	0.11	-0.22
stature	0.38**	0.12	0.10	0.30*	-0.18	-0.27*	0.12	-0.14
Biac	0.20	-0.11	0.21	0.09	-0.06	-0.26*	0.31*	-0.25
age	0.31*	-0.11	0.27*	0.15	-0.16	-0.37**	0.31*	-0.29*
weight	-0.11	0.09	-0.14	0.02	0.14	0.12	0.02	0.07
stature	-0.31*	-0.21	0.01	-0.41***	0.36***	0.19	0.20	-0.04
Bi-iliac	0.08	**-0.64*** **	**0.54** **	**-0.45* **	-0.06	-0.29	0.36	**-0.49** **
age	0.31	**-0.62*** **	**0.62*** **	-0.31	-0.42*	**-0.56** **	0.38	**-0.65*** **
weight	**-0.49** **	-0.32	-0.04	**-0.49** **	0.42*	0.34	0.002	0.10
stature	-0.35	**-0.60*** **	0.36	**-0.69*** **	0.21	0.02	0.19	-0.30
Sit H	**0.51*** **	0.17	0.19	**0.55*** **	-0.37**	**-0.46*** **	0.20	-0.21
age	**0.55*** **	0.17	0.17	**0.56*** **	-0.39**	**-0.48*** **	0.20	-0.20
weight	0.44***	**0.45*** **	-0.09	**0.70*** **	-0.36**	-0.28*	-0.10	0.06
stature	-0.12	0.25	-0.27*	0.16	0.18	0.26	-0.10	0.28*
Calf C	0.006	0.03	-0.02	0.09	0.15	-0.04	0.26	0.003
age	0.17	0.02	0.08	0.19	0.003	-0.20	0.27*	-0.07
weight	**-0.46*** **	0.32*	**-0.55*** **	0.01	**0.52*** **	**0.55*** **	-0.08	**0.53*** **
stature	-0.43***	-0.02	-0.21	-0.26	**0.51*** **	0.37**	0.15	0.21

Table 7.14: Complete and partial correlations between mean body measurements and climate: females.

	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
Weight	-0.07	-0.28	0.18	-0.25	0.12	-0.10	0.30*	-0.30*
age	0.22	-0.36*	0.44**	-0.15	-0.20	**-0.47*** **	0.32*	**-0.51*** **
stature	-0.20	-0.33*	0.14	-0.42**	0.19	-0.0004	0.27	-0.28
Stature	**0.51*** **	0.18	0.19	**0.51*** **	-0.31*	**-0.51*** **	0.28	-0.15
age	**0.50*** **	0.20	0.14	**0.49*** **	-0.27	**-0.51*** **	0.29	-0.11
Hum L	**0.52*** **	0.05	0.30*	0.40**	-0.33*	**-0.58*** **	0.35*	-0.35*
age	**0.51*** **	0.07	0.26	0.37*	-0.29	**-0.58*** **	0.36*	-0.32*
weight	**0.56*** **	0.14	0.27	**0.50*** **	-0.38*	**-0.58*** **	0.29	-0.29
stature	0.17	-0.32*	0.35*	-0.25	-0.13	-0.34*	0.25	**-0.57*** **
Rad L	**0.59*** **	0.17	0.25	**0.54*** **	-0.43**	**-0.61*** **	0.25	-0.22
age	**0.54*** **	0.20	0.17	**0.51*** **	-0.35*	**-0.57*** **	0.27	-0.16
weight	**0.61*** **	0.23	0.23	**0.61*** **	**-0.46** **	**-0.60*** **	0.22	-0.18
stature	0.36*	0.02	0.20	0.21	-0.37*	-0.40**	-0.01	-0.20
Fem L	**0.55*** **	0.09	0.29	**0.49*** **	-0.33*	**-0.57*** **	0.34*	-0.22
age	**0.53*** **	0.11	0.24	**0.46** **	-0.27	**-0.56*** **	0.35*	-0.18
weight	**0.57*** **	0.15	0.27	**0.56*** **	-0.36*	**-0.57*** **	0.30*	-0.18
stature	0.24	-0.20	0.30*	0.05	-0.12	-0.30*	0.21	-0.22
Tib L	**0.66*** **	0.12	0.34*	**0.56*** **	**-0.48*** **	**-0.67*** **	0.27	-0.27
age	**0.60*** **	0.14	0.25	**0.52*** **	-0.38*	**-0.62*** **	0.30*	-0.20
weight	**0.67*** **	0.15	0.33*	**0.61*** **	**-0.50*** **	**-0.67*** **	0.25	-0.26
stature	**0.66*** **	-0.20	**0.54*** **	0.27	**-0.63*** **	**-0.71*** **	0.01	-0.44**
Biac	0.001	-0.24	0.19	-0.16	0.12	-0.14	0.36*	-0.27
age	0.25	-0.29	0.40**	-0.07	-0.12	-0.43**	0.37*	-0.42**
weight	0.13	0.005	0.08	0.11	0.04	-0.10	0.20	-0.02
stature	-0.27	-0.36*	0.13	**-0.49*** **	0.29	0.10	0.28	-0.23
Bi-iliac	-0.12	-0.30	0.16	-0.24	0.04	-0.07	0.16	-0.23
age	0.40	-0.17	0.30	0.10	-0.44	-0.44	0.16	-0.36
weight	-0.41	0.21	-0.44	-0.06	0.38	0.44	-0.14	0.37
stature	-0.43	-0.23	-0.04	-0.32	0.27	0.19	0.05	-0.01
Sit H	0.32*	0.25	0.01	**0.46*** **	-0.09	-0.28	0.27	0.04
age	0.43**	0.24	0.06	**0.51*** **	-0.18	-0.40**	0.27	0.01
weight	0.37*	0.38**	-0.05	**0.60*** **	-0.14	-0.26	0.18	0.17
stature	-0.28	0.18	-0.31*	0.04	0.39**	0.38**	0.06	0.35*
Calf C	-0.26	-0.21	-0.01	-0.31*	0.26	0.12	0.20	-0.09
age	0.05	-0.31*	0.29	-0.20	-0.10	-0.28	0.22	-0.32*
weight	**-0.51*** **	0.14	**-0.45** **	-0.20	0.40**	**0.55*** **	-0.22	**0.52*** **
stature	-0.38*	-0.24	-0.03	-0.43**	0.32*	0.21	0.18	-0.07

7.2.3 Body size and climate in adult male and female Australian Aborigines

The correlations between body size variables and climate are presented in Tables 7.7 to 7.14.

7.2.3.1 Weight

Bergmann's rule predicts that weight should be negatively associated with temperature. In this analysis correlations between weight and Coldest Month produce negative coefficients in both the male and females samples, however they are non-significant (Tables 7.7 and 7.8). In fact, no correlation reaches the 0.45 criterion.

The very weak correlations that are present suggest that male weight tends to be greater in areas that are hotter and drier (Figure 7.4), and both males and females are heavier in areas with a greater annual variation in temperature and moisture. The results of the MSR analysis reinforce the bivariate results, but emphasise the pre-eminence of moisture over temperature (Tables 7.11 and 7.12).

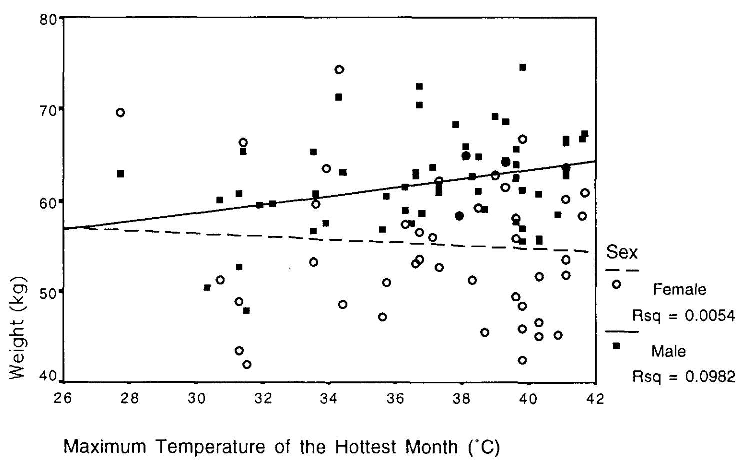

Figure 7.4: Bivariate scatterplot of Male and Female Weight vs Maximum Temperature of the Hottest Month

In males the overall pattern does not seem to be directly related to latitude, however there is a very weak, negative correlation with longitude, indicating a slight west to east decline in average male body weight. A different pattern is seen in the female group with a very weak, significant, positive relationship with latitude, but no relationship with longitude.

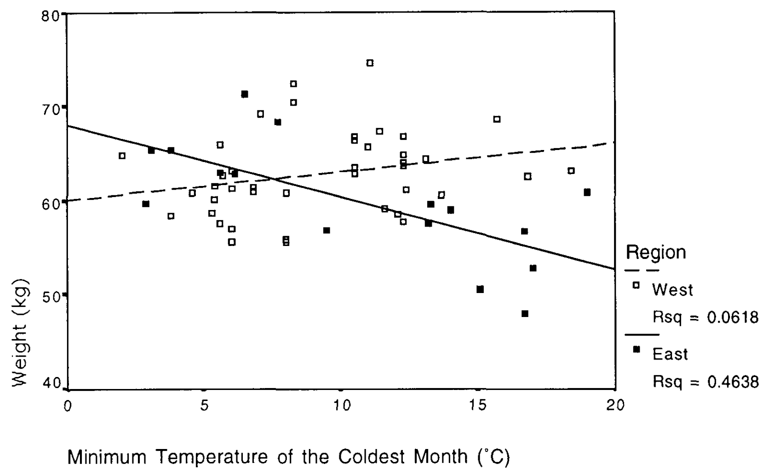

Figure 7.5: Bivariate scatterplot of Male Weight vs Minimum Temperature of the Coldest Month: Est/West sub-samples

When eastern and western sub-samples are considered a different pattern emerges (Tables 7.9 and 7.10). In the eastern male sample weight has moderately strong to strong, negative correlations with Coldest Month (Figure 7.5), Annual Rainfall, and Least Humid Month and a positive correlation with Temperature Range. The western male sample, meanwhile, produces only one significant, positive correlation with Annual Rainfall, however this below 0.45.

In females the differences between the east and west sub-samples follow a similar pattern to that seen with the males, but significance levels differ because of the very small sample size of the eastern female group (n = 8). The only significant correlations in the east are with Coldest Month and Annual Rainfall. In the western female sample there is a single very weak, positive correlation with Humidity Range.

Thus in the east there is a Bergmann-like relationship between weight and temperature, which is clearly absent in the west. It could be that in the better-watered east, temperature might be the critical factor affecting weight, whilst in the more arid west, moisture is more important - perhaps indirectly via biomass. It is also possible that demographic factors are involved, as will be discussed at a later time.

In looking at partial correlations (Tables 7.13 and 7.14) it is seen that when age is removed as a co-factor the correlations between weight and Hottest Month and Least Humid Month rise above 0.45, with over 30% of variation in weight being explained by variation in Least Humid Month. In the female sample this effect is somewhat more marked. When one controls for age, the correlation between Coldest Month and weight becomes significant, and moderately strong relationships appear with Temperature Range and Least Humid Month. This would suggest that age disparities between the groups have affected the size of some correlations.

When stature is controlled for, however, the correlation between Hottest Month and weight in males disappears, and a significant, but very weak, negative relationship appears with Coldest Month and Annual Temperature. In females, the negative correlations between weight and Coldest Month and Annual Temperature also become significant. Thus it would appear that populations in areas with cold winters and cooler average yearly temperatures are somewhat heavier for their height than those who live in areas where winters are milder and average temperatures higher. The significant correlation between weight and Annual Rainfall is also lost, suggesting that there are no real differences in weight for height between populations in areas of high and low rainfall.

7.2.3.2 Stature

The absence of a negative relationship between weight and temperature can be explained primarily by the geographic patterning of stature, which in both males and females is positively related to temperature. However, it should be noted that only in males is there a significant relationship between stature and body weight (Tables 7.3 and 7.4), but this may be due to age related factors (Table 7.2). Stature has moderately strong and highly significant. positive correlations with Hottest Month (Figure 7.6) and Annual Temperature and these correlations appear stable (ie. the parametric and non-parametric correlations are similar). If stature is taken as the measure of body size, this result is clearly contra to the expectations of Bergmann's rule. There are also moderately strong and highly significant, negative correlations between humidity variables and stature, with the smallest male stature occurring in regions of high humidity. Given the strong negative correlations between temperature and humidity (Table 7.1), this finding is not unexpected, however whilst the MSR results confirm that Hottest Month is the most influential factor in males, in females it is Least Humid Month, with some additional variance shared with Annual Temperature. Overall, climate accounts for 35% of variance in male stature and 38% of female stature.

The full-sample correlations also reveal slight north-to-south and west-to-east declines in male and female stature, however the correlations are very weak.

When the east-west sub-samples are considered a very different picture emerges. In the east, male stature has moderately strong, positive correlations with Hottest Month and Temperature Range and a Bergmann-like negative relationship with Coldest Month (Figure 7.7). There are also moderately strong, negative correlations with Most Humid Month, Least Humid Month and Annual Rainfall. In contrast, no correlation attains significance in the eastern female sample. In the western male sample, meanwhile, the correlation between stature and Hottest Month is very weak, but there are moderately strong to strong, positive correlations with Coldest Month, Annual Temperature and

Annual Rainfall. In western females there are also a moderately strong, positive correlations with Coldest Month, Annual Temperature and Annual Rainfall.

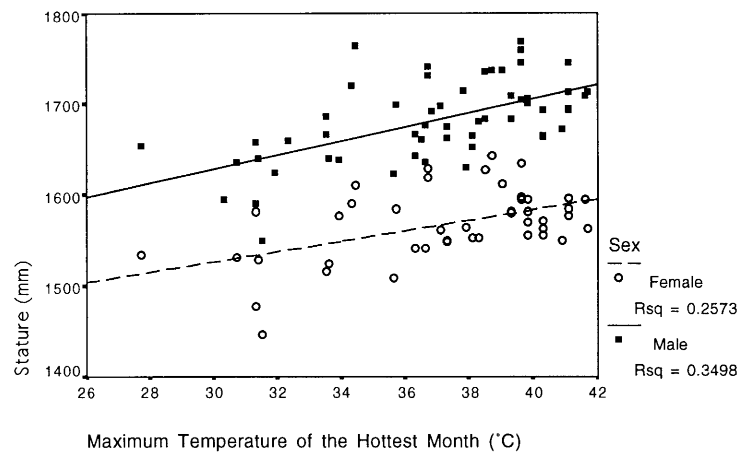

Figure 7.6: Bivariate Scatterplot of Male and Female Stature vs Maximum Temperature of the Hottest Month

It would appear, therefore, that in the east the tallest statures are found in areas with the greatest annual fluctuation in temperature - hot summers and cold winters - and with the lowest humidity and rainfall. The smallest statures, meanwhile, are found in areas where there is high rainfall and humidity and little annual variation in temperature (such as in the tropical rainforest). The results suggest this applies only to males, but the eastern female sample may be too small to gain a clear picture of trends.

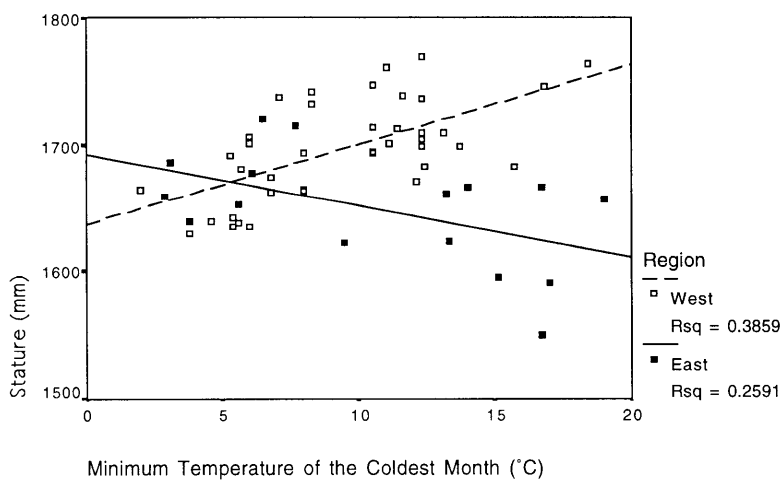

Figure 7.7: Bivariate Scatterplot of Male Stature vs Minimum Temperature of the Coldest Month: East/West sub-samples

In the west the tallest statures are found in areas of high annual average temperature, with hot summers, but more importantly, mild winters. There appears to be no relationship between humidity and stature in the west, but there is a positive relationship with annual rainfall. These relationships apply to females as well as males.

The only co-variate used in the partial correlations with stature was age. As can be seen in Table 7.2 there is only a very weak relationship between mean stature and mean age in both male and female Aborigines. Accordingly, correcting for age in the partial correlations has little effect.

7.2.3.3 Humerus Length

As might be predicted by the strong correlations between stature and the limb segment lengths seen in Tables 7.3 and 7.4, the pattern of correlations between humerus length and the climatic variables is similar to that of stature, with longer upper arms occurring in areas that are hot and dry. There is also a very weak, negative correlation with longitude in both males and females, indicating a west to east decline in humerus length. The MSR results indicate that humidity is the most influential variable. Overall, climate explains 33% of variance in male humerus length and 34% in females.

Again when the east and west sub-samples are examined, the pattern of correlations is different. Of particular note is how Coldest Month (winter temperature) becomes more influential when the effect of longitude is removed by the partitioning of the sample. In eastern males humerus length has a moderately strong and significant, negative correlation with Coldest Month and moderately strong, negative correlations with Least Humid Month and Annual Rainfall. The highest positive correlation, however, occurs with Temperature Range. No correlation attains significance in the eastern female sample.

In western males, by contrast, there is also a strong and very highly significant correlation with Coldest Month, however in this case it is positive. There is also a moderately strong, negative correlation with Temperature Range in males (absent in females), however in both sexes there are moderately strong, positive correlations with Annual Temperature and Annual Rainfall. As with stature, there is no relationship between humerus length and humidity in the west.

When the partial correlations for limb segment lengths were calculated, variation in stature was accounted for in order to assess the effect of overall body size on the correlations, and weight was also removed as another aspect of size, as well as to assess the effect of variable tissue thickness. The results in Table 7.13 and 7.14 would suggest that variation in age and weight have only a moderate effect on the correlations with humerus length. The largest effect is seen where variation in stature is taken into account. The correlations with temperature variables change direction (from positive to negative) and in some cases they attain significance. For instance, both males and females lose the significant positive correlation between Hottest Month and humerus length and males gain a negative and significant correlation with Annual Temperature and females gain a very weak, but significant negative correlation with Coldest Month. This would indicate that the positive correlations between humerus length and temperature in the Australia-wide sample were primarily due to variation in body size. Indeed with size removed, humerus length gets smaller with increasing temperature, indicating that those in hotter areas have relatively shorter humeri for their height. Thus there would appear to be no intrinsic increase in upper arm length with increases in environmental temperature.

7.2.3.4 Radius Length

The pattern of correlations for radius length parallel those seen in humerus length and stature, however they are somewhat stronger. As with the correlations for stature, the results of the MSR confirm that in males the primary relationship is with temperature, whilst in females it is with humidity. Climate is seen to account for 38% of variance in male radius length and 48% in females.

Where the major differences occur are in the east-west sub-samples and in the partial correlations. Radius length, like stature, has moderately strong and significant, positive correlations with Hottest Month in both the eastern and western male groups (Figure 7.8), but in females this occurs only in the west.

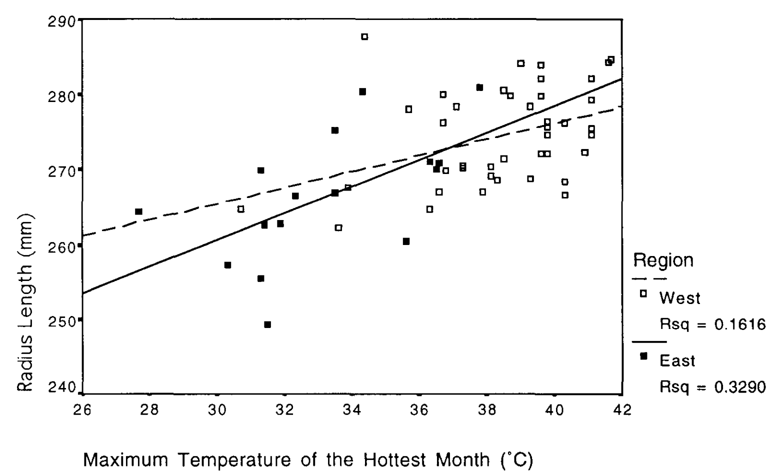

Figure 7.8: Bivariate scatterplot of Male Radius length vs Maximum Temperature of the Hottest Month: East/West sub-samples

In the partial correlations, meanwhile, when stature is removed most correlations become non-significant, but do not change direction as with humerus length. In fact, in females the relationship between radius length and Hottest Month remains significant, indicting that there is an intrinsic lengthening of the radius with increasing temperature, independent of body size. It is also interesting to note that the increase in radius length in less humid areas is also independent of changes in body size in females, but not in males.

7.2.3.5 Femur Length

Again, the bivariate and multivariate correlations for femur length follow the pattern set by stature and the upper limb lengths. Therefore little will be said on this score. Overall climate explains 31% of variance in male femur length and 47% in females.

As far as partial correlations are concerned, when variation in stature is removed, the significant correlations between climatic variables and femur length disappear. It would thus appear that in males the increase in femur length seen in hot/dry regions is entirely due to an increase in overall body size. In females, however, the correlation is preserved with Least Humid Month and a very weak, but significant correlation appears with Temperature Range, indicating there is a slight trend for a real increase in female femur length in areas that are dry or subject to large variations in temperature.

7.2.3.6 Tibia Length

Again, the interest in the relationship of tibia length and climate lies primarily in the partial correlations where variation in stature is removed. The same pattern in the upper distal limb segment is seen here, with an increase in tibia length with increasing temperature independent of overall body size. This effect is seen somewhat more strongly in females than males. The results of the MSR indicate that in both males and females, climate has the greatest apparent effect on tibia length, accounting for 57% of variance in males and 56% in females.

7.2.3.7 Biacromial Diameter

When the Australia-wide samples are examined biacromial diameter is seen to have very few significant correlations with climate and none that reach the 0.45 level. Of the correlations that are significant, the results of the MSR indicate that in both males and females Humidity Range is the primary climatic correlate (Figure 7.9).

When east/west comparisons are made, meanwhile, it can be seen that in eastern males there are moderately strong, negative correlations with Coldest Month (Figure 7.10), Annual Temperature, Least Humid Month and Annual Rainfall and a moderately strong positive correlation with Temperature Range. In eastern females, even with their much smaller sample size, there are strong and significant, negative correlations with Coldest Month and Annual Rainfall.

In western males there are fewer significant correlations, and only one, a positive correlation with Annual Rainfall, reaches 0.45. In the female sample all correlations are below 0.45. Thus it would appear that populations in the cooler, drier parts of the east are broader across the shoulders than those in the warmer, wetter areas. This effect is particularly strong in eastern females. In the west it is probable that the increase in shoulder breadth is associated with overall body size.

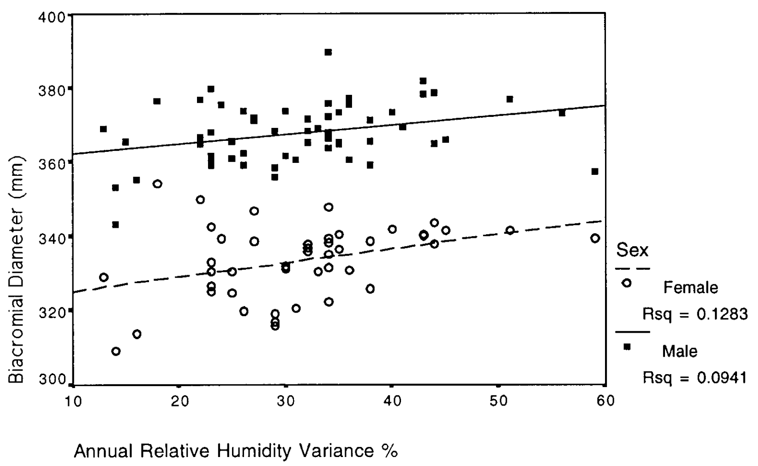

Figure 7.9: Bivariate Scatterplot of Male and Female Biacromial diameter vs Annual Relative Humidity Variance

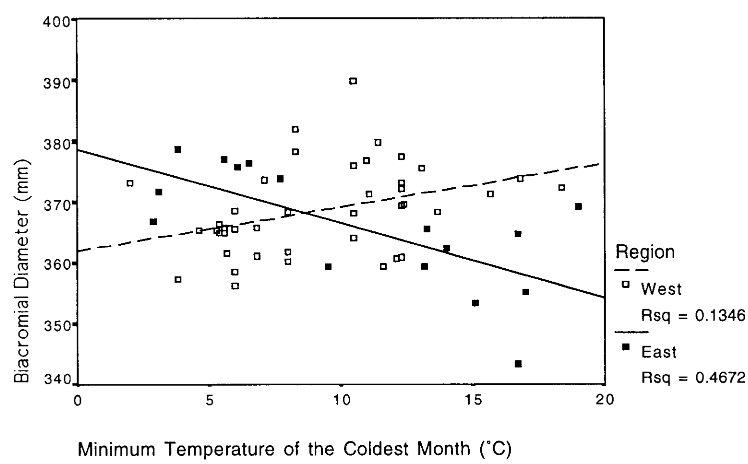

Figure 7.10: Bivariate Scatterplot of Male Biacromial Diameter vs Minimum Temperature of the Coldest Month: East/West sub-samples

The partial correlations reveal that when age is accounted for in the male sample a significant, positive correlation appears with Hottest Month and Temperature Range, and a negative correlation appears with Annual Rainfall. When stature is controlled for there is a very weak, but significant, negative correlation with Hottest Month (reversing direction) and Annual Temperature, and a weak, positive correlation with Most Humid Month, however no correlation reaches 0.45.

When age is controlled for in females, a weak, but significant correlation appears with Temperature Range and negative correlations appear with Least Humid Month and Annual Rainfall. As with the male sample there are no changes to the correlations when variation in weight is removed, but again, when stature is controlled for a very weak but significant negative correlation appears with temperature (Coldest Month in this case) and a moderately strong negative correlation with Annual Temperature. This suggests that relatively narrower shoulders are associated with increased temperature, particularly so in the female sample.

7.2.3.8 Bi-iliac Diameter

As has been mentioned previously, bi-iliac diameter was measured in Birdsell's first expedition only, and therefore the overall size and distribution of samples for this variable are much reduced.

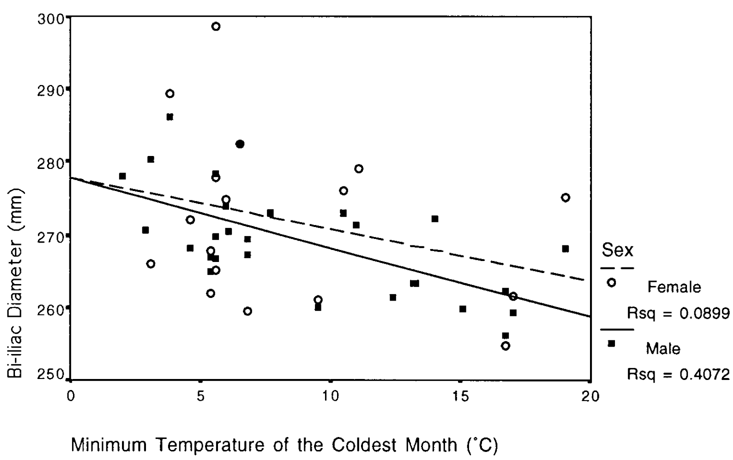

Figure 7.11: Bivariate scatterplot of Male and Female Bi-iliac diameter vs Minimum Temperature of the Coldest Month

In the Australia-wide male sample there are moderately strong, significant and stable, negative correlations with Coldest Month (Figure 7.11), Annual Rainfall and latitude, and a moderately strong positive correlation with Temperature Range. MSR analysis reveals that Coldest Month is the primary correlate and explains 41% of variance in male bi-iliac breadth. These relationships are not, however, apparent in the female sample, in which no correlation attains significance. Also of interest is the lack of sexual dimorphism in the measurement. In absolute terms the average bi-iliac breadth of males and females is very similar. However, there appears to be slightly greater dimorphism in populations in the warmer areas.

In eastern males there are also strong and significant, negative correlations with Coldest Month (Figure 7.12) and Annual Temperature, as well as a moderately strong, negative correlation with Annual Rainfall, and a moderately strong, positive correlation with Temperature Range. In eastern females, despite the tiny sample size (n = 8), there is a strong and significant, negative correlation between Bi-iliac and Annual Temperature.

In the western males, as in the east, there is a strong positive correlation with Temperature Range, however there are no significant correlations in the western female sample. Thus it would appear that in the east there is an inverse relationship between pelvic breadth and temperature, a situation also seen at a continental level in males, but not in females. There is also a trend for hip breadth in males to be larger in areas with greater annual variation in temperature.

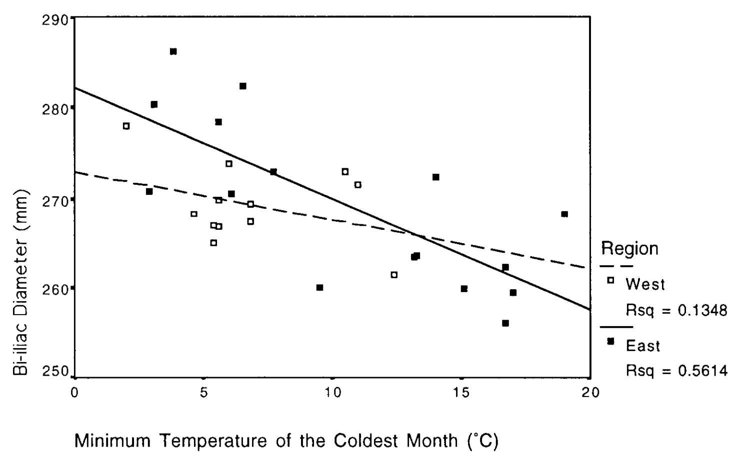

Figure 7.12: Bivariate scatterplot of Male Bi-iliac diameter vs Minimum Temperature of the Coldest Month: East/West sub-samples

Given the location points for measuring bi-iliac breadth, it was suspected that variation in weight might bias the results because of increased tissue thickness over the bony landmarks. Also, as weight can change with advancing age, this variable might be a co-factor, and indeed there are significant positive correlations between age and bi-iliac breadth (Table 7.2).

When one controls for age in males, the significant negative correlation with Temperature Range is lost and significant and moderately strong negative correlations appear with Most Humid Month and Least Humid Month. A different pattern emerges when weight is removed suggesting that the changes occurring in age are not associated with weight. With weight controlled for a moderately strong negative correlation appears with Hottest Month and the significant negative correlation with Coldest Month disappears, as does that with Annual Rainfall and the correlations with humidity variables change direction. The removal of stature, meanwhile, has relatively little effect. None of the partial correlations for female bi-iliac diameter attains significance.

7.2.3.9 Sitting Height

Sitting height is highly intercorrelated with stature and limb length (Tables 7.3 and 7.4) and therefore exhibits a pattern of correlation similar to these variables: positive correlations with temperature (Figure 7.13) and negative correlations with humidity. However, there are differences between the male and female samples, with the female sample producing weaker correlations with Hottest Month and Annual Temperature, slightly higher correlations with Coldest Month, but no significant correlations with humidity variables.

The MSR analysis reveals that Annual Temperature is the primary correlate in both sample groups. Interestingly, some variance is also shared with Coldest Month in males, and Humidity Range in females, neither of which attain significant relationships in the bivariate correlations. Overall, climate explains 40% of variance in male sitting height and 33% in females.

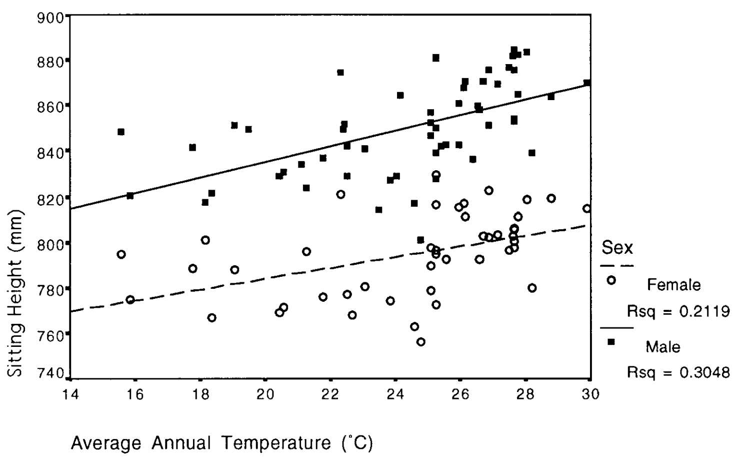

Figure 7.13: Bivariate scatterplot of Male and Female Sitting Height vs Average Annual Temperature

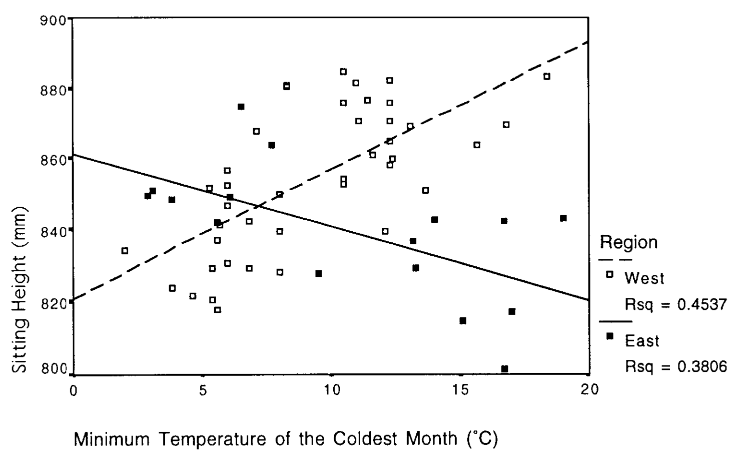

Figure 7.14: Bivariate scatterplot of Male Sitting Height vs Minimum Temperature of the Coldest Month: East/West sub-samples

When the eastern and western groups are compared, the eastern male sample is seen to have negative correlations with Coldest Month (Figure 7.14), Most Humid Month, Least Humid Month and Annual Rainfall, and a positive correlation with Temperature Range. In eastern females the direction of the correlations is similar, however none are significant.

In the west, male sitting height exhibits positive correlations with temperature variables and Annual Rainfall, and a negative correlation with Temperature Range. The western female sample has the same pattern as seen in the males, except the significant correlation with Hottest Month is absent. Populations in the east, therefore, have absolutely longer trunks where temperatures are lower and shorter trunks were it is warmer. Yet in contrast, western males have longer trunks in hotter areas. It is likely that this pattern reflects stature variation and is not directly linked to temperature. This is confirmed in the Australia-wide sample by the results of the partial correlation analysis. When stature is accounted for the positive correlations between sitting height and temperature disappear. The partial correlations also indicate that variation in age has affected some correlations in male sample.

7.2.3.10 Calf Circumference

Despite the fact that calf circumference has a strong correlation with weight in both males and females, it does not share weight's pattern of significant correlations. This may well be because of its lack of correlation with stature. In both the male and female samples all correlations are below 0.45, and the very weak correlations that are significant, do not appear to be stable.

When the eastern and western sub-samples are considered it can be seen that in eastern males there are strong negative correlations with Coldest Month (Figure 7.15), Annual Rainfall and Least Humid Month, and a positive correlation with Temperature Range. In eastern females only the negative correlations with temperature are significant, those with humidity are not. This suggests that in the east, calf circumference is greater where temperatures are colder and drier, and where there is more annual variation in temperature.

In western males, meanwhile, there are weak positive correlations with Coldest Month, Annual Temperature, Humidity Range and Annual Rainfall, and a negative correlation with Temperature Range. In western females there is only one significant correlation with Humidity Range. This would suggests those populations living in areas of mild winters, with little variation in yearly temperature, but greater variation in humidity (as seen in the far northwest) have larger calves, although this is probably linked to larger body size.

When the partial correlations are examined it is clear that the removal of weight has affected some correlations. Given the strong relationship between weight and calf circumference this not surprising. Variation in age, meanwhile, is seen to have relatively little effect. When either weight or stature is taken into account moderately strong negative correlations appear with Hottest Month and Temperature Range, as well as moderately strong positive correlations with Most Humid Month, Least Humid Month and Annual Rainfall. There is also a weak positive correlation with Coldest Month. Thus, males with the narrowest calves relative to body size are found in areas with very hot summers, high annual fluctuations in temperature and low annual humidity. The greatest relative calf circumferences are found in areas with warm summers and mild winters, little annual variation in temperature and high humidity and rainfall (suggestive of the wet tropics). In females, age seems to have had a greater effect on the correlations than in males, however females in hotter, drier areas also tend to have relatively smaller calves, than those in wetter areas.

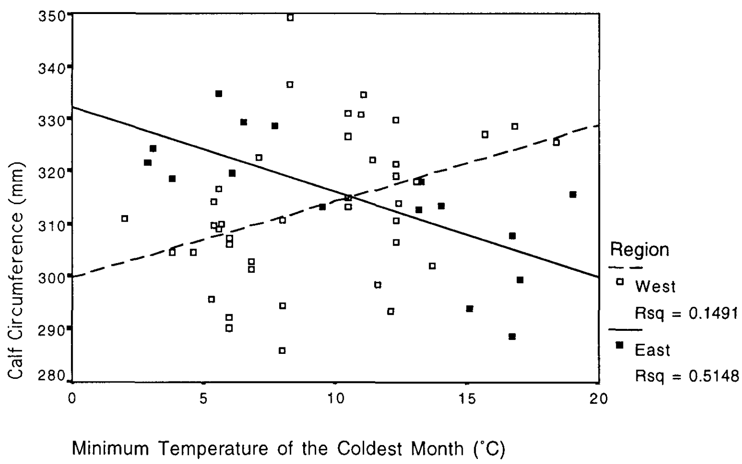

Figure 7.15: Bivariate scatterplot of Male Calf Circumference vs Minimum Temperature of the Coldest Month: East/West sub-samples

7.2.3.11 Summary: Body Size

Bivariate correlations

- Overall body and limb lengths to be positively associated with temperature and negatively associated with humidity. Body weight, on the other hand, exhibits relatively little association with either temperature or humidity.
- There is a difference between the male and female correlations between body breadth and climate. In the Australia-wide male sample there is a strong negative correlation with temperature of the coldest month. In the female sample this relationship is not apparent.

- The east/west sub-samples produce contradictory differences in the size, direction and significance of some ecogeographic correlations. Possible reasons for these differences will be discussed in Chapter 10.
- An examination of the partial correlations indicates that many of the bivariate relationships are linked to variation in body size. Variation in age and weight between sample groups may have also affected the size and significance of some correlations.

MSR

- In males, climate accounts for at least 20% of shared variance in 7 out of 10 variables, however all measurements, excluding calf circumference, are significantly associated with climate.
- In females, climate accounts for at least 20% of shared variance in 6 out of 10 variables, and all measurements except bi-iliac breadth are significantly associated with climate.
- In both males and females a small percentage of variance in weight is shared with humidity variables.
- In males, most length measurements of the body are primarily associated with temperature, particularly maximum temperature of the hottest month, whilst in females it is the humidity of the least humid month.
- The greatest influence of climate on a body measurement is with tibia length. This is common to both the male and female samples, with a combination of temperature and humidity explaining 57% of variance in male tibia length and 56% in female tibia length. Climate also explains 38% of male radius length and 48% of female radius length.
- In males, bi-iliac breadth shares the greatest variance with Coldest Month, however as was revealed in the bivariate correlations, this association is absent in females.

7.2.4 Body shape and climate in adult male and female Australian Aborigines

The bivariate, multivariate and partial correlations between body shape indices and climate are presented in Tables 7.15 to 7.22.

7.2.4.1 Surface Area

Skin surface area was calculated using the formula of Dubois and Dubois (1916), which combines both stature and weight in its equation: (Weight(kg)$^{0.425}$ *Stature(cm) $^{0.725}$* 71.84). Accordingly, an absolutely larger body (in length and/or mass) will have a larger skin surface area.

With all male sample groups considered, it is found that only two correlations reach the 0.45 (20% shared variance) level (Table 7.15). These are a positive correlation with Hottest Month (Figure 7.16) and a negative correlation with Least Humid Month: a pattern of correlations that, not surprisingly, matches that of stature. By contrast, in the female sample no correlation reaches the 0.45 level, and indeed, the correlation between Hottest Month and surface area in females is close to zero (Table 7.16). MSR analysis reveals that in both males and females the primary correlates are related to moisture: Least Humid Month in males and Humidity Range in females. Climate is seen to account for 26% of male variation in skin surface area, but only 14% in females (Tables 7.19 and 7.20).

As with the absolute measures of body morphology, there are differences in the pattern of correlations between the eastern and western sub-samples (Tables 7.17 and 7.18). In the eastern male group moderately strong negative correlations are revealed with Coldest Month, Most Humid Month, Least Humid Month and Annual Rainfall, and a strong positive correlation with Temperature Range. The eastern female sample, meanwhile, produced no significant correlations. In western samples the correlations are opposite in sign to those of the east. In males, there are moderately strong positive correlations with Coldest Month, Annual Temperature and Annual Rainfall, but these relationships are not apparent in the female group. Again these clines follow those of stature.

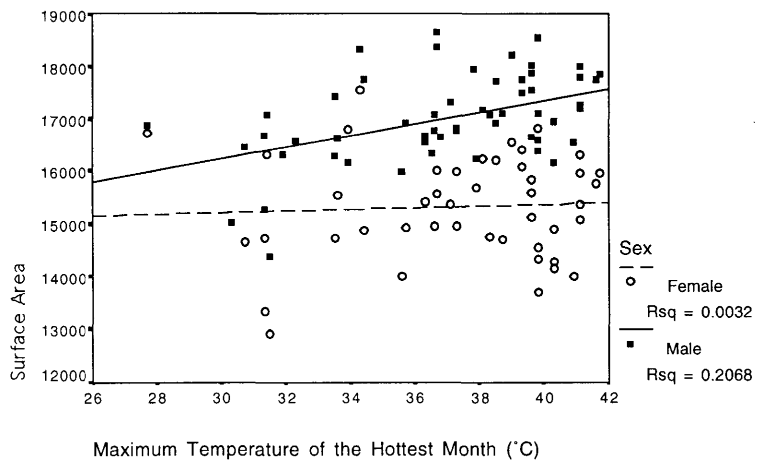

Figure 7.16: Bivariate scatterplot of Male and Female Surface Area vs Maximum Temperature of the Hottest Month

Table 7.15: Pearson's and Spearman's correlation coefficients between mean body indices and climate: males.

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
SA	*r*	**0.45*****	-0.11	0.36**	0.28*	-0.30*	**-0.51*****	0.36**	-0.37**	-0.10	-0.34**
	ρ	0.40**	0.03	0.13	0.40**	-0.30*	-0.32*	0.33*	-0.05	-0.12	-0.28*
SA/W	*r*	-0.10	0.30*	-0.29*	0.15	-0.02	0.22	-0.35**	0.31*	-0.28*	0.15
	ρ	-0.05	0.30*	-0.18	0.12	-0.04	0.06	-0.35**	0.24	-0.30*	0.12
RPB	*r*	-0.35	-0.42*	0.15	**-0.62*****	0.34	0.07	0.24	-0.10	**0.59*****	0.10
	ρ	-0.27	**-0.46***	0.06	**-0.56****	0.30	0.16	0.14	-0.17	**0.45***	0.18
RShB	*r*	**-0.56*****	-0.21	-0.18	**-0.60*****	**0.53*****	**0.47*****	0.001	0.17	**0.52*****	0.30*
	ρ	**-0.52*****	-0.22	-0.17	**-0.56*****	**0.54*****	**0.52*****	-0.04	-0.03	0.39**	0.23
RSitH	*r*	-0.34**	0.20	-0.37**	-0.10	0.35**	0.44***	-0.19	0.39**	0.004	0.35**
	ρ	-0.25	0.20	-0.34**	-0.06	0.31*	0.41**	-0.16	0.34**	-0.09	0.25
PI	*r*	0.32*	0.33*	-0.06	**0.52*****	-0.34**	-0.20	-0.16	0.04	**-0.51*****	-0.13
	ρ	0.34**	0.38**	-0.04	**0.52*****	-0.36**	**-0.26***	-0.17	0.19	**-0.47*****	-0.12
Calf/Tib	*r*	**-0.54*****	-0.06	-0.29*	-0.41**	**0.55*****	**0.48*****	0.01	0.29*	0.29*	0.40**
	ρ	**-0.52*****	-0.10	-0.32*	-0.38**	**0.57*****	**0.58*****	0.03	0.32*	0.13	0.32*
Rad/Hum	*r*	0.31*	0.21	0.03	0.35**	-0.21	-0.14	-0.07	0.06	-0.33*	-0.07
	ρ	0.21	0.13	0.20	0.13	-0.15	-0.12	-0.11	-0.07	-0.12	-0.02
Tib/Fem	*r*	**0.50*****	0.26*	0.10	**0.50*****	-0.31*	-0.40**	0.19	-0.24	-0.33*	-0.42***
	ρ	0.42**	0.30*	0.03	**0.48*****	-0.30*	-0.33*	0.15	-0.15	-0.23	-0.36**
Interm	*r*	-0.41**	-0.07	-0.19	-0.44***	0.33*	0.35**	-0.09	0.04	**0.48*****	0.11
	ρ	-0.39**	-0.10	-0.25	-0.40**	0.33*	0.36**	-0.12	-0.13	**0.45*****	0.07
Fem/SitH	*r*	0.28*	-0.23	0.36**	0.07	-0.27*	-0.36**	0.17	-0.29*	-0.02	-0.23
	ρ	0.29*	-0.23	0.38**	0.09	-0.30*	-0.37**	0.17	-0.23	0.06	-0.22
Tib/SitH	*r*	**0.55*****	-0.01	0.35**	0.39**	-0.43***	**-0.55*****	0.26	-0.39**	-0.23	**-0.47*****
	ρ	0.44***	0.003	0.28*	0.36**	-0.40**	**-0.47*****	0.19	-0.23	-0.11	-0.33*
Hum/SitH	*r*	0.12	-0.28*	0.30*	-0.15	-0.14	-0.27*	0.22	-0.43***	0.30*	-0.35**
	ρ	0.08	-0.15	0.08	0.01	-0.14	-0.20	0.10	-0.27*	0.23	-0.24
Rad/SitH	*r*	0.39**	-0.11	0.33*	0.14	-0.31*	-0.40**	0.18	-0.40**	0.04	-0.42***
	ρ	0.32*	-0.08	0.28*	0.15	-0.27	-0.33*	0.14	-0.37**	0.17	-0.37**

Table 7.16: Pearson's and Spearman's correlation coefficients between mean body indices and climate: females.

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
SA	*r*	0.06	-0.22	0.21	-0.11	0.05	-0.22	0.38*	-0.31*	0.25	-0.17
	ρ	0.02	-0.12	-0.05	0.04	0.08	-0.11	0.39**	-0.12	0.21	-0.17
SA/W	*r*	0.23	0.35*	-0.13	0.42**	-0.23	-0.03	-0.28	0.27	**-0.53*** **	-0.02
	ρ	0.17	0.35*	0.004	0.27	-0.18	0.02	-0.32*	0.28	**-0.48*** **	0.09
RPB	*r*	-0.30	-0.21	-0.003	-0.27	0.10	0.06	0.04	-0.04	0.36	0.38
	ρ	0.04	-0.10	0.09	-0.07	-0.09	-0.05	0.03	-0.07	0.20	0.30
RShB	*r*	-0.44**	-0.41**	0.03	**-0.61*** **	0.40**	0.30*	0.14	-0.15	**0.66*** **	0.21
	ρ	-0.32*	-0.41**	-0.08	**-0.45** **	0.39**	0.26	0.18	-0.16	**0.56*** **	-0.02
RSitH	*r*	-0.43**	0.09	-0.36*	-0.17	**0.47*** **	**0.52*** **	-0.07	0.39**	0.06	**0.48*** **
	ρ	-0.26	0.06	-0.34*	-0.07	0.37*	0.37*	-0.03	0.40**	-0.04	0.18
PI	*r*	0.37*	0.38**	-0.06	**0.55*** **	-0.31*	-0.19	-0.17	0.21	**-0.62*** **	-0.15
	ρ	0.31*	0.39**	0.05	0.43**	-0.27	-0.12	-0.19	0.29	**-0.58*** **	-0.01
Calf/Tib	*r*	**-0.55*** **	-0.24	-0.17	**-0.55*** **	**0.47*** **	0.41**	0.08	0.05	**0.56*** **	0.37*
	ρ	-0.40**	-0.26	-0.23	-0.40**	0.42**	0.31*	0.12	0.001	0.40**	0.12
Rad/Hum	*r*	-0.03	0.21	-0.19	0.16	-0.09	0.13	-0.30*	0.36*	-0.26	0.19
	ρ	0.01	0.25	-0.08	0.03	-0.11	0.002	-0.34*	0.14	-0.23	0.01
Tib/Fem	*r*	**0.48*** **	0.11	0.23	0.38*	**-0.48*** **	**-0.45** **	-0.04	-0.20	-0.26	**-0.53*** **
	ρ	0.39**	0.19	0.21	0.27	-0.44**	-0.32*	-0.04	-0.26	-0.07	**-0.51*** **
Interm	*r*	-0.37*	-0.06	-0.20	-0.37*	0.22	0.31*	-0.13	-0.04	**0.46** **	0.12
	ρ	-0.19	-0.06	-0.18	-0.23	0.17	0.26	-0.13	-0.12	0.37*	-0.03
Fem/SitH	*r*	**0.52*** **	-0.07	0.40**	0.31*	-0.42**	**-0.57*** **	0.21	-0.35*	-0.22	-0.40**
	ρ	0.40**	-0.04	0.38**	0.25	-0.38*	**-0.47*** **	0.13	-0.21	-0.15	-0.06
Tib/SitH	*r*	**0.69*** **	-0.05	**0.49*** **	0.41**	**-0.62*** **	**-0.75*** **	0.18	**-0.45** **	-0.26	**-0.63*** **
	ρ	**0.53*** **	0.04	0.43**	0.31*	**-0.58*** **	**-0.57*** **	0.04	-0.26	-0.17	-0.26
Hum/SitH	*r*	**0.47*** **	-0.17	0.44**	0.14	-0.40**	**-0.59*** **	0.27	**-0.55*** **	0.06	**-0.56*** **
	ρ	0.34*	-0.12	0.36*	0.12	-0.31*	-0.39**	0.16	-0.38**	0.11	-0.21
Rad/SitH	*r*	**0.52*** **	-0.02	0.36*	0.29	**-0.54*** **	**-0.59*** **	0.07	-0.38**	-0.13	**-0.52*** **
	ρ	0.41**	0.051	0.36*	0.15	**-0.53*** **	**-0.54*** **	-0.07	**-0.45** **	0.04	-0.32*

Table 7.17: Pearson's correlation coefficients between mean body indices and climate: male eastern and western sub-samples. (E: n = 16; W: n = 41, except relative bi-iliac breadth: n = 12).

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Abs Latitude
SA	E	0.38	**-0.65****	**0.72****	-0.37	**-0.51***	**-0.61***	0.41	**-0.73*****	**0.50***
	W	0.24	**0.45****	-0.28	**0.52*****	0.01	-0.12	0.11	**0.55*****	**-0.57*****
SA/W	E	-0.10	**0.73*****	**-0.69****	**0.59***	0.34	**0.52***	-0.44	**0.70****	**-0.69****
	W	0.03	-0.03	0.04	0.01	-0.24	-0.05	-0.29	-0.20	-0.007
RPB	E	**-0.55***	-0.45	0.15	**-0.81*****	0.43	0.11	0.26	-0.10	**0.74****
	W	-0.18	-0.50	0.34	-0.37	0.39	0.11	0.46	-0.44	0.30
RShB	E	**-0.65****	-0.27	-0.05	**-0.69****	0.42	0.18	0.14	0.04	**0.62***
	W	-0.28	-0.34*	0.15	**-0.50*****	0.39*	0.29	0.30	-0.23	**0.54*****
RSitH	E	**-0.59***	0.02	-0.27	-0.37	0.47	0.42	-0.17	0.29	0.21
	W	0.23	0.22	-0.07	0.13	0.05	-0.07	0.21	0.13	-0.14
PI	E	0.28	**0.61***	-0.41	**0.75*****	-0.004	0.19	-0.28	0.38	**-0.76*****
	W	0.22	0.32*	-0.17	0.43**	-0.32*	-0.16	-0.32*	0.16	**-0.46****
Calf/Tib	E	**-0.54***	**-0.51***	0.21	**-0.72****	0.12	0.004	0.11	-0.22	**0.68****
	W	-0.23	-0.01	-0.13	-0.19	**0.45****	0.28	0.40**	0.27	0.15
Rad/Hum	E	0.41	0.47	-0.23	**0.62***	-0.22	-0.04	-0.16	0.15	**-0.58***
	W	**0.47****	0.04	0.25	0.27	-0.27	-0.41**	-0.03	-0.05	-0.17
Tib/Fem	E	**0.54***	0.15	0.10	0.39	-0.19	-0.27	0.21	-0.18	-0.29
	W	0.26	**0.47****	-0.29	**0.46****	-0.14	-0.15	-0.07	0.07	-0.37*
Interm	E	**-0.64****	-0.40	0.07	**-0.71****	0.32	0.20	0.01	0.07	**0.61***
	W	-0.21	-0.05	-0.08	-0.32*	0.19	0.24	0.07	-0.36*	**0.49****
Fem/SitH	E	0.47	-0.12	0.30	0.24	-0.47	-0.37	0.10	-0.26	-0.08
	W	-0.17	-0.24	0.12	-0.16	0.01	0.08	-0.06	0.01	0.04
Tib/SitH	E	**0.66****	0.01	0.27	0.40	-0.44	-0.42	0.21	-0.29	-0.23
	W	0.04	0.15	-0.12	0.22	-0.11	-0.04	-0.13	0.07	-0.27
Hum/SitH	E	0.21	-0.41	0.44	-0.17	-0.30	-0.34	0.22	-0.34	0.29
	W	**-0.47****	-0.13	-0.17	-0.37*	0.23	0.42**	-0.04	-0.24	0.39*
Rad/SitH	E	**0.65****	-0.04	0.31	0.38	**-0.55***	-0.44	0.12	-0.27	-0.20
	W	-0.06	-0.08	0.04	-0.12	-0.01	0.06	-0.06	-0.28	0.23

Table 7.18: Pearson's correlation coefficients between mean body indices and climate: female eastern and western sub-samples. (E: n = 8; W: n = 37, except relative bi-iliac breadth: n = 9).

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Abs Latitude
SA	E	-0.14	-0.67	0.56	-0.62	-0.17	-0.48	0.33	-0.69	0.65
	W	-0.03	0.12	-0.14	0.02	0.22	-0.05	0.38*	0.06	0.02
SA/W	E	0.25	**0.76***	-0.61	**0.77***	0.06	0.53	-0.45	**0.73***	**-0.80***
	W	0.18	0.14	-0.02	0.29	-0.25	-0.03	-0.34*	0.22	-0.37*
RPB	E	**-0.73***	-0.51	0.22	**-0.80***	0.40	-0.18	0.43	-0.38	**0.82***
	W	0.56	0.33	0.50	0.49	-0.39	-0.44	-0.10	-0.29	-0.46
RShB	E	-0.30	**-0.88****	0.69	**-0.90****	0.03	-0.61	0.58	**-0.74***	**0.92*****
	W	-0.23	-0.29	0.12	**-0.45****	0.30	0.17	0.30	-0.33*	**0.54*****
RSitH	E	0.11	-0.43	0.43	-0.38	0.02	-0.41	0.39	-0.26	0.36
	W	0.02	0.30	-0.27	0.23	0.26	0.15	0.24	0.26	-0.24
PI	E	0.30	**0.78***	-0.61	**0.82***	0.003	0.54	-0.50	0.69	**-0.82****
	W	0.22	0.27	-0.12	0.41*	-0.23	-0.05	-0.29	0.36*	**-0.54*****
Calf/Tib	E	-0.47	**-0.73***	0.50	**-0.86****	0.20	-0.46	0.55	-0.58	**0.88****
	W	-0.23	-0.09	-0.07	-0.30	0.32	0.16	0.33*	-0.16	0.38*
Rad/Hum	E	0.37	0.34	-0.19	0.52	-0.21	0.17	-0.29	0.41	-0.54
	W	0.30	0.14	0.06	0.27	-0.34*	-0.37*	-0.16	0.15	-0.25
Tib/Fem	E	0.49	0.07	0.10	0.45	**-0.83***	-0.04	-0.49	-0.02	-0.42
	W	0.20	0.20	-0.06	0.22	-0.29	-0.17	-0.27	0.10	-0.17
Interm	E	**-0.77***	-0.33	0.04	-0.69	0.58	0.04	0.33	-0.19	0.70
	W	-0.10	0.04	-0.11	-0.17	0.02	0.17	-0.13	-0.28	0.31
Fem/SitH	E	0.003	0.35	-0.31	0.45	-0.35	0.35	-0.54	0.22	-0.40
	W	0.12	-0.22	0.29	-0.01	-0.12	-0.25	0.05	-0.11	-0.05
Tib/SitH	E	0.08	0.08	-0.05	0.17	-0.26	0.08	-0.24	-0.11	-0.14
	W	0.36*	-0.03	0.26	0.24	**-0.49****	**-0.46****	-0.30	0.02	-0.27
Hum/SitH	E	-0.49	-0.07	-0.10	-0.29	0.28	0.14	0.05	-0.16	0.32
	W	0.02	-0.24	0.24	-0.19	-0.13	-0.08	-0.11	-0.39*	0.23
Rad/SitH	E	-0.38	0.24	-0.35	0.08	0.21	0.39	-0.22	0.16	-0.05
	W	0.29	-0.07	0.26	0.09	**-0.45****	-0.42*	-0.28	-0.21	-0.03

Table 7.19: Multiple stepwise regression analysis on male body indices.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
	Percent Shared Variance									
SA	.	.	.	.	.	25.95***	.	.	0.51	0.26***
SA/W	.	.	.	.	.	.	12.53**	.	0.35	0.13**
RPB	.	.	.	38.87***	.	.	.	.	0.62	0.39***
RShB	.	.	.	35.81***	.	9.19**	.	.	0.67	0.45***
RSitH	.	.	.	.	.	19.13***	.	.	0.44	0.19***
PI	.	.	.	27.06***	.	.	.	.	0.52	0.27***
Calf/Tib	.	.	.	.	29.84***	.	.	.	0.55	0.30***
Rad/Hum	.	.	.	12.35**	.	.	.	.	0.35	0.12**
Tib/Fem	.	.	.	24.96***	.	.	.	9.01**	0.58	0.34***
Interm	.	11.04**	.	19.27***	.	.	.	.	0.55	0.30***
Fem/SitH	.	.	.	.	.	12.80**	.	.	0.36	0.13**
Tib/SitH	.	.	.	5.35*	.	30.72***	.	.	0.60	0.36***
Hum/SitH	.	.	.	.	.	.	.	18.23***	0.43	0.18***
Rad/SitH			.	.			.	16.13**	0.40	0.16**

Table 7.20: Multiple stepwise regression analysis on female body indices.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
				Percent Shared Variance						
SA	.	.	.	.	.	.	14.15*	.	0.38	0.14*
SA/W	.	.	.	18.00**	.	.	.	.	0.42	0.18**
RPB	.	.	.	.	.	.	.	.	.	.
RShB	.	.	.	37.75***	.	.	.	.	0.61	0.38***
RSitH	.	.	.	.	.	26.61***	.	.	0.52	0.27***
PI	.	.	.	30.37***	.	.	.	.	0.55	0.30***
Calf/Tib	29.97***	.	.	.	.	.	.	.	0.55	0.30***
Rad/Hum	.	.	.	.	8.29*	.	.	13.11*	0.46	0.21**
Tib/Fem	.	.	.	.	23.45***	.	.	.	0.48	0.23***
Interm	13.79*	.	.	.	.	.	.	.	0.37	0.14*
Fem/SitH	.	.	.	.	.	32.46***	.	.	0.57	0.32***
Tib/SitH	.	.	.	.	.	55.71***	.	.	0.75	0.56***
Hum/SitH	.	.	.	.	.	35.08***	.	.	0.59	0.35***
Rad/SitH	.	.	.	.	.	35.20***	.	.	0.59	0.35***

Table 7.21: Complete and partial correlations between mean body indices and climate: males.

	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
SA	**0.45*** **	-0.10	0.36**	0.28*	-0.30*	**-0.51*** **	0.36**	-0.37**
age	**0.56*** **	-0.11	0.40**	0.32*	-0.39**	**-0.60*** **	0.36**	-0.40**
SA/W	-0.10	0.30*	-0.29*	0.15	-0.02	0.22	-0.35**	0.31*
age	-0.32*	0.32*	-0.44***	0.06	0.19	0.44***	-0.38**	0.42***
RPB	-0.35	-0.42*	0.15	**-0.62*** **	0.34	0.07	0.24	-0.10
age	-0.20	-0.37	0.18	**-0.53** **	0.08	-0.14	0.25	-0.21
weight	**-0.49** **	-0.39*	0.02	**-0.61*** **	**0.45* **	0.23	0.18	0.04
RShB	**-0.56*** **	-0.21	-0.18	**-0.60*** **	**0.53*** **	**0.47*** **	0.002	0.17
age	-0.44***	-0.24	-0.06	**-0.55*** **	0.41**	0.35**	0.002	0.07
weight	**-0.61*** **	-0.20	-0.22	**-0.61*** **	**0.55*** **	**0.55*** **	-0.03	0.21
RSitH	-0.34**	0.20	-0.37**	-0.10	0.35**	0.44***	-0.19	0.39**
age	-0.21	0.21	-0.29*	0.01	0.21	0.33*	-0.20	0.33*
weight	-0.38**	0.22	-0.42***	-0.11	0.37**	**0.51*** **	-0.23	0.44***
PI	0.32*	0.33*	-0.06	**0.52*** **	-0.34**	-0.20	-0.16	0.04
age	0.13	0.38**	-0.24	**0.45*** **	-0.14	0.01	-0.18	0.18
Calf/Tib	**-0.54*** **	-0.06	-0.29*	-0.41**	**0.55*** **	**0.48*** **	0.01	0.29*
age	-0.40**	-0.08	-0.17	-0.32*	0.40**	0.34*	0.02	0.21
weight	**-0.72*** **	0.003	**-0.45*** **	**-0.47*** **	**0.65*** **	**0.71*** **	-0.12	**0.46*** **
stature	**-0.47*** **	-0.04	-0.21	-0.30	**0.48*** **	0.39**	0.10	0.21
Rad/Hum	0.31*	0.21	0.03	0.35**	-0.21	-0.14	-0.07	0.06
age	0.28*	0.21	-0.01	0.33*	-0.16	-0.09	-0.07	0.09
weight	0.34**	0.21	0.04	0.36**	-0.22	-0.17	-0.06	0.05
stature	0.39**	0.22	0.03	0.42***	-0.24	-0.18	-0.07	0.06
Tib/Fem	**0.50*** **	0.26*	0.10	**0.50*** **	-0.31*	-0.40**	0.19	-0.24
age	**0.49*** **	0.26*	0.06	**0.48*** **	-0.28*	-0.38**	0.19	-0.22
weight	**0.47*** **	0.30*	0.05	**0.49*** **	-0.29*	-0.37**	0.14	-0.20
stature	0.34**	0.25	-0.03	0.36**	-0.15	-0.21	0.09	-0.12
Interm	-0.41**	-0.07	-0.19	-0.43***	0.33*	0.35**	-0.09	0.04
age	-0.28*	-0.09	-0.09	-0.37**	0.17	0.22	-0.10	-0.06
weight	**-0.46*** **	-0.06	-0.24	**-0.45*** **	0.35**	0.43***	-0.14	0.08
stature	-0.18	-0.04	-0.06	-0.24	0.14	-0.11	0.03	-0.14
Fem/SitH	0.28*	-0.23	0.36**	0.07	-0.27*	-0.36**	0.17	-0.29*
age	0.16	-0.24	0.29*	-0.03	-0.14	-0.25	0.18	-0.24
weight	0.31*	-0.25	0.39**	0.07	-0.29*	-0.41**	0.20	-0.33*
stature	0.04	-0.30*	0.26*	-0.21	-0.10	-0.15	0.07	-0.18
Tib/SitH	**0.55*** **	-0.01	0.35**	0.39**	-0.43***	**-0.55*** **	0.26	-0.39**
age	**0.47*** **	-0.01	0.28*	0.32*	-0.32*	**-0.48*** **	0.27*	-0.34*
weight	**0.56*** **	0.004	0.34**	0.38**	-0.42***	**-0.57*** **	0.24	-0.39**
stature	0.30*	-0.08	0.22	0.08	-0.21	-0.30*	0.13	-0.25
Hum/SitH	0.12	-0.28*	0.30*	-0.15	-0.14	-0.27*	0.22	-0.43***
age	0.10	-0.28*	0.29*	-0.18	-0.11	-0.26*	0.23	-0.42***
weight	0.09	-0.26	0.27*	-0.16	-0.11	-0.24	0.19	-0.41**
stature	-0.09	-0.33*	0.22	-0.41**	0.02	-0.11	0.16	-0.36**
Rad/SitH	0.39**	-0.11	0.33*	0.14	-0.31*	-0.40**	0.18	-0.40**
age	0.35**	-0.11	0.29*	0.09	-0.25	-0.36**	0.19	-0.37**
weight	0.37**	-0.10	0.31	0.13	-0.30*	-0.39**	0.15	-0.39**
stature	0.25	-0.15	0.25	-0.05	-0.18	-0.26*	0.11	-0.33*

Table 7.22: Complete and partial correlations between mean body indices and climate: females.

	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
SA	0.06	-0.22	0.21	-0.11	0.05	-0.22	0.38*	-0.31*
age	0.32*	-0.26	0.42**	-0.01	-0.23	**-0.55*** **	0.39**	**-0.47*** **
SA/W	0.23	0.35	-0.13	0.42**	-0.23	-0.03	-0.28	0.27
age	-0.05	**0.45** **	-0.42**	0.35*	0.09	0.34*	-0.31*	**0.51*** **
RPB	-0.30	-0.21	-0.003	-0.27	0.10	0.06	0.04	-0.04
age	0.20	-0.04	0.12	0.12	-0.43	-0.33	0.01	-0.13
weight	-0.47	0.08	-0.38	-0.17	0.29	0.36	-0.15	0.35
RShB	-0.44**	-0.41**	0.03	**-0.61*** **	0.40**	0.30*	0.14	-0.15
age	-0.23	**-0.52*** **	0.30*	**-0.58*** **	0.15	0.02	0.14	-0.36*
weight	**-0.55*** **	-0.30*	-0.13	**-0.64*** **	**0.46** **	**0.53*** **	-0.11	0.10
RSitH	-0.43**	0.09	-0.36*	-0.17	**0.47*** **	**0.52*** **	-0.07	0.39**
age	-0.24	0.07	-0.21	-0.05	0.25	0.34*	-0.11	0.31*
weight	-0.43**	0.17	-0.42**	-0.12	**0.45** **	**0.56*** **	-0.15	**0.50*** **
PI	0.37*	0.38**	-0.06	**0.55*** **	-0.31*	-0.19	-0.17	0.21
age	0.13	**0.49*** **	-0.34*	**0.51*** **	-0.01	0.14	-0.18	0.44**
Calf/Tib	**-0.55*** **	-0.24	-0.17	**-0.55*** **	**0.47*** **	0.41**	0.08	0.05
age	-0.33*	-0.38*	0.12	**-0.52*** **	0.16	0.10	0.07	-0.18
weight	**-0.72*** **	-0.05	-0.44**	**-0.55*** **	**0.57*** **	**0.71*** **	-0.21	0.41**
stature	**-0.45** **	-0.19	-0.11	**-0.45** **	0.41**	0.29	0.20	-0.004
Rad/Hum	-0.03	0.21	-0.19	0.16	-0.09	0.13	-0.30*	0.36*
age	-0.11	0.22	-0.26	0.14	-0.02	0.23	-0.30*	0.41**
weight	-0.06	0.14	-0.14	0.09	-0.05	0.10	-0.23	0.30
stature	0.18	0.30*	-0.13	0.42**	-0.22	-0.06	-0.23	0.33*
Tib/Fem	**0.48*** **	0.11	0.23	0.38*	**-0.48*** **	**-0.45** **	-0.04	-0.20
age	0.36*	0.15	0.10	0.31*	-0.35*	-0.32*	-0.03	-0.11
weight	**0.48*** **	0.08	0.26	0.36*	**-0.48*** **	**-0.47*** **	-0.01	-0.25
stature	0.35*	0.04	0.17	0.22	-0.41**	-0.32*	-0.18	-0.16
Interm	-0.37*	-0.06	-0.20	-0.37*	0.22	0.31*	-0.13	-0.04
age	-0.26	-0.08	-0.09	-0.31*	0.06	0.18	-0.15	-0.14
weight	-0.37*	0.03	-0.27	-0.31*	0.19	0.36*	-0.25	0.06
stature	-0.30*	-0.01	-0.16	-0.29	0.16	0.23	-0.07	-0.08
Fem/SitH	**0.52*** **	-0.07	0.40**	0.31*	-0.42**	**-0.57*** **	0.21	-0.35*
age	0.38*	-0.05	0.28	0.22	-0.24	-0.44**	0.25	-0.27
weight	**0.51*** **	-0.11	0.43**	0.29	-0.42**	**-0.59*** **	0.25	-0.40**
stature	0.35*	-0.19	0.36*	0.07	-0.33*	-0.42**	0.08	-0.32*
Tib/SitH	**0.69*** **	-0.05	**0.49*** **	0.41**	**-0.62*** **	**-0.75*** **	0.18	**-0.45** **
age	**0.57*** **	-0.02	0.37*	0.34*	**-0.45** **	**-0.64*** **	0.24	-0.37*
weight	**0.69*** **	-0.08	**0.52*** **	0.40**	**-0.61*** **	**-0.77*** **	0.23	**-0.51*** **
stature	**0.54*** **	-0.23	**0.50*** **	0.12	**-0.58*** **	**-0.63*** **	-0.007	**-0.47*** **
Hum/SitH	**0.47*** **	-0.17	0.44**	0.14	-0.40**	**-0.59*** **	0.27	**-0.55*** **
age	0.36*	-0.15	0.35*	0.05	-0.26	**-0.51*** **	0.31*	**-0.51*** **
weight	**0.48*** **	-0.15	0.44**	0.16	-0.41**	**-0.59*** **	0.26	**-0.55*** **
stature	0.26	-0.33*	0.41**	-0.21	-0.28	-0.43**	0.15	**-0.57*** **
Rad/SitH	**0.52*** **	-0.02	0.36*	0.29	**-0.54*** **	**-0.59*** **	0.07	-0.38**
age	0.36*	0.02	0.21	0.19	-0.36*	-0.44**	0.11	-0.29
weight	**0.52*** **	-0.06	0.39**	0.27	**-0.53*** **	**-0.62*** **	0.12	**-0.45** **
stature	0.40**	-0.11	0.32*	0.10	**-0.48*** **	**-0.49*** **	-0.05	-0.36*

When calculating the partial correlations for surface area, weight and stature were not included as they were used to calculate the ratio. This left only age. In the male sample, correcting for age had the effect of slightly increasing the size of the correlations (Table 7.21 and 7.22). In females, this effect was somewhat greater, with weak to moderately strong, negative correlations appearing with Annual Rainfall and Least Humid Month and a very weak (below 0.45), but significant, positive correlations appearing with Hottest Month and Temperature Range. This suggests that age differences between the female sample groups are masking the true size of the ecogeographic correlations.

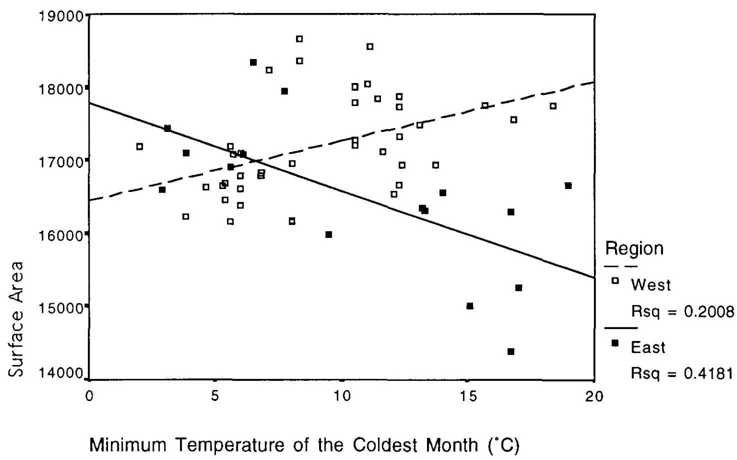

Figure 7.17: Bivariate scatterplot of Male Body Surface Area vs Minimum Temperature of the Coldest Month: East/West sub-samples

7.2.4.2 Surface Area to Weight Ratio

This ratio divides body surface area by body weight. A large value is indicative of a low surface area to weight ratio (lateral body shape) and a small value, a high surface area to weight ratio (linear body shape). A low ratio is seen as being adaptive to colder climates, with a high ratio being adaptive to warmer climates (see Chapter 3).

Given the importance of this ratio to theories on thermoregulation (and to the ecogeographic rules) it is noteworthy that this study has found very little evidence of a close correlation between this ratio and climate. In the total male sample no correlation reaches the 0.45 level, although there are very weak correlations with Annual Rainfall (positive), Humidity Range, Temperature Range and latitude (negative). MSR analysis indicates that of the climatic variables, Temperature Range is the primary correlate (latitude was not included in the analysis).

In females the only significant correlation to reach above 0.45 is a moderately strong negative relationship with latitude (28% shared variance). There are also very weak positive correlations with Coldest Month and Annual Temperature (primary correlate, Figure 7.18), and a negative correlation with Humidity Range. Overall, climate explains 13% of male variation in SA/Weight ratio and 18% in females. These results suggest that populations in the hotter north are more linear than those in the cooler south, however the results are not strong enough to be considered unequivocal support for Bergmann's rule.

Yet in the eastern male sample there are strong positive correlations with Coldest Month, Annual Temperature (Figure 7.19), Annual Rainfall and Least Humid Month. In fact, 53% of variance in SA/Weight is explained by variation in Coldest Month. There is also a moderately strong negative correlation with Temperature Range. In eastern females, meanwhile, there are strong positive correlations with Coldest Month, Annual Temperature and Annual Rainfall. Indeed Coldest Month and SA/Weight share 58% of variance.

In the west the situation is quite different, with the male sample having no significant correlations and the female sample having a single significant, but very weak, negative correlation with Humidity Range. Given that minimum winter temperatures in the west can equal those in the east at any given latitude, it is interesting that SA/Weight does not follow a similar north-south cline.

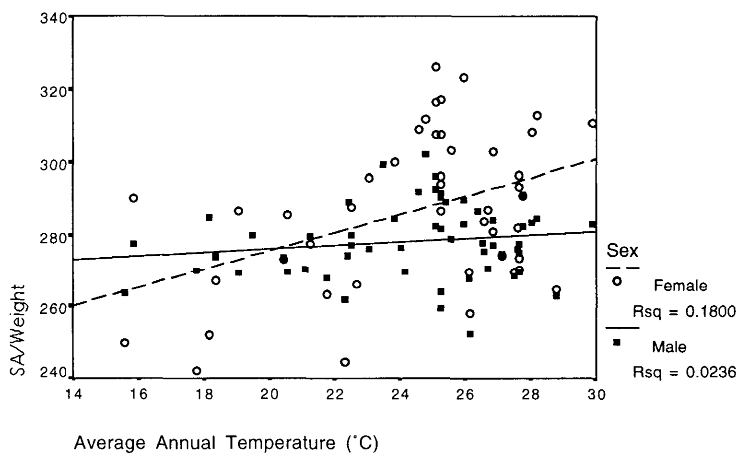

Figure 7.18: Bivariate scatterplot of Male and Female SA/Weight vs Average Annual Temperature

Again age was the only variable to be partialled out. In males, removing variance in age has the effect of increasing some correlations, but none reached 0.45. In the female sample, age has a more significant effect, with moderately strong, positive correlations appearing with Coldest Month and Annual Rainfall.

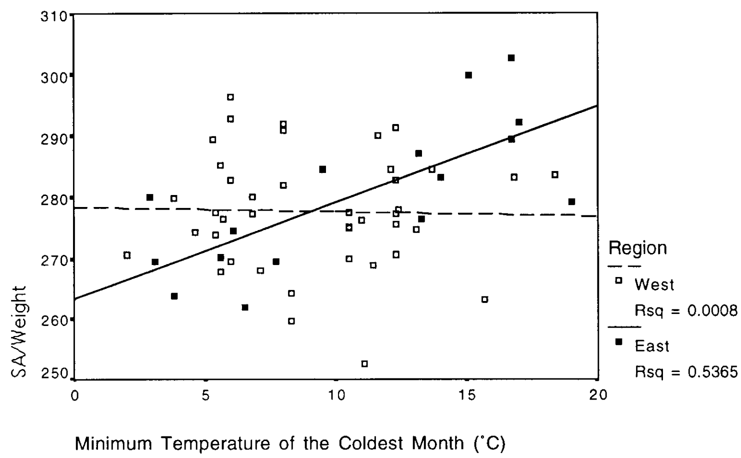

Figure 7.19: Bivariate Scatterplot of Male SA/Weight vs Minimum Temperature of the Coldest Month: East/West sub-samples

7.2.4.3 Relative Pelvic Breadth

This ratio describes the width of the pelvis relative to stature. A large value indicates a relatively wide pelvis (lateral build), and a small value, a relatively narrow pelvis (linear build). Due to obstetric necessity, females tend to have higher average ratios than do males.

As bi-iliac breadth was measured in the first expedition only, the correlations between relative pelvic breadth and climate are based on a smaller sample size, which is biased towards eastern and southern populations.

The total male sample produced a moderately strong, negative correlation with Annual Temperature (Figure 7.20) and a weak, negative correlation with Coldest Month. MSR analysis reveals Annual Temperature as the primary correlate, explaining 39% of the variation in male relative pelvic breadth. This negative relationship with temperature is reflected in the moderately strong positive correlation with latitude. In the female sample there are no significant correlations.

In the correlations produced by the eastern sub-sample, a strong negative relationship with temperature is revealed, however it is annual and summer temperatures that are involved (Figure 7.21), rather than winter temperature. In both eastern males and females, about 64% of variance in relative pelvic breadth is explained by variation in average annual temperature. In neither the western male or female groups are there any significant correlations with climate, however as the sample is largely confined to the southern half of the continent, an absence of a cline in this ratio is not unexpected.

When calculating the partial correlations stature was not used as a co-variate, as it is the denominator of the ratio. Variation in male age is seen to reduce the size of some correlations and when variation in weight is accounted for, a negative correlation appeared with Hottest Month and a positive correlation with Most Humid Month. In females there is no change.

Overall, it was found that in males there is a clear inverse relationship between temperature and relative pelvic breadth, indicating that males in colder climates have a more lateral build, and those in warmer climates are more linear. This relationship is not evident in the female sample.

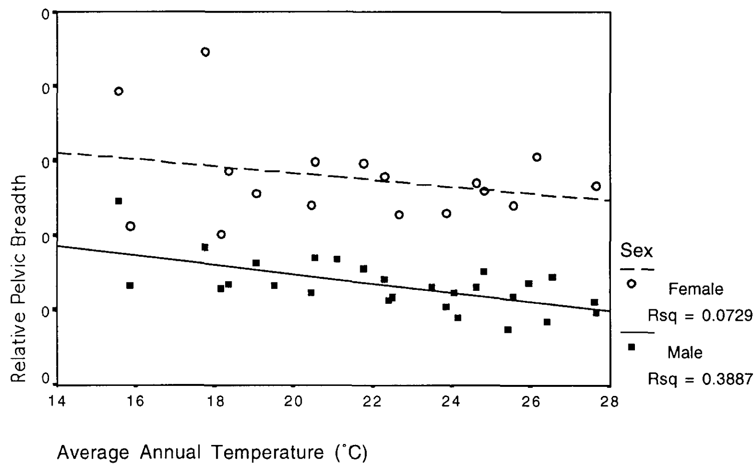

Figure 7.20: Bivariate Scatterplot of Male and Female Relative Pelvic Breadth vs Average Annual Temperature

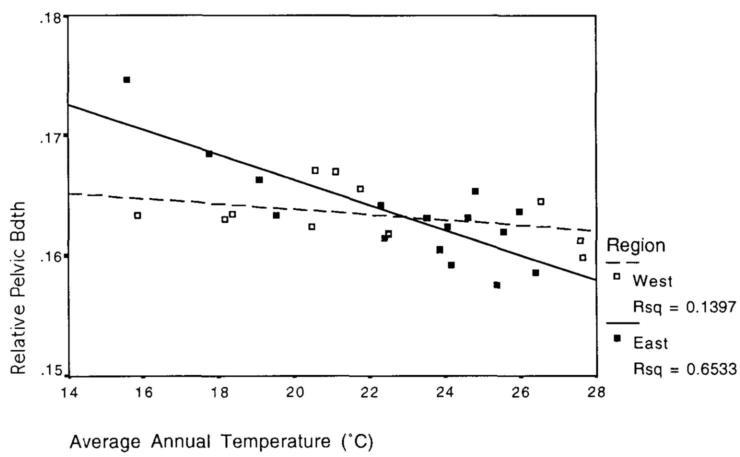

Figure 7.21: Bivariate Scatterplot of Male Relative Pelvic Breadth vs Average Annual Temperature: East/West sub-samples

7.2.4.4 Relative Shoulder Breadth

This ratio describes the breadth of the shoulders relative to stature. A high value indicates relatively broad shoulders (lateral build) and a low value, relatively narrow shoulders (linear build).

When all groups are utilised the male sample reveals moderately strong, negative correlations with Hottest Month and Annual Temperature (Figure 7.22), and moderately strong, positive correlations with Most Humid Month and Least Humid Month and latitude. In females there is also a moderately strong, negative correlation with Annual Temperature and a moderately strong, positive correlation with latitude, however these are the only significant correlations over 0.45. MSR analysis reveals that in both males and females Annual Temperature is the primary correlate. Overall climate explains 45% of variation in male relative shoulder breadth and 38% in females.

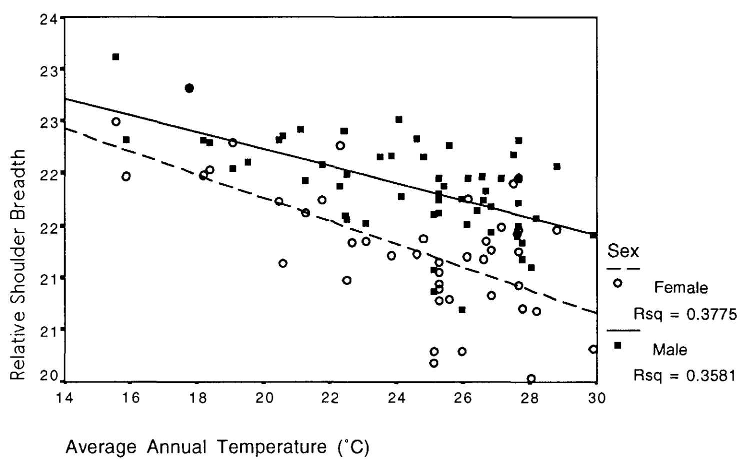

Figure 7.22: Bivariate Scatterplot of Male and Female Relative Shoulder Breadth vs Average Annual Temperature

Relationships in the eastern male sub-sample include moderately strong, negative correlations with Hottest Month and Annual Temperature (Figure 7.23). In eastern females, meanwhile, the correlations are with Coldest Month and Annual Temperature, in fact, 81% of variance in relative shoulder breadth in eastern females is explained by variation in annual temperature (compared to only 48% in males). In females there is also a negative correlation with Annual Rainfall. In the west, the male sample has a moderately strong negative correlation with Annual Temperature with a similar, but slightly lower correlation in females.

The partial correlations reveal that variation in male age and weight has little effect on the size of correlations, whilst in females, it is clear that average differences in these variables is of more importance.

These results indicate that there is increased body linearity in areas of warmer climate in the both the male and female samples. Further, the effect appears to be strongest in eastern females.

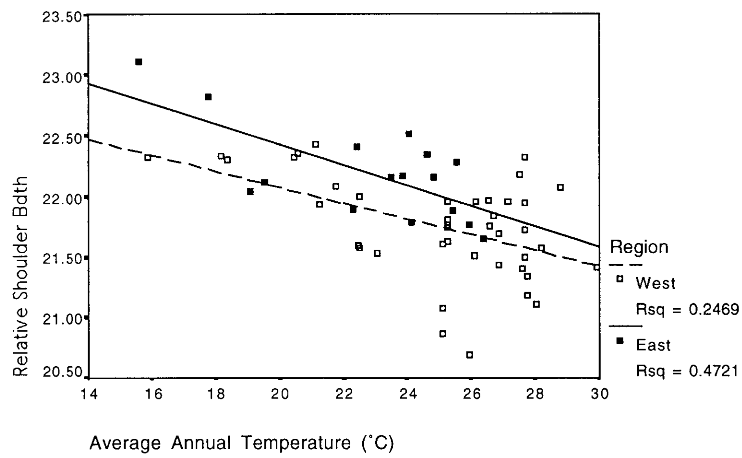

Figure 7.23: Bivariate Scatterplot of Male Relative Shoulder Breadth vs Average Annual Temperature: East/West sub-samples

7.2.4.5 Relative Sitting Height

This index measures length of the trunk and head relative to stature. It can also be viewed as the relative length of the lower limbs. A high value indicates a long trunk (or short legs) relative to stature and a low value, a relatively short trunk or long legs.

When all male groups are included no correlation reaches the 0.45 level. In the female sample there are weak to moderately strong, positive correlations with Most Humid Month, Least Humid Month (Figure 7.24) and longitude. MSR analysis revealed that in both males and females Least Humid Month is the primary correlate, however the relationship is stronger in females. Climate is seen to account for 19% of male variation in relative sitting height, compared to 27% in females.

In the eastern male sub-sample there is a moderately strong negative correlation with Hottest Month (Figure 7.25), however significant correlations are absent in all other sub-samples.

In the partial correlations it is found that variation in male age has some effect on the size of correlations, and when variation in weight is removed the positive correlation with Least Humid Month rises above 0.45. In females, the removal of age has the effect of reducing the size of some correlations, whilst accounting for variation in weight causes an increase in the correlation with Annual Rainfall.

These results suggest that populations in warmer and, in particular, drier areas have longer legs and shorter trunks relative to stature, as would be predicted by Allen's rule, however, the evidence is stronger in females than in males.

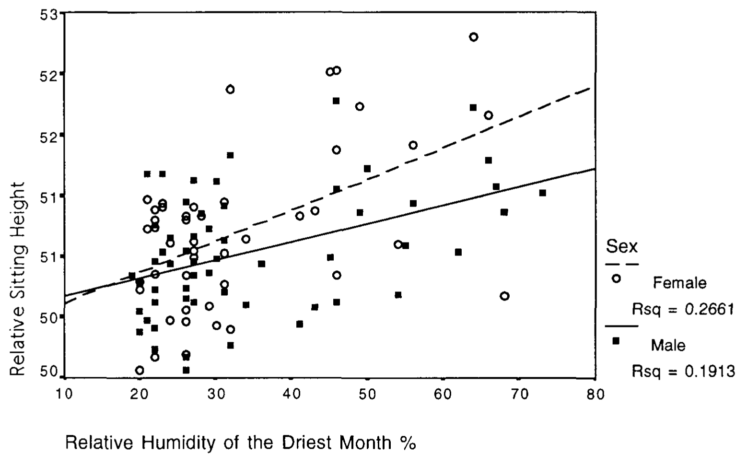

Figure 2.24: Bivariate Scatterplot of Male and Female Relative Sitting Height vs Relative Humidity of the Driest Month

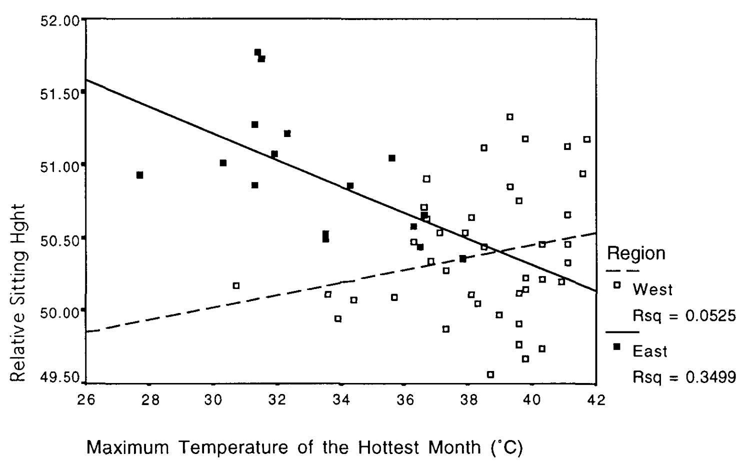

Figure 7.25: Bivariate Scatterplot of Male Relative Sitting Height vs Maximum Temperature of the Hottest Month: East/West sub-samples

7.2.4.6 Ponderal Index

This ratio is also a measure of total body shape, and is calculated with the equation: PI = Stature (cm)/ $\sqrt[3]{\text{Weight}}$ (kg). A low value indicates a lateral body shape and a high value a more linear one.

In both the male and female groups there are several significant correlations, however only the moderately strong, positive correlation with Annual Temperature, and the moderately strong, negative correlation with latitude (Figure 7.26) are above 0.45. Results of the MSR analysis confirm that Annual Temperature is the primary correlate. Overall, climate explains 27% of male variation in ponderal index and 30% in females.

In eastern males there are moderately strong to very strong, positive correlations with Coldest Month and Annual Temperature (Figure 7.27), with the latter explaining 56% of variance. The situation is similar in the eastern females with the correlation with Annual Temperature explaining 67% of shared variance. In the western groups the correlation with Annual Temperature is also positive and significant, but in both cases below 0.45.

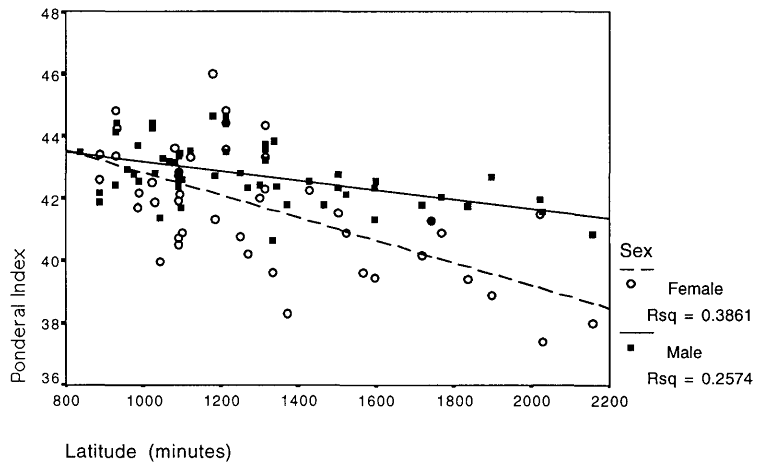

Figure 2.26: Bivariate Scatterplot of Male and Female Ponderal Index vs Latitude

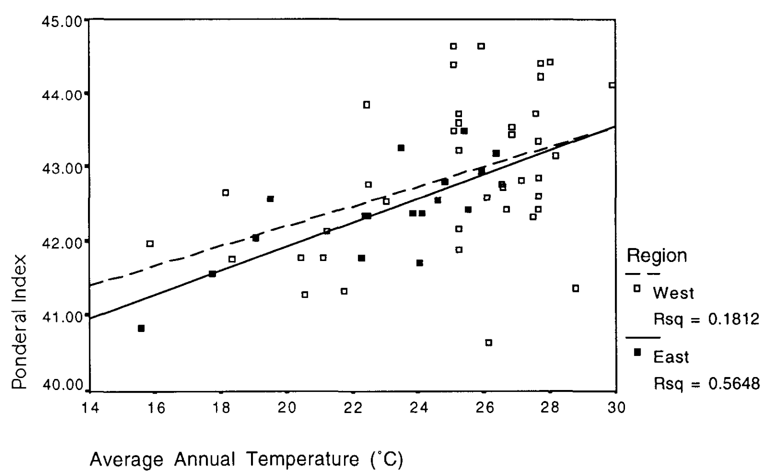

Figure 7.27: Bivariate Scatterplot of Male Ponderal Index vs Average Annual Temperature: East/West sub-samples

Age is the only co-variate to be removed and this had little effect on correlations in the male sample. In females, the removal of age caused the correlation with Coldest Month to rise above 0.45. This is a clear indication that populations in cooler areas are heavier for their weight, or more lateral, than populations in warmer areas.

7.2.4.7 Calf-Tibial Index

This ratio compares the circumference of the lower leg to its length. A high index indicates a thick calf relative to length and a low index, a narrow calf.

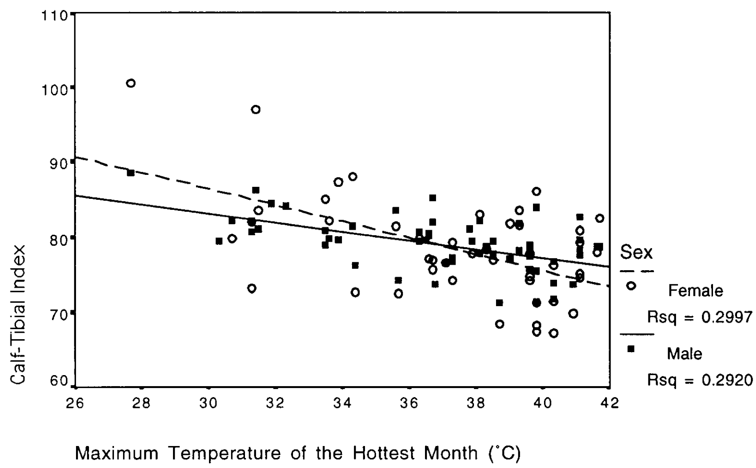

Figure 7.28: Bivariate Scatterplot of Male and Female Calf-Tibial Index vs Maximum Temperature of the Hottest Month

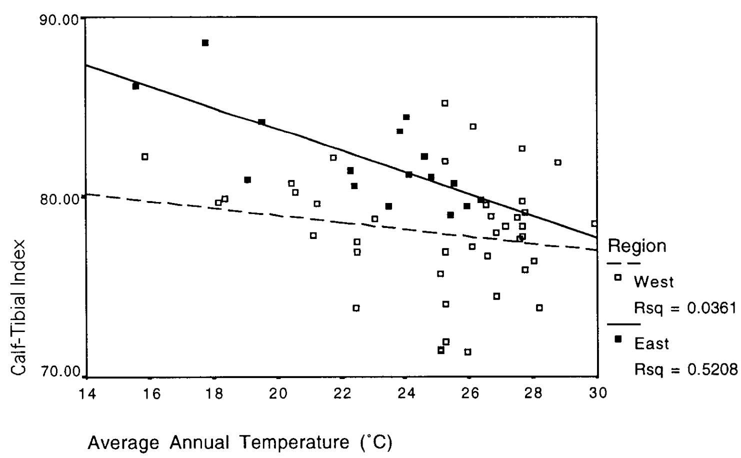

Figure 7.29: Bivariate Scatterplot of Male Calf-Tibial Index vs Average Annual Temperature: East/West sub-samples

In both the male and female samples there are moderately strong, positive correlations with Most Humid Month and Least Humid Month and a moderately strong, negative correlation with Hottest Month (Figure 7.28). Results of the MSR analysis reveal that in males the primary correlate is Most Humid Month, whilst in females it is Hottest Month. Climate accounts for 30% of variation in both male and female calf-tibial index. Therefore, populations in warmer, drier areas have narrower lower legs relative to length.

However, when the east-west sub-samples are examined it is apparent that the eastern populations supply the strongest evidence for temperature adaptation in the lower leg. The eastern male sub-sample has moderately strong to strong, negative correlations with Hottest Month, Coldest Month and Annual Temperature (the latter explaining 52% of variance: Figure 7.29) and the female sample has strong, negative correlations with Coldest Month, Annual Temperature (explaining 74% of variance) and a moderately strong positive correlation with latitude. In western males the only significant correlation above 0.45 is a positive one with Most Humid Month. Western females have no significant correlations above 0.45.

When variation in male age is removed most of the significant correlations are reduced below 0.45. Accounting for weight increases the size of the correlations, whilst removing variance in stature reduces the correlations somewhat. A similar pattern is seen in the female sample.

7.2.4.8 Radio-Humeral Index

Radio-humeral index compares the length of the distal to proximal sections of the upper limb. A high value indicates a relatively long radius, and a low value, a relatively short radius.

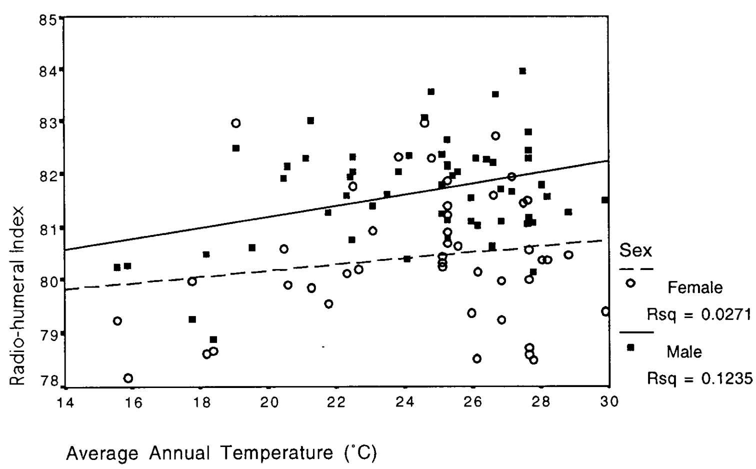

Figure 7.30: Bivariate Scatterplot of Male and Female Radio-humeral Index vs Average Annual Temperature

This ratio is often seen as an important indicator of temperature adaptation following Allen's rule. In this study, however, only very weak correlations between radio-humeral index and climate were found in both the male and female Australia-wide samples (Figure 7.30). The MSR results indicate that in males Annual Temperature is the primary correlate and in females it is Most Humid Month. In the Australia-wide samples climate accounts for only 12% of variation in male radio-humeral index and 21% in females.

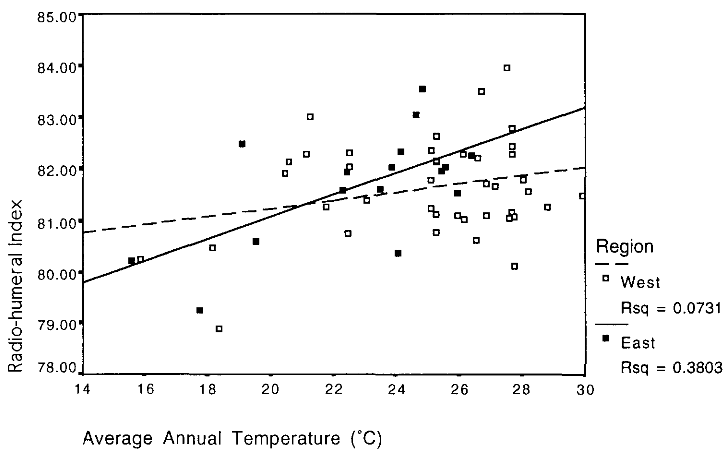

Figure 7.31: Bivariate Scatterplot of Male Radio-humeral Index vs Average Annual Temperature: East/West sub-samples

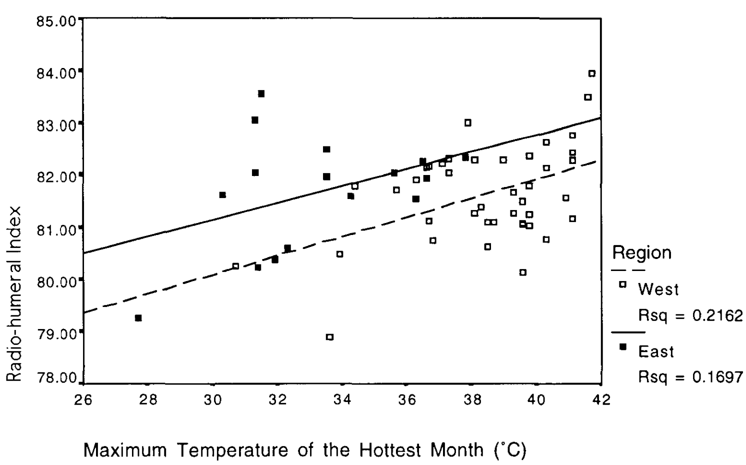

Figure 7.32: Bivariate Scatterplot of Male Radio-humeral Index vs Maximum Temperature of the Hottest Month: East/West sub-samples

When the east/west male sub-samples are examined, however, a moderately strong, positive correlation appears with temperature: in the east with Annual Temperature (Figure 7.31) and in the west with Hottest Month (Figure 7.32). There is also a weak, negative correlation with Least Humid Month in the west, but this is below 0.45. In the female western sample there are very weak, negative correlations with humidity, however again, these are below 0.45. This suggests that populations in the hotter areas have relatively longer distal segments in the upper limb.

When the partial correlations are calculated it is found that variation in age, weight or stature has little effect on the correlations between radio-humeral index and climate. In females, meanwhile, when stature is accounted for, positive and significant, but very weak, correlations appear with temperature variables.

7.2.4.9 Tibio-Femoral Index

This index compares the length of the tibia relative to the femur. A high value indicates a relatively long tibia, and a low value, a relatively short tibia. As with the radio-humeral index it is seen as a measure of temperature adaptation following Allen's rule.

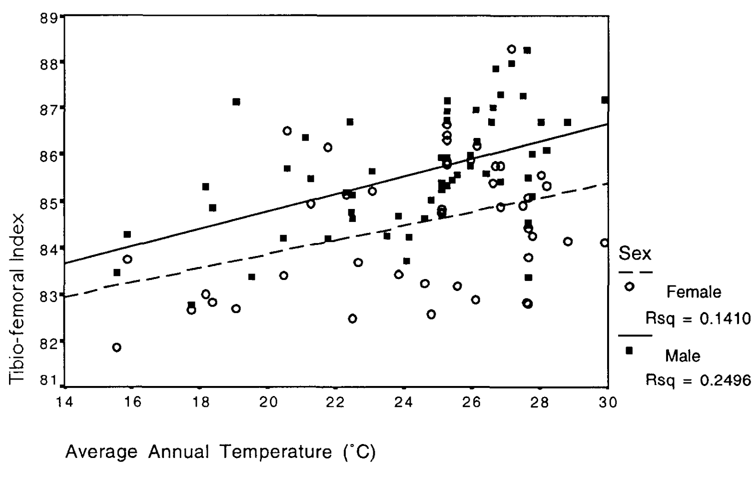

Figure 7.33: Bivariate Scatterplot of Male and Female Tibio-femoral Index vs Average Annual Temperature

In the male sample, moderately strong, positive correlations occur with Hottest Month (Figure 7.33) and Annual Temperature. MSR analysis reveals the latter to be the primary correlate with climate accounting for 34% of variance. Other bivariate correlations occur with Coldest Month (positive), and with Least Humid Month, Most Humid Month, latitude and longitude (negative), however these are below 0.45. In the female sample positive correlations above 0.45 occur with Hottest Month and negative correlations with

Most Humid Month (primary correlate: Figure 7.34), Least Humid Month and longitude. Climate accounts for 23% of variance in female tibio-femoral index.

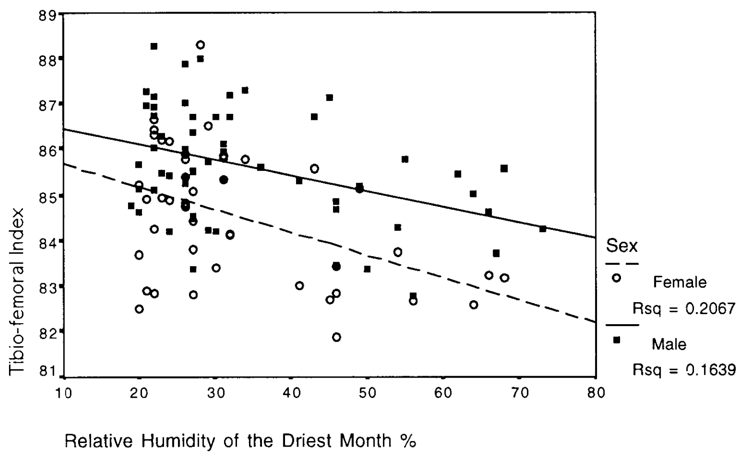

Figure 7.34: Bivariate Scatterplot of Male and Female Tibio-femoral Index vs Relative Humidity of the Driest Month

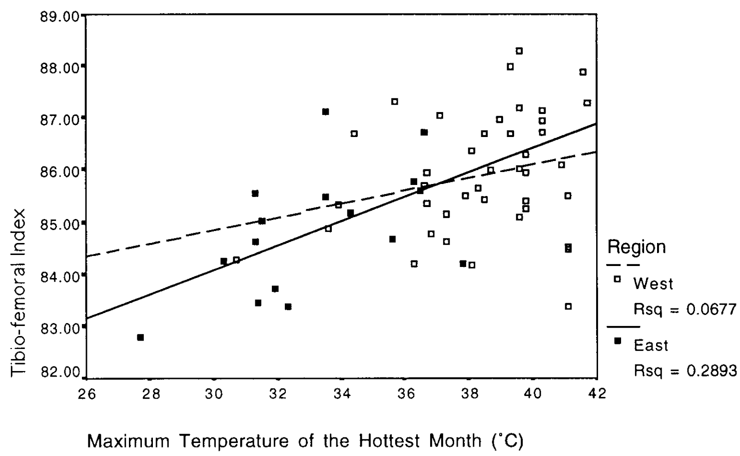

Figure 7.35: Bivariate Scatterplot of Male Tibio-femoral Index vs Maximum Temperature of the Hottest Month: East/West sub-samples

When the east/west sub-samples are considered, the tibio-femoral index in eastern males is found to have a moderately strong, positive correlation with Hottest Month (Figure 7.35). The pattern of correlations with temperature is similar in eastern females, however none attain significance. Instead, there is a strong, negative correlation with Most Humid Month. In western males there are weak, positive correlations with Coldest Month and Annual Temperature, however there are no significant correlations in the western female sample.

In the partial correlations variation in male age and weight are seen to have only minor effects on the ecogeographic correlations. Meanwhile, when stature is accounted for, the positive correlations with temperature fall below 0.45, and the weak, but significant correlations with humidity disappear. In females, variation in age has somewhat more of an effect on the correlations, whilst variation in weight has no apparent effect. The removal of variation in stature has a similar effect as that seen in males.

Overall, there is evidence for temperature adaptation in distal limb segment length, but more so in males than in females. However, the effect of removing stature in the partial correlations, would suggest that some of the relationship between tibio-femoral index and climate might be due to variation in body size.

7.2.4.10 Intermembral Index

This index compares the length of the upper limbs relative to the length of the lower limbs. A high value indicates relatively long arms (or short legs), and a low value, relatively short arms (or long legs).

In males, the general pattern of significant correlations is negative with temperature, and positive with humidity, however the relationships are very weak. The only bivariate correlation to reach the 0.45 level is a negative correlation with latitude (Figure 7.36). Surprisingly, however, MSR analysis reveals that 30% of variance is explained by a combination of Annual Temperature and Coldest Month. The same pattern is seen in females but the correlations are not as strong, with only 14% of variance explained by Hottest Month.

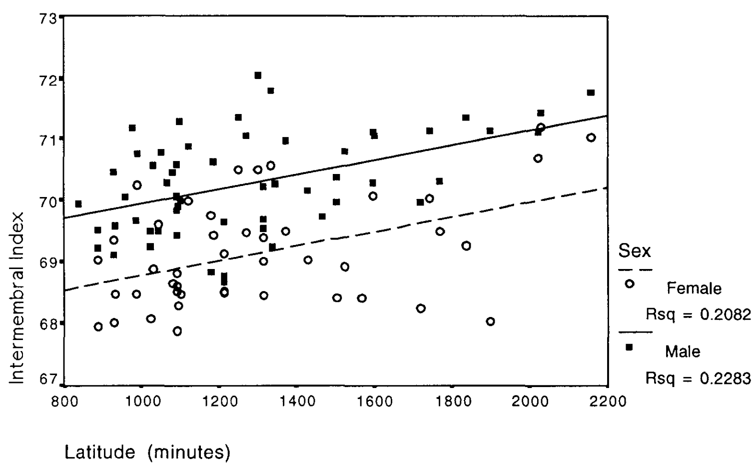

Figure 7.36: Bivariate Scatterplot of Male and Female Intermembral Index vs Latitude

This pattern of relatively shorter legs in southern populations is highlighted in the east/west samples. In eastern males there are moderately strong to strong, negative correlations with Hottest Month and Annual Temperature (Figure 7.37), and in eastern females there is a strong, negative correlation with Hottest Month. Western males also have significant negative correlations with temperature, however none reach the 0.45 level. In the western female sample no correlation attains significance.

The partial correlations reveal that in males variation in age, weight and stature all affect the size of correlations. When age is accounted for correlations are reduced in size, whilst accounting for weight increases the size of the negative correlations with Hottest Month and Annual Temperature to above 0.45. By contrast, when stature is removed all significant correlations are lost, which might be expected given that leg length makes up a considerable proportion of stature. In the female sample, however, the removal of the co-variates produces very little effect.

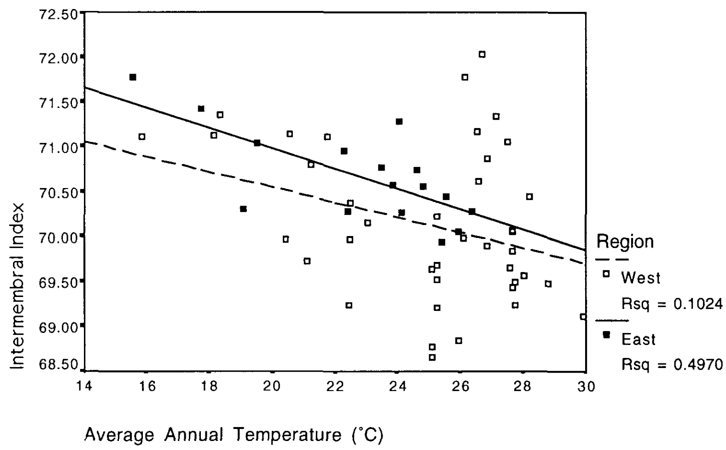

Figure 7.37: Bivariate Scatterplot of Male Intermembral Index vs Average Annual Temperature: East/West sub-samples

7.2.4.11 Femur/Sitting Height Index

This index compares the length of the femur relative to the length of the trunk and head. A low value indicates a relatively short femur (or long trunk) and a high value, a relatively long femur (or short trunk).

In the male sample the pattern of correlations is positive with temperature and negative with humidity, however none reach the 0.45 level. In the female sample some correlations do rise above this level, with a moderately strong, positive correlation with

Hottest Month (Figure 7.38), and moderately strong, negative correlation with Least Humid Month. MSR analysis reveal that in both males and females Least Humid Month is the primary correlate, however in the male sample it explains only 13% of variance, compared to 32% in females. Therefore, populations in warmer areas have longer femurs relative to trunk length, particularly in females. However, when the east and west sub-samples are examined no correlation attains significance.

In the partial correlations it is found that accounting for age, weight and stature in males has some effect, although no correlation rises above 0.45. In the female sample variation in age and stature reduces the size of correlations, however the removal of weight has no effect.

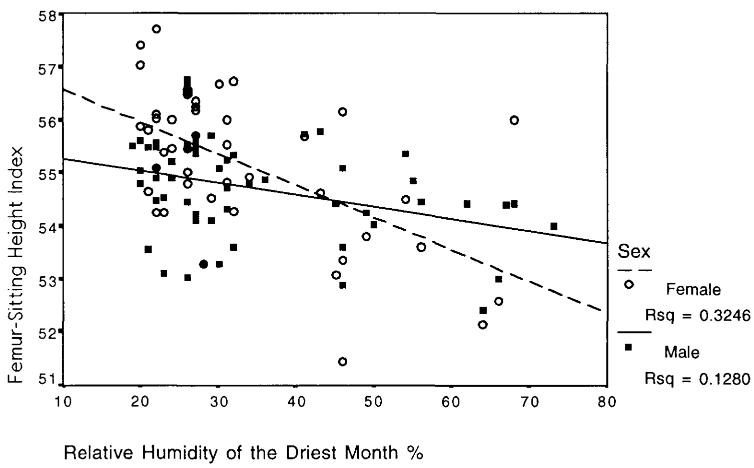

Figure 7.38: Bivariate Scatterplot of Male and Female Femur-Sitting Height Index vs Relative Humidity of the Driest Month

7.2.4.12 Tibia/Sitting Height Index

This index compares the length of the tibia relative to the trunk. The pattern of correlations for tibia-sitting height is the same as that observed in femur-sitting height, however there is stronger evidence for adaptive clines.

In the male sample there is a moderately strong, positive correlation with Hottest Month (Figure 7.39) and moderately strong, negative correlations with Least Humid Month and longitude. All other significant correlations are below 0.45. Overall, climate accounts for 36% of variation in male tibia-sitting height index, with 31% of this attributable to variation in Least Humid Month.

In the female sample a similar, but stronger, result is observed, with moderately strong, positive correlations with Hottest Month and Temperature Range, and moderately strong to strong, negative correlations with Most Humid Month, Least Humid Month, Annual Rainfall and longitude. Again, Least Humid Month is found to be the primary correlate and in females it explains 56% of variance.

As with the femur/sitting height ratio, there is evidence that populations in warmer areas have longer limb segments relative to trunk length (or, alternatively shorter trunks), than those in cooler areas. Again, this is more apparent in the female sample.

In the eastern male sub-sample, meanwhile, there is a moderately strong, positive correlation with Hottest Month (Figure 7.40), but no significant correlations in the female sample. In western males there are also no significant correlations, however in the female sample there are weak, negative correlations with Most Humid Month and Least Humid Month.

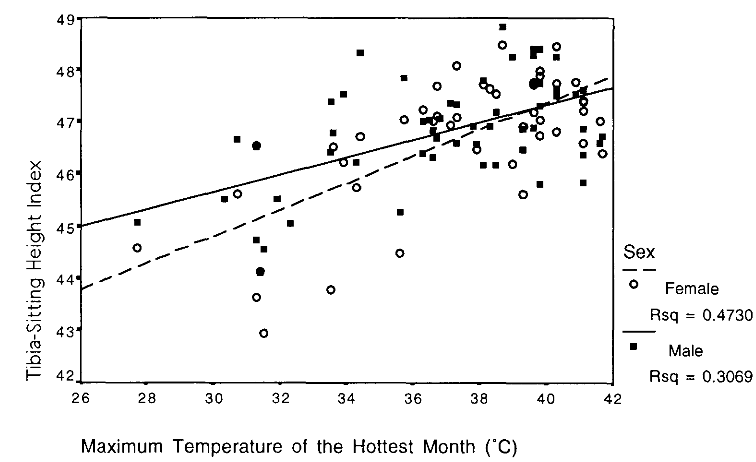

Figure 7.39: Bivariate Scatterplot of Male and Female Tibia-Sitting Height Index vs Maximum Temperature of the Hottest Month

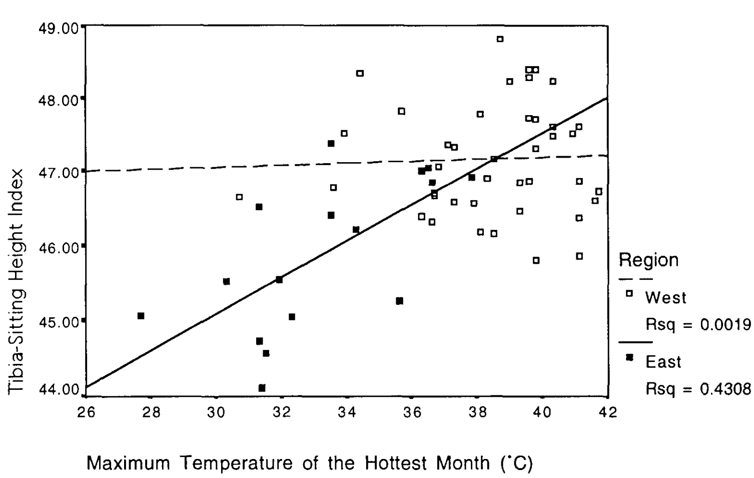

Figure 7.40: Bivariate Scatterplot of Male Tibia-Sitting Height Index vs Maximum Temperature of the Hottest Month: East/West sub-samples

In the partial correlations age is found to have only a moderate effect in the male sample, whilst the removal of variation in weight has no effect. When stature is removed correlations are reduced in size. Variation in female age has more effect in acting to reduce the size of some correlations. The removal of weight has no effect, and in contrast to males, variation in female stature has little apparent effect on the size of correlations.

7.2.4.13 Humerus/Sitting Height Index

This index compares the length of the humerus relative to the length of the trunk and head. A low value indicates a relatively short humerus (or long trunk) and a high value a relatively long humerus (or short trunk).

In males, no correlation between the humerus/sitting height index and climate reaches 0.45, however of the correlations that are significant, Annual Rainfall is the most influential. Only 18% of variance in this index is explained by climate. In the female sample, meanwhile, there is a weak, positive correlation with Hottest Month, and moderately strong, negative correlations with Least Humid Month (Figure 7.41), Annual Rainfall and longitude. Of the climatic variables, MSR analysis reveals that Least Humid Month is the primary correlate, with 35% of variance in this index in females explained by climate. As with the lower limb/sitting height ratios, it appears that females in warmer areas are more consistently linear in this index than are males.

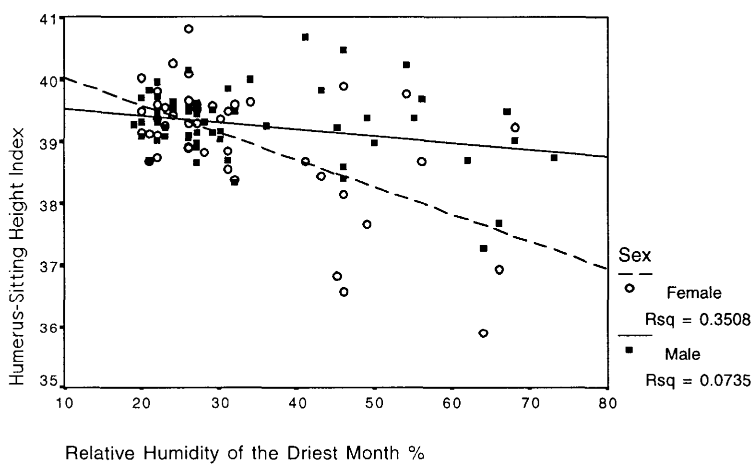

Figure 7.41: Bivariate Scatterplot of Male and Female Humerus-Sitting Height Index vs Relative Humidity of the Driest Month

In eastern males there are no significant correlations, whilst in the west there is a weak, negative correlation with Hottest Month. Neither the eastern or western female sub-samples attain significant correlations.

When variation in male age and weight are removed little change is seen in the size of correlations. When stature is accounted for, a negative correlation appears with Annual Temperature, but it is below 0.45. In the female sample accounting for age reduces some correlations, but removing weight has no effect. When stature is controlled for the correlation with Hottest Month disappears and a negative (but under 0.45) correlation with Coldest Month appears. This would indicate that some of the variation seen in this index is due to variation in body size.

7.2.4.14 Radius/Sitting Height Index

This index compares the length of the radius relative to the length of the trunk and head.

The pattern of correlations for this index is similar to that of humerus/sitting height. In the male sample no correlation achieves the 0.45 level (Annual Rainfall is revealed as the primary correlate explaining 16% of variance), however in the female sample there is a moderately strong, positive correlation with Hottest Month (Figure 7.42) and moderately strong, negative correlations with Most Humid Month, Least Humid Month, Annual Rainfall and longitude. MSR analysis reveals that in females Least Humid Month is the primary correlate, explaining 35% of variance.

When the east/west correlations are examined eastern males are found to have a moderately strong, positive correlation with Hottest Month (Figure 7.43) and a moderately strong, negative correlation with Most Humid Month. In eastern females, meanwhile, no significant correlations are observed. In the west the situations are reversed, with no significant correlations found in the male sample and a weak negative correlation with Most Humid Month in females.

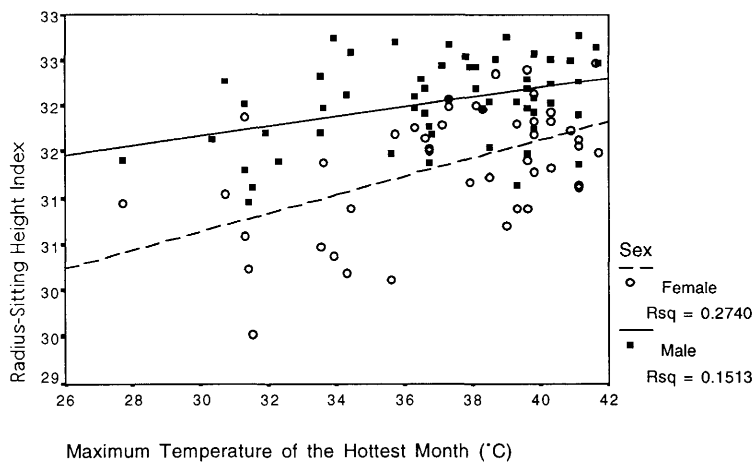

Figure 7.42: Bivariate Scatterplot of Male and Female Radius-Sitting Height Index vs Maximum Temperature of the Hottest Month

When the co-variates of age and weight are removed from the male sample there is little change to the correlations, however when stature is removed some correlations are much reduced in size and/or significance. Again, in the female sample, variation in age appears as an important co-variate, with its removal reducing all correlations in size. Controlling for weight has little effect, and although the removal of stature reduces the size of correlations, the effect is weaker than that seen in the male sample.

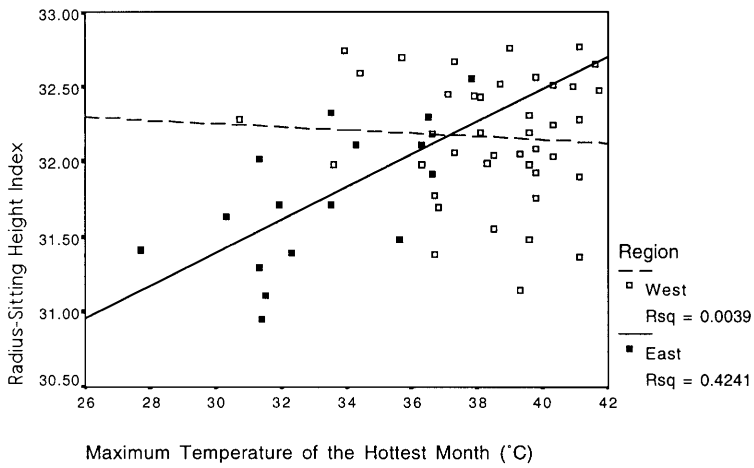

Figure 7.43: Bivariate Scatterplot of Male Radius-Sitting Height Index vs Maximum Temperature of the Hottest Month: East/West sub-samples

7.2.4.15 Summary: Body Shape

Bivariate Correlations

- There is clear evidence of body linearity associated with warmer climates, however this evidence is stronger in the east, where there are distinct clines in the ratios of relative body breadth and overall measures of body linearity.
- Differences occur between males and females in the size and significance of some correlations. This may simply be due to sampling differences, or may reflect sexually dimorphic differences in the adaptive response to climate due to sexual differences in body size and shape, fat and muscle distribution and physiology.
- Partial correlations reveal that differences in age between the female sample groups has had a greater effect on the size of some correlations than in male sample.

MSR

- In 8 out of 14 indices, variation in climate explains more than 20% of variance in the male sample and all indices are significantly associated with climate.
- In the female sample all indices except relative bi-iliac breadth were significantly associated with climate, and in 10 out of 14 indices climate explained more than 20% of variance.
- In males the greatest influence of climate on body shape was seen in relative shoulder breadth (45%), whilst in females it was in tibia length/sitting height index (56%).
- For ratios comparing limb segment lengths, those of the lower limb show a greater association with climate than those of the upper limb, although in males the relationship is primarily with temperature and, in females, with humidity.
- Other relative limb indices such as Intermembral index and limb segment - sitting height indices are most strongly related to moisture variables in both males and females, however in all cases the female sample exhibits stronger associations with climate.
- Absolute limb length and limb to sitting height (trunk length) seems to play a more significant role in thermoregulation in females, whilst in males it is relative body breadth.

7.2.5 Cranio-facial size and climate in adult male and female Australian Aborigines

The bivariate, multivariate and partial correlations between cranio-facial measurements and climate are presented in tables 7.23 to 7.30. It should be noted that many of the cranio-facial measurements are intercorrelated (Tables 7.5 and 7.6). These inter-correlations will be examined in Chapter 8, which reports the results of a principal components analysis.

7.2.5.1 Head Length

In males, head length exhibits a number of significant correlations with climatic variables including weak, negative correlations with Least Humid Month (Figure 7.44) and Annual Rainfall, and a moderately strong, positive correlation with Temperature Range. MSR analysis reveals the latter to be the primary correlate, explaining 25.35% of variance. In the female sample there are also negative correlations with moisture variables, but all are below 0.45. Annual Rainfall is identified as the primary correlate, however this explains only 14% of the variance in female head length.

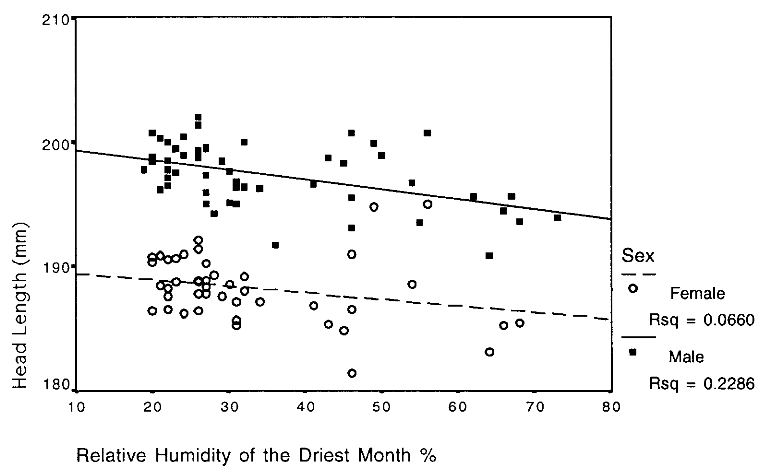

Figure 7.44: Bivariate Scatterplot of Male and Female Head Length vs Relative Humidity of the Driest Month

Table 7.23: Pearson's and Spearman's correlation coefficients between mean cranio-facial measurements and climate: males.

Variables		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
Head L	*r*	0.28*	-0.42***	**0.50*****	-0.12	-0.42***	**-0.48*****	0.16	**-0.47*****	0.33*	-0.25
	ρ	0.31*	-0.37**	0.37**	-0.07	-0.41**	-0.44***	0.04	-0.34**	0.37**	-0.14
Head B	*r*	0.02	-0.13	0.11	-0.09	0.08	-0.12	0.28*	-0.28*	0.23	-0.25
	ρ	0.01	-0.11	-0.12	0.07	0.07	0.09	0.30*	-0.03	0.16	-0.28*
Head H	*r*	0.15	0.13	-0.01	0.28*	-0.03	-0.19	0.26	0.02	-0.20	-0.25
	ρ	0.23	0.11	-0.03	0.35**	-0.10	-0.13	0.25	0.19	-0.19	-0.26
Min Front D	*r*	0.42***	0.07	0.20	0.29*	-0.34**	-0.41**	0.16	-0.31*	-0.07	**-0.60*****
	ρ	0.38**	0.10	0.07	0.36**	-0.32*	-0.31*	0.17	-0.18	-0.06	**-0.60*****
Bizyg	*r*	**0.48*****	-0.20	**0.45*****	0.24	-0.43***	**-0.60*****	0.33*	-0.36**	-0.11	-0.43***
	ρ	0.42***	-0.11	0.34**	0.25	**-0.45*****	**-0.52*****	0.26	-0.24	-0.05	-0.35**
Bigonial	*r*	**0.49*****	-0.04	0.34*	0.33*	**-0.46*****	**-0.55*****	0.21	-0.42**	-0.10	**-0.50*****
	ρ	**0.50*****	0.08	0.18	**0.45*****	**-0.47*****	-0.37**	0.18	-0.14	-0.10	**-0.51*****
Tot Fac H	*r*	-0.09	0.15	-0.17	0.16	0.24	-0.16	0.12	0.15	-0.15	0.21
	ρ	-0.04	0.13	-0.24	0.26	0.19	0.24	0.17	0.32*	-0.22	0.13
Up Fac H	*r*	0.16	0.07	0.04	0.26*	0.04	0.13	0.29*	-0.09	-0.16	-0.14
	ρ	0.19	0.08	-0.10	0.41**	-0.01	0.02	0.31*	0.16	-0.20	-0.18
Nose H	*r*	0.08	0.07	-0.01	0.17	0.18	-0.04	0.30*	-0.02	-0.10	-0.07
	ρ	0.07	0.07	-0.17	0.31*	0.12	0.17	0.31*	0.19	-0.13	-0.09
Nose B	*r*	**0.62*****	0.23	0.20	**0.61*****	**-0.51*****	**-0.49*****	0.05	-0.18	**-0.40****	**-0.55*****
	ρ	**0.65*****	0.28*	0.19	**0.66*****	**-0.53*****	-0.43***	0.06	-0.09	-0.29*	**-0.59*****
Nose D	*r*	-0.03	-0.32*	0.22	-0.23	-0.08	-0.12	0.28*	-0.24	0.37**	-0.09
	ρ	-0.06	-0.30*	0.05	-0.12	0.14	0.12	0.35**	-0.09	0.30*	-0.11
Mand D	*r*	0.13	0.11	-0.01	0.27*	-0.05	-0.14	0.15	0.06	-0.24	-0.09
	ρ	0.12	0.13	-0.06	0.31*	-0.06	-0.01	0.16	0.15	-0.21	-0.07

Table 7.24: Pearson's and Spearman's correlation coefficients between mean cranio-facial measurements and climate: females.

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
Head L	*r*	0.08	-0.25	0.25	-0.09	-0.27	-0.26	-0.02	-0.37*	0.26	-0.0002
	ρ	0.20	-0.15	0.10	0.02	-0.35*	-0.31*	-0.07	-0.22	0.27	0.01
Head B	*r*	-0.34*	-0.17	-0.09	-0.34*	0.36*	0.22	0.19	-0.13	0.43**	0.01
	ρ	-0.23	-0.08	-0.36*	-0.06	0.33*	0.32*	0.25	0.02	0.22	-0.19
Head H	*r*	-0.38**	0.13	-0.36*	-0.10	**0.47*** **	0.34*	0.18	0.37*	0.03	0.23
	ρ	-0.31*	0.12	**-0.46** **	0.04	**0.46** **	0.35*	0.24	0.41**	-0.12	0.09
Min Front D	*r*	0.16	0.06	0.06	0.15	-0.26	-0.25	-0.01	-0.22	0.02	-0.20
	ρ	0.17	0.15	-0.12	0.21	-0.27	-0.29	-0.003	-0.16	0.11	-0.29*
Bizyg	*r*	0.05	-0.21	0.23	-0.09	-0.07	-0.26	0.27	-0.29	0.24	-0.14
	ρ	-0.001	-0.15	-0.04	-0.004	-0.02	-0.13	0.20	-0.12	0.17	-0.08
Bigonial	*r*	0.23	-0.15	0.27	0.05	-0.21	-0.41**	0.28	-0.33*	0.15	-0.39**
	ρ	0.16	-0.001	-0.03	0.14	-0.14	-0.19	0.20	-0.16	0.13	-0.33*
Tot Fac H	*r*	0.02	0.04	-0.02	0.001	0.15	-0.06	0.29	-0.12	0.12	-0.08
	ρ	0.04	0.07	-0.26	0.18	0.11	0.10	0.31*	0.07	0.05	-0.14
Up Fac H	*r*	0.14	0.12	-0.002	0.20	0.01	-0.21	0.31*	-0.15	-0.05	-0.13
	ρ	0.14	0.20	-0.23	0.38**	-0.01	-0.01	0.32*	0.12	-0.15	-0.09
Nose H	*r*	0.22	0.32*	-0.10	0.33*	0.04	-0.16	0.27	-0.10	-0.19	-0.27
	ρ	0.19	0.34*	-0.30*	**0.48*** **	0.04	0.06	0.32*	0.15	-0.21	-0.25
Nose B	*r*	**0.45** **	0.24	0.11	**0.52*** **	-0.22	-0.38**	0.23	-0.08	-0.36*	**-0.48*** **
	ρ	**0.45** **	0.37*	-0.08	**0.65*** **	-0.20	-0.14	0.26	0.16	-0.35*	**-0.46** **
Nose D	*r*	-0.07	-0.24	0.15	-0.27	0.25	-0.05	0.41**	-0.24	0.35*	-0.22
	ρ	-0.08	-0.24	-0.03	-0.11	0.24	0.10	0.42**	-0.12	0.25	-0.16
Mand D	*r*	-0.17	-0.03	-0.10	-0.12	0.18	0.08	0.14	0.07	0.14	0.04
	ρ	-0.17	-0.07	-0.21	-0.05	0.17	0.14	0.14	0.13	0.09	0.03

Table 7.25: Pearson's correlation coefficients between mean cranio-facial measurements and climate: male eastern and western sub-samples. (E: n = 16; W: n = 41).

Variables		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Abs Latitude
Head L	E	-0.23	**-0.76*** **	**0.56***	**-0.81*** **	-0.13	-0.25	0.24	-0.47	**0.79*** **
	W	0.21	-0.05	0.17	0.07	-0.37*	-0.36*	-0.22	-0.13	-0.02
Head B	E	0.14	**-0.72** **	**0.68** **	**-0.62** **	-0.21	**-0.59***	**0.67** **	**-0.79*** **	**0.72** **
	W	-0.20	0.28	-0.39*	0.08	0.29	0.40**	0.06	0.35*	-0.07
Head H	E	-0.45	-0.43	0.17	**-0.59***	0.06	0.02	0.02	-0.21	**0.56***
	W	0.10	**0.49*** **	-0.41**	**0.48*** **	0.16	0.01	0.21	**0.66*** **	**-0.57*** **
Min Fr D	E	0.09	-0.26	0.26	-0.27	0.05	-0.23	0.38	**-0.54***	0.29
	W	0.16	0.35*	-0.24	0.29	-0.17	-0.03	-0.21	0.22	-0.18
Bizyg	E	0.29	**-0.55***	**0.59***	-0.39	-0.15	-0.49	**0.58***	**-0.62***	0.47
	W	0.13	0.11	-0.02	0.30	-0.24	-0.27	-0.10	**0.46** **	**-0.44** **
Bigonial	E	0.32	**-0.65** **	**0.70** **	-0.48	-0.26	**-0.60***	**0.64** **	**-0.79*** **	**0.59***
	W	0.27	**0.50*** **	-0.32*	**0.56*** **	-0.32*	-0.17	-0.31*	0.43**	**-0.54*** **
Tot Fac H	E	-0.04	**-0.71** **	**0.59***	**-0.69** **	-0.10	-0.39	0.49	**-0.50***	**0.75*** **
	W	0.12	**0.51*** **	-0.42**	**0.51*** **	0.22	0.16	0.18	**0.55*** **	**-0.59*** **
Up Fac H	E	-0.01	**-0.74*** **	**0.63** **	**-0.70** **	-0.16	-0.48	**0.56***	**-0.62** **	**0.80*** **
	W	0.09	**0.50*** **	-0.43**	**0.51*** **	0.23	0.22	0.13	**0.57*** **	**-0.59*** **
Nose H	E	0.04	**-0.74*** **	**0.65** **	**-0.70** **	-0.07	-0.45	**0.60***	**-0.51***	**0.76*** **
	W	0.04	**0.48** **	-0.44**	0.43**	0.33*	0.32*	0.20	**0.52*** **	**-0.50*** **
Nose B	E	0.38	0.04	0.13	0.23	-0.12	-0.11	0.04	-0.18	0.20
	W	**0.48** **	**0.50*** **	-0.19	**0.65*** **	-0.38*	-0.27	-0.30	0.34*	**-0.56*** **
Nose D	E	0.05	**-0.76*** **	**0.67** **	**-0.63** **	-0.37	**-0.53***	0.44	**-0.58***	**0.78*** **
	W	-0.23	0.08	-0.22	-0.06	0.36*	0.37*	0.19	0.29	0.03
Mand D	E	0.15	-0.47	0.47	-0.32	-0.30	-0.40	0.30	**-0.50***	0.45
	W	0.09	0.34*	-0.28	0.39*	0.05	-0.02	0.08	**0.59*** **	**-0.49** **

Table 7.26: Pearson's correlation coefficients between mean cranio-facial measurements and climate: female eastern and western sub-samples. (E: n = 8; W: n = 37)

Variables		**Max Hot**	**Min Cold**	**Ann Temp Var**	**Av Ann Temp**	**RH Wet**	**RH Dry**	**Ann RH Var**	**Ann Rain**	**Abs Latitude**
Head L	E	-0.43	-0.51	0.32	-0.59	-0.06	-0.22	0.16	-0.45	0.63
	W	0.24	0.03	0.14	0.13	-0.41*	-0.37*	-0.26	-0.30	-0.04
Head B	E	-0.47	-0.61	0.39	**-0.72***	0.08	-0.32	0.34	-0.58	**0.77***
	W	-0.32	0.14	-0.34*	-0.15	**0.46****	**0.46****	0.26	0.05	0.18
Head H	E	-0.58	-0.48	0.24	-0.62	0.02	-0.16	0.16	-0.34	0.68
	W	-0.19	0.37*	**-0.47****	0.17	**0.46****	0.29	0.41*	**0.57*****	-0.30
Min Fr D	E	-0.24	-0.34	0.23	-0.28	-0.34	-0.11	-0.12	-0.34	0.35
	W	0.20	0.30	-0.16	0.26	-0.23	-0.31	-0.06	-0.08	-0.13
Bizyg	E	-0.38	-0.68	0.49	-0.70	-0.08	-0.38	0.30	-0.62	**0.75***
	W	0.02	0.13	-0.11	0.12	0.04	-0.12	0.18	0.14	-0.12
Bigonial	E	-0.46	-0.62	0.41	**-0.76***	0.20	-0.33	0.43	-0.60	**0.80***
	W	0.12	0.21	-0.12	0.20	-0.10	-0.18	0.02	0.18	-0.17
Tot Fac H	E	-0.12	**-0.84****	**0.72***	**-0.91****	0.24	-0.68	**0.79***	**-0.81***	**0.89****
	W	0.05	0.43**	-0.38*	0.26	0.18	0.11	0.16	0.21	0.23
Up Fac H	E	-0.51	-0.65	0.41	**-0.87****	0.39	-0.38	0.60	-0.62	**0.88****
	W	0.11	**0.52*****	-0.43**	0.44**	0.11	0.05	0.11	0.29	-0.44**
Nose H	E	-0.23	-0.42	0.31	-0.57	0.25	-0.31	0.45	-0.53	0.57
	W	0.13	**0.61*****	**-0.50****	**0.45****	0.19	0.15	0.13	0.25	-0.39*
Nose B	E	-0.24	-0.64	0.50	-0.61	-0.10	-0.36	0.26	-0.56	0.64
	W	0.31	**0.61*****	-0.38*	**0.64*****	0.01	-0.01	0.02	**0.49****	**-0.63*****
Nose D	E	-0.40	-0.57	0.38	-0.70	0.17	-0.31	0.40	-0.57	**0.71***
	W	-0.28	-0.11	-0.08	-0.30	0.44**	0.32*	0.35*	0.002	0.29
Mand D	E	-0.11	**-0.76***	0.65	-0.67	-0.13	-0.52	0.40	-0.59	0.69
	W	-0.18	0.21	-0.31	0.02	0.19	0.15	0.15	0.28	-0.04

Table 7.27: Multiple stepwise regression analysis on male cranio-facial measurements.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
	Percent Shared Variance									
Head L	.	.	25.35***	.	.	.	.	.	0.50	0.25***
Head B	.	.	.	.	.	.	7.75*	.	0.28	0.08*
Head H	.	.	.	7.68*	.	.	8.49*	.	0.40	0.16**
Min Front D	17.44**	.	.	.	.	.	.	.	0.42	0.17**
Bizyg	.	.	.	.	.	35.86***	.	.	0.60	0.36***
Bigon	.	.	.	.	.	30.55***	.	.	0.55	0.31***
Tot Fac H	.	.	.	.	.	.	.	.	.	.
Upp Fac H	.	.	.	8.89*	.	.	8.34*	.	0.42	0.17**
Nose H	.	.	.	.	.	.	8.83*	.	0.30	0.09*
Nose B	38.34***	.	.	8.11**	.	.	.	.	0.68	0.46***
Nose D	.	9.93*	.	.	.	.	.	.	0.32	0.10*
Mand D	.	.	.	7.34*	.	.	.	.	0.27	0.07*

Table 7.28: Multiple stepwise regression analysis on female cranio-facial measurements.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
	Percent Shared Variance									
Head L	.	.	.	.	.	.	.	13.93*	0.37	0.14*
Head B	.	.	.	.	13.01*	.	.	10.95*	0.49	0.24**
Head H	.	.	.	.	22.18**	.	.	.	0.47	0.22**
Min Front D	.	.	.	.	.	.	.	.	.	.
Bizyg	.	.	.	.	.	.	.	.	.	.
Bigon	.	.	.	.	.	16.94**	.	.	0.41	0.17**
Tot Fac H	.	.	.	.	.	.	.	.	.	.
Upp Fac H	.	.	.	.	.	.	9.40*	.	0.31	0.09*
Nose H	.	.	.	10.98*	.	.	10.45*	.	0.46	0.21**
Nose B	.	.	.	26.78***	.	.	9.65*	.	0.60	0.36***
Nose D	.	.	.	.	.	.	16.70**	.	0.41	0.17**
Mand D	.	.	.	.	.	.	.	.	.	.

Table 7.29: Complete and partial correlations between mean cranio-facial measurements and climate: males.

	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
Head L	0.28*	-0.42***	**0.50*****	-0.12	-0.42***	**-0.48*****	0.16	**-0.47*****
age	0.22	-0.43***	**0.48*****	-0.18	-0.38**	**-0.45*****	0.16	**-0.45*****
weight	0.18	-0.38**	0.42***	-0.18	-0.38**	-0.37**	0.01	-0.39**
stature	-0.03	**-0.54*****	0.43***	**-0.54*****	-0.24	-0.26	0.04	-0.38**
Head B	0.02	-0.13	0.11	-0.09	0.08	-0.12	0.28*	-0.28*
age	0.31*	-0.16	0.30*	0.05	-0.20	-0.40**	0.31*	**-0.45*****
weight	-0.27*	-0.004	-0.17	-0.22	0.27*	0.22	0.05	-0.07
stature	-0.30*	-0.18	-0.01	-0.40**	0.33*	0.16	0.20	-0.17
Head H	0.15	0.13	-0.01	0.28*	-0.03	-0.19	0.26	0.02
age	0.19	0.13	0.003	0.30*	-0.05	-0.24	0.26	0.01
weight	-0.03	0.29*	-0.25	0.27*	0.08	0.03	0.08	0.26*
stature	-0.32	0.10	-0.25	-0.07	0.36**	0.23	0.14	0.29*
Min Front D	0.42***	0.07	0.20	0.29*	-0.34**	-0.41**	0.16	-0.31*
age	0.44***	0.07	0.19	0.28*	-0.36**	-0.43***	0.16	-0.31*
weight	0.30*	0.26	-0.03	0.29*	-0.30*	-0.22	-0.10	-0.13
stature	0.13	0.03	0.04	-0.03	-0.11	-0.12	0.02	-0.16
Bizyg	**0.48*****	-0.20	**0.45*****	0.24	-0.43***	**-0.60*****	0.33*	-0.36**
age	**0.50*****	-0.19	**0.45*****	0.23	**-0.45*****	**-0.63*****	0.33*	-0.35**
weight	0.38**	-0.10	0.32*	0.23	-0.42***	**-0.49*****	0.13	-0.19
stature	0.11	-0.35**	0.35**	0.24	-0.16	-0.33*	0.22	-0.18
Bigon	**0.49*****	-0.04	0.34*	0.33*	**-0.46*****	**-0.55*****	0.21	-0.42**
age	**0.61*****	-0.04	0.38**	0.37**	**-0.58*****	**-0.66*****	0.21	**-0.45*****
weight	0.41**	0.13	0.15	0.37**	**-0.48*****	-0.42***	-0.06	-0.27*
stature	0.17	-0.12	0.19	-0.04	-0.23	-0.28*	0.07	-0.28*
Tot Fac H	-0.09	0.15	-0.17	0.16	0.24	-0.16	0.12	0.15
age	0.26*	0.17	0.01	0.42***	-0.07	-0.17	0.15	0.01
weight	-0.36**	0.33*	**-0.49*****	0.12	0.43***	**0.49*****	-0.12	**0.46*****
stature	**-0.48*****	0.13	-0.35**	-0.10	**0.55*****	**0.52****	0.02	0.34**
Upp Fac H	0.16	0.07	0.04	0.26*	0.04	0.13	0.29*	-0.09
age	0.39**	0.07	0.16	0.40**	-0.16	-0.36**	0.31*	-0.18
weight	-0.04	0.25	-0.23	0.26	0.19	0.12	0.09	0.17
stature	-0.33*	0.03	-0.19	-0.11	**0.48*****	0.32*	0.18	0.16
Nose H	0.08	0.07	-0.01	0.17	0.18	-0.04	0.30*	-0.02
age	0.39**	0.07	0.16	0.37**	-0.07	-0.31*	0.34*	-0.15
weight	-0.13	0.21	-0.25	0.14	0.34*	0.24	0.12	0.22
stature	-0.32*	0.03	-0.20	-0.14	**0.54*****	0.36**	0.20	0.18
Nose B	**0.62*****	0.23	0.20	**0.61*****	**-0.51*****	**-0.49*****	0.05	-0.18
age	**0.69*****	0.23	0.20	**0.63*****	**-0.56*****	**-0.53*****	0.05	-0.18
weight	**0.56*****	0.38**	0.05	**0.65*****	**-0.49*****	-0.37**	-0.14	-0.02
stature	0.40**	0.23	0.02	0.42**	-0.31*	-0.20	-0.13	0.03
Nose D	-0.03	-0.32*	0.22	-0.23	-0.08	-0.12	0.28*	-0.24
age	0.20	-0.35**	0.41**	-0.13	-0.16	-0.37**	0.31*	-0.39**
weight	-0.33*	-0.26	0.002	-0.40**	0.26	0.20	0.07	-0.03
stature	-0.29*	-0.36**	0.14	**-0.50*****	0.27*	0.08	0.22	-0.15
Mand D	0.13	0.11	-0.01	0.27*	-0.05	-0.14	0.15	0.06
age	0.40**	0.12	0.13	**0.45*****	-0.32*	-0.39**	0.16	-0.04
weight	-0.09	0.30*	-0.30*	0.27*	0.08	0.15	-0.11	0.38**
stature	-0.18	0.09	-0.16	0.04	0.19	0.15	0.04	0.24

Table 7.30: Complete and partial correlations between mean cranio-facial measurements and climate: females.

	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
Head L	0.08	-0.25	0.25	-0.09	-0.27	-0.26	-0.02	-0.37*
age	0.18	-0.26	0.34*	-0.05	-0.44**	-0.40**	-0.03	-0.44**
weight	0.15	-0.11	0.18	0.07	-0.42**	-0.24	-0.25	-0.26
stature	-0.12	-0.34*	0.20	-0.33*	-0.19	-0.10	-0.13	-0.35*
Head B	-0.34*	-0.17	-0.09	-0.34*	0.36*	0.22	0.19	-0.13
age	0.02	-0.30	0.27	-0.24	-0.05	-0.24	0.23	**-0.46****
weight	-0.42**	0.06	-0.32*	-0.24	0.40**	0.43**	-0.04	0.15
stature	**-0.50*****	-0.21	-0.13	**-0.51*****	0.44**	0.36*	0.15	-0.10
Head H	-0.38**	0.13	-0.36*	-0.10	**0.47*****	0.34*	0.18	0.37*
age	-0.13	0.11	-0.18	0.06	0.22	0.05	0.19	0.27
weight	-0.41**	0.34*	**-0.54*****	0.04	**0.48*****	**0.47*****	0.03	**0.66*****
stature	**-0.57*****	0.10	-0.41**	-0.24	**0.57*****	**0.52*****	0.15	0.41**
Min Front D	0.16	0.06	0.06	0.15	-0.26	-0.25	-0.01	-0.22
age	0.31*	0.05	0.15	0.22	**-0.47*****	-0.44**	-0.02	-0.30
weight	0.32*	0.42**	-0.11	**0.53*****	**-0.53*****	-0.30	-0.38*	0.01
stature	-0.06	-0.02	-0.02	-0.06	-0.16	-0.07	-0.14	-0.18
Bizyg	0.05	-0.21	0.23	-0.09	-0.07	-0.26	0.27	-0.29
age	0.30*	-0.30*	0.44**	0.01	-0.37*	**-0.59*****	0.27	-0.44**
weight	0.18	-0.05	0.16	0.19	-0.28	-0.30*	0.04	-0.09
stature	-0.24	-0.39**	0.17	-0.42**	0.08	-0.04	0.16	-0.25
Bigon	0.23	-0.15	0.27	0.05	-0.21	-0.41**	0.28	-0.33*
age	0.42**	-0.17	0.41**	0.11	-0.43**	**-0.65*****	0.28	-0.42**
weight	0.39**	0.06	0.21	0.32*	-0.41**	**-0.48*****	0.10	-0.18
stature	0.03	-0.29	0.21	-0.28	-0.07	-0.21	0.17	-0.30*
Tot Fac H	0.02	0.04	-0.02	0.001	0.15	-0.06	0.29	-0.12
age	0.33*	0.01	0.20	0.14	-0.15	-0.41**	0.31*	-0.29
weight	0.09	0.31*	-0.18	0.24	0.10	0.01	0.12	0.12
stature	-0.20	-0.03	-0.09	-0.22	0.29	0.15	0.22	-0.07
Up Fac H	0.14	0.12	-0.003	0.20	0.01	-0.21	0.31*	-0.15
age	0.37*	0.11	0.14	0.31*	-0.22	**-0.47*****	0.31*	-0.26
weight	0.20	0.29	-0.09	0.36*	-0.05	-0.18	0.20	-0.01
stature	-0.18	0.03	-0.12	-0.10	0.22	0.09	0.19	-0.10
Nose H	0.22	0.32*	-0.10	0.33*	0.04	-0.16	0.27	-0.10
age	0.39**	0.31*	-0.03	0.41**	-0.10	-0.32*	0.27	-0.17
weight	0.27	**0.47*****	-0.19	**0.47*****	-0.01	-0.13	0.18	0.01
stature	-0.09	0.26	-0.26	0.06	0.27	0.19	0.14	-0.02
Nose B	**0.45****	0.24	0.11	**0.52*****	-0.22	-0.38**	0.23	-0.08
age	**0.71*****	0.23	0.24	**0.63*****	**-0.46****	**-0.64*****	0.23	-0.17
weight	**0.53*****	0.41**	0.04	**0.71*****	-0.30	-0.38*	0.12	0.05
stature	0.23	0.17	-0.001	0.31*	-0.05	-0.12	0.09	0.01
Nose D	-0.07	-0.24	0.15	-0.27	0.25	-0.05	0.41**	-0.24
age	0.16	-0.29	0.35*	-0.19	0.04	-0.32*	0.43**	-0.39**
weight	-0.02	-0.05	0.03	-0.13	0.23	0.04	0.29	-0.04
stature	-0.23	-0.30*	0.10	**-0.48*****	0.35*	0.10	0.36*	-0.21
Mand D	-0.17	-0.03	-0.10	-0.12	0.18	0.08	0.14	0.07
age	0.004	-0.05	0.05	-0.03	-0.02	-0.13	0.14	-0.03
weight	-0.16	0.16	-0.23	0.02	0.14	0.16	-0.02	0.29
stature	-0.29	-0.05	-0.13	-0.23	0.24	0.18	0.11	0.10

As was seen in the correlations involving body measurements and indices, there are marked east/west differences in the correlations between climate and measurements of the head and face. In eastern males there are strong negative correlations with Coldest Month and Annual Temperature (the latter explaining 66% of variance; Figure 7.45) and a moderately strong positive correlation with Temperature Range. In eastern females the pattern of correlations is similar to that seen in males, but none attain significance. In the west there are very weak, negative correlations between head length and humidity variables in both males and females. Overall, it is suggested that in the west, longer heads are found in areas that are drier and, in the east, where it is cooler.

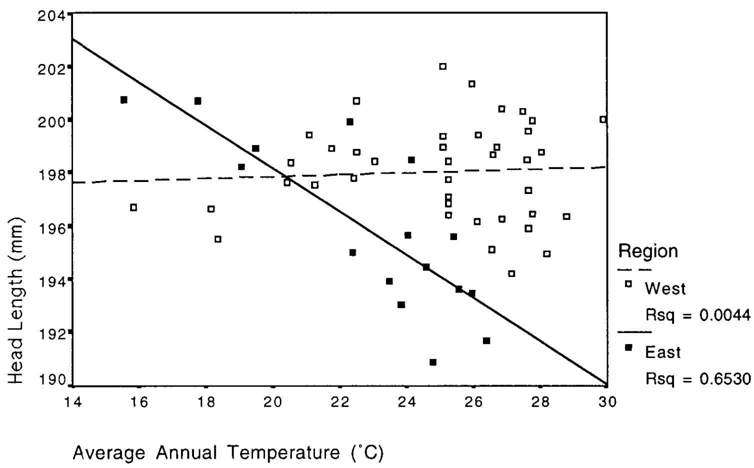

Figure 7.45: Bivariate Scatterplot of Male Head Length vs Average Annual Temperature: East/West sub-samples

The partial correlations reveal that accounting for variation in male age has no effect, whilst removing weight decreases the size of correlations somewhat. When stature is accounted for, correlations with Coldest Month and Annual Temperature increase above 0.45, whilst those with humidity decrease. This suggests that average male head length increases relative to body size as temperature decreases, but that the correlations with humidity are associated primarily with body size. In females, removing age or weight has the effect of increasing the size of some correlations. When variation in stature is accounted for, meanwhile, weak, but significant negative correlations appear with Coldest Month and Annual Temperature (as in males,) however no correlation in the female sample reaches the 0.45 level.

7.2.5.2 Head Breadth

In neither the male or female sample do correlations between head breadth and climate reach the 0.45 level. However, climate accounts for 24% of variation in female head breadth, with both Most Humid Month and Annual Rainfall contributing. In males Humidity Range accounts for only 8% of variance.

When the east/west sub-samples are examined a very different picture emerges. In eastern males there are moderately strong to strong, negative correlations with Coldest Month (Figure 7.46), Annual Temperature, Least Humid Month and Annual Rainfall, and moderately strong, positive correlations with Temperature Range and Humidity Range. In eastern females there is a strong, negative correlation with Annual Temperature, but no other correlation attains significance. These results indicate that in the east heads are broader where it is cooler, and in males, where it is drier.

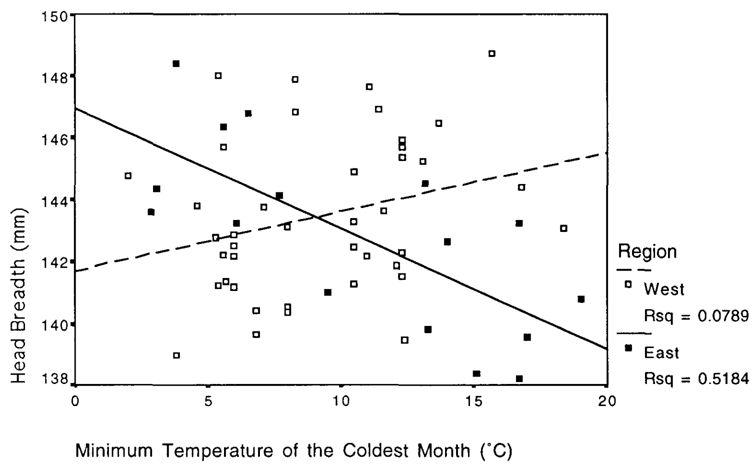

Figure 7.46: Bivariate Scatterplot of Male Head Breadth vs Minimum Temperature of the Coldest Month: East/West sub-samples

In western males there are a number of significant correlations that are opposite in direction to those of the eastern males, however none are over 0.45. In western females, meanwhile, there are weak, positive correlations with Most Humid Month and Least Humid Month. In the west, in contrast to the east, broader heads are found in the more humid areas.

In the partial correlations it is seen that when variation in age is accounted for some correlations increase in size, with the negative correlation with Annual Rainfall increasing to 0.45. When body size (weight or stature) is accounted for a very weak, but negative correlations appear with Hottest Month and Annual Temperature. In the female sample accounting for age decreases the size of some correlations and when body size (particularly stature) is accounted for moderately strong, negative correlations appear with Hottest Month and Annual Temperature. This suggests that groups in hotter areas have narrower heads relative to body size than groups in colder areas.

7.2.5.3 Head Height

In the male sample there is a single significant, but very weak, positive correlation with Annual Temperature. However, the results of the MSR analysis reveal that both Annual Temperature and Humidity Range explain a proportion of variance in male head height, together explaining a total of 16% of variance.

In females, two correlations reach the 0.45 level: the first a positive correlation with Most Humid Month (primary correlate: Figure 7.47) and the second a negative correlation with Temperature Range. The other significant correlations indicate that female head height has a negative relationship with moisture variables. Overall, climate explains 22% of variation in female head height.

When the east/west sub-samples are examined it is found that in eastern males there is a moderately strong, negative correlation with Annual Temperature (Figure 7.48). The pattern of correlations is the same in eastern females, but none of the correlations are significant. In western males there are weak to moderately strong, positive correlations with Coldest Month, Annual Temperature and Annual Rainfall, whilst in western females there is a weak ,negative correlation with Temperature Range, and weak to moderately strong, positive correlations with Most Humid Month and Annual Rainfall.

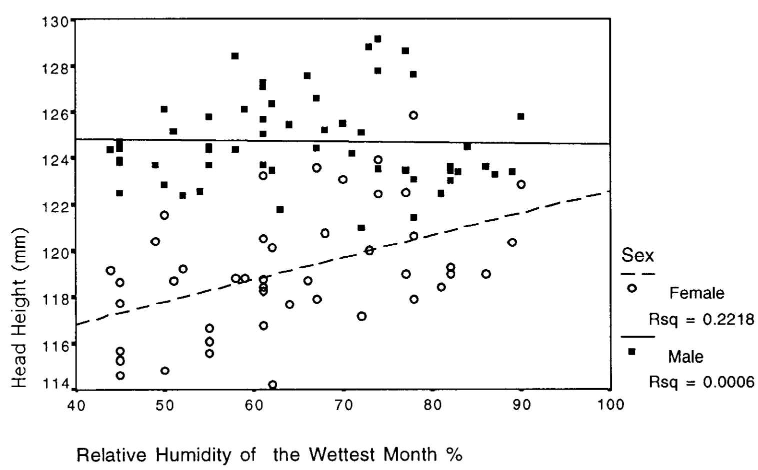

Figure 7.47: Bivariate Scatterplot of Male and Female Head Height vs Relative Humidity of the Wettest Month

Removing co-variates from the male sample has relatively little effect. When age is accounted for in the female sample, all significant correlations disappear. Correcting for body size, meanwhile, has the effect of increasing the size of many of the significant correlations.

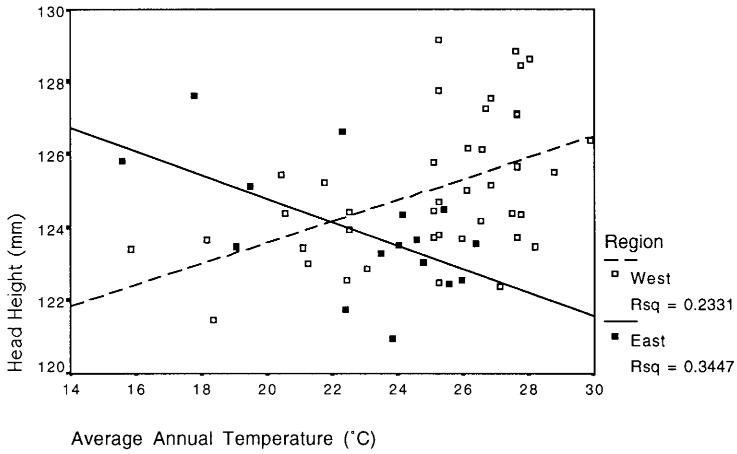

Figure 7.48: Bivariate Scatterplot of Male Head Height vs Average Annual Temperature: East/West sub-samples

7.2.5.4 Minimum Frontal Diameter

In the male sample there are a number significant correlations with climate, but all are below 0.45. The overall pattern is one of positive relationships with temperature and negative relationships with humidity (reflective of the pattern set by stature), and as with male stature the relationship with Hottest Month is of primary importance, explaining 17% of variance (Figure 7.49). There is also a moderately strong negative correlation with longitude. In females there are no significant correlations with climate and only a very weak negative correlation with longitude.

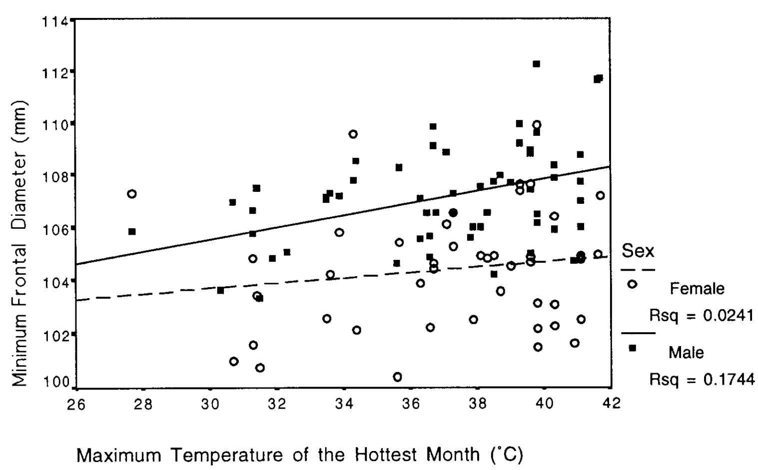

Figure 7.49: Bivariate Scatterplot of Male and Female Minimum Frontal Diameter vs Maximum Temperature of the Hottest Month

The east/west correlations are even less illuminating. In eastern males there is a moderately strong negative correlation with Annual Rainfall, whilst in eastern females there are no significant correlations at all. In the west, the male sample has a single significant positive correlation with Coldest Month, but this is below 0.45, and again there are no significant correlations in the female sample.

When the partial correlations are considered, it can be seen that accounting for variation in male age or weight has little effect, however when stature is removed all significant correlations disappear. In the female sample co-variates are seen to have a greater effect on the size of correlations. When age is accounted for weak, negative correlations appear with Most Humid Month and Least Humid Month and when variation in weight is removed a moderately strong, positive correlation appears with Annual Temperature and a moderately strong, negative correlation with Most Humid Month. Accounting for stature reduces the already weak correlations further. These results suggest that the relationship between breadth of the forehead and climate is related to variation in body size.

7.2.5.5 Bizygomatic Diameter

In the Australia-wide sample, male bizygomatic diameter is seen to have weak, positive correlations with Hottest Month and Temperature Range, and a moderately strong, negative correlation with Least Humid Month (Figure 7.50). All other significant correlations are below 0.45. MSR analysis reveals that Least Humid Month is the primary correlate and overall, climate accounts for 36% of variance in male bizygomatic diameter. In the female sample no correlation attains significance.

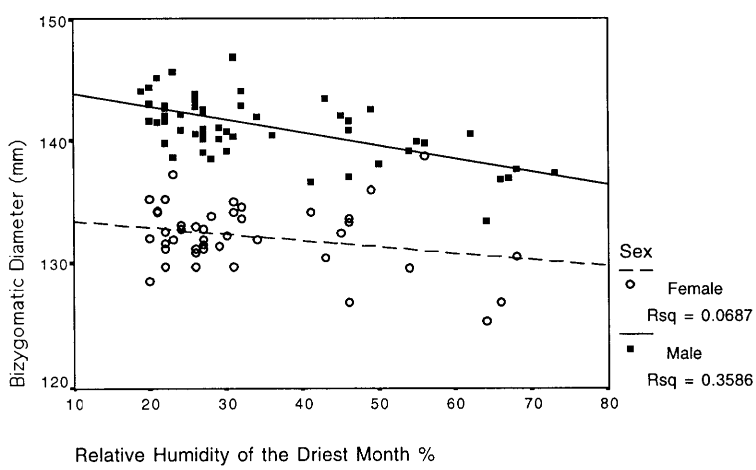

Figure 7.50: Bivariate Scatterplot of Male and Female Bizygomatic Diameter vs Relative Humidity of the Driest Month

When the east/west sub-samples are considered, eastern males are seen to have moderately strong, negative correlations with Coldest Month (Figure 7.51) and Annual Rainfall, and moderately strong, positive correlations with Temperature Range and Humidity Range. Correlations for the eastern female sample follow the same pattern, but the correlations are not significant. In the west, the male sample has a single positive correlation with Annual Rainfall, but again there are no significant correlations in the female sample.

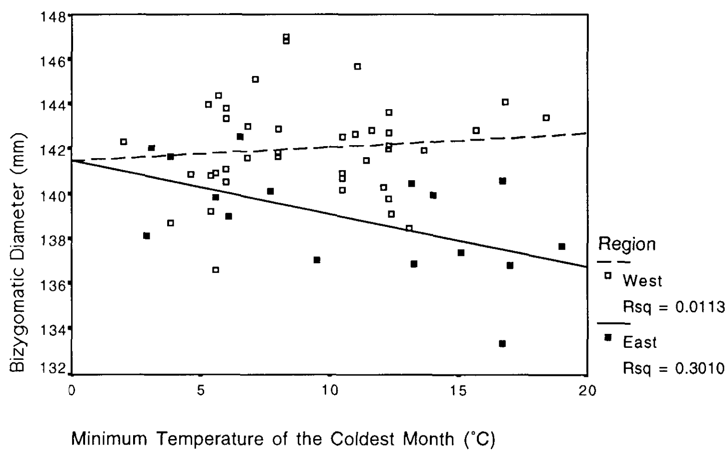

Figure 7.51: Bivariate Scatterplot of Male Bizygomatic Diameter vs Minimum Temperature of the Coldest Month: East/West sub-samples

In the partial correlations it is seen that accounting for the variation in male age has little or no effect, whereas removing variation in weight reduces the size of correlations. When stature is accounted for, meanwhile, the positive correlation with Hottest Month is lost and a very weak, negative correlation appears with Coldest Month. In females it appears that the differences in age between sample groups has overwhelmed any correlation with climate. With age accounted for, a series of significant correlations appear that mirroring those seen in males: the largest being a moderately strong, negative correlation with Least Humid Month. Accounting for variation in stature has a moderate effect, with very weak, negative correlations appearing with Coldest Month and Annual Temperature. Removing weight, on the other hand, has little effect. Overall, this pattern of correlations suggests a relationship with body size.

7.2.5.6 Bigonial Diameter

In males, the pattern of correlations for bigonial diameter follows that seen in bizygomatic diameter, with a positive correlation with Hottest Month (Figure 7.52) and negative correlations with humidity variables. There is also a moderately strong, negative correlation with longitude, indicating that lower facial breadth decreases west to east. In females far fewer correlations are significant and none reach the 0.45 level. MSR analysis reveals that in both males and females Least Humid Month is the primary correlate, explaining 31% of variance in male bigonial diameter, but only 17% of female variation.

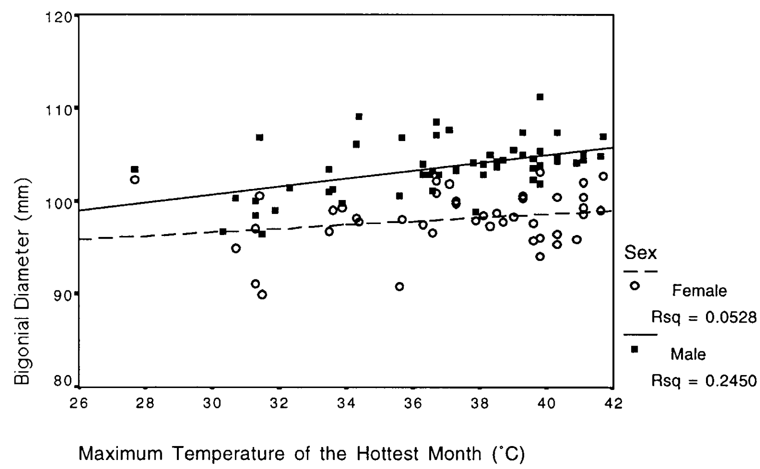

Figure 7.52: Bivariate Scatterplot of Male and Female Bigonial Diameter vs Maximum Temperature of the Hottest Month

In the eastern male sub-sample there are moderately strong to strong, negative correlations with Coldest Month (Figure 7.53), Least Humid Month and Annual Rainfall, and moderately strong to strong, positive correlations Temperature Range and Humidity Range. In eastern females there is a strong negative correlation with Annual Temperature. The directions of correlations in the west are, for the most part, opposite to those seen in the east. In the western male sample there are moderately strong, positive correlations Coldest Month and Annual Temperature, however no correlation in the western female sample is significant.

The partial correlations reveal an interesting picture. In males, both age and weight have some effect, however when variation in stature is removed all correlations are reduced in size, with those with Hottest Month and Most Humid Month disappearing and those with Least Humid Month and Annual Rainfall reducing significantly. This suggests that the observed pattern of correlations is primarily due to variation in body size, rather than to some intrinsic relationship between climate and lower facial breadth. In the female sample the situation is somewhat more complex, with both variation in age and weight affecting the size of correlations. For instance, a moderately strong, negative correlation appears with Least Humid Month, however again with stature removed, most correlations reduce in size.

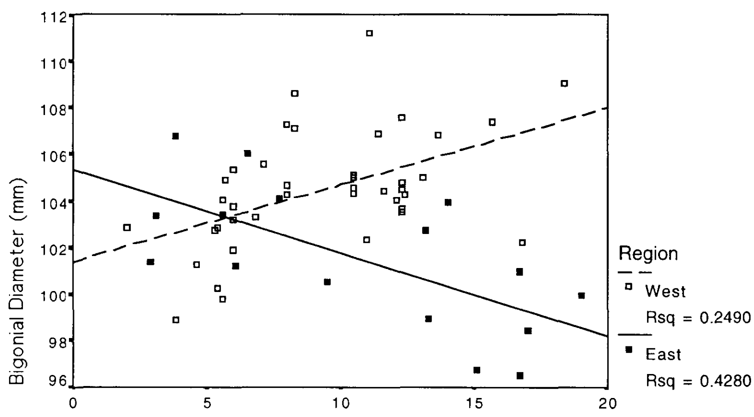

Figure 7.53: Bivariate Scatterplot of Male Bigonial Diameter vs Minimum Temperature of the Coldest Month: East/West sub-samples

7.2.5.7 Total Facial Height

In both the total male and female samples there is a single significant correlation, but neither reaches the 0.45 level.

The situation is quite different when the eastern and western samples are considered separately. In eastern males there are moderately strong to strong, negative correlations with Coldest Month ($r^2 = 0.50$: Figure 7.54), Annual Temperature and Annual Rainfall, and a moderately strong, positive correlation with Temperature Range. The situation is similar, but more pronounced, in eastern females, with 82% of variance in total facial height shared with Annual Temperature.

In the west, whilst there are significant correlations with a similar range of variables as in the east, the direction of the correlations are in the opposite direction. A similar pattern is seen in females, however all correlations are below 0.45.

When co-variates are partialled out it can be seen that in males, variation in age, weight and stature have masked the true relationship between climate and total facial height. With age accounted for, very weak, positive correlations appear with Hottest Month and Annual Temperature. However, when weight is accounted for a very weak, negative correlation appears with Hottest Month and a weak, negative correlation appears with Temperature Range. Weak, positive correlations also appear with Least Humid Month and Annual Rainfall. With stature removed, a weak, negative correlation with Hottest Month and moderately strong, positive correlations with Most Humid Month and Least Humid Month appear. This would indicate that for males, in particular, facial height decreases with increasing temperature, irrespective of body size. In females, whilst variation in stature does not have such a marked effect, it is clear that both age and weight do affect the correlations to some degree.

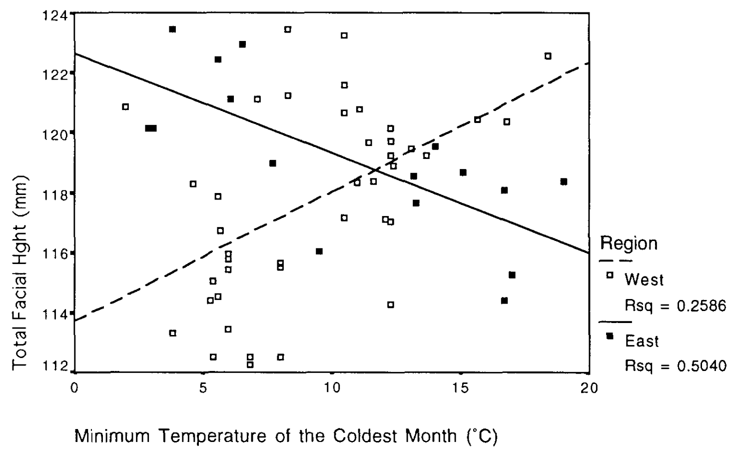

Figure 7.54: Bivariate Scatterplot of Male Total Facial Height vs Minimum Temperature of the Coldest Month: East/West sub-samples

7.2.5.8 Upper Facial Height

Both the male and female sample groups produce very weak, positive correlations between upper facial height and Humidity Range. Males also have a very weak, positive relationship with Annual Temperature (Figure 7.55). MSR analysis indicates that in males only 17% of total variance is explained by these two variables. In females, Humidity Range alone accounts for only 9% of variance.

Not unexpectedly the pattern of correlations for upper facial height in the east and west samples is very similar to that of total facial height. In eastern males there are moderately strong to strong, negative correlations with Coldest Month (r^2 = 0.55: Figure 7.56), Annual Temperature and Annual Rainfall and moderately strong, positive correlations with Temperature Range and Humidity Range. In eastern females there is a single significant negative correlation with Annual Temperature, but it explains a high percentage of variation (r^2 = 0.77).

In western males there are moderately strong, positive correlations with Coldest Month, Annual Temperature and Annual Rainfall and in western females a moderately strong ,positive correlation with Coldest Month. Again, the differences in sign should be noted.

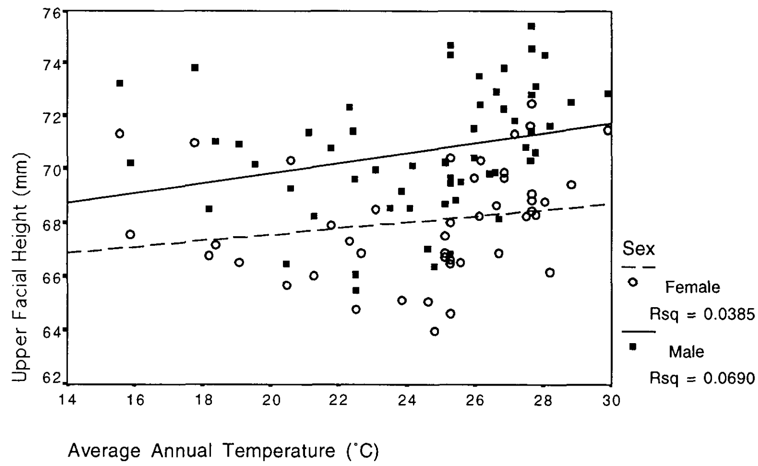

Figure 7.55: Bivariate Scatterplot of Male and Female Upper Facial Height vs Average Annual Temperature

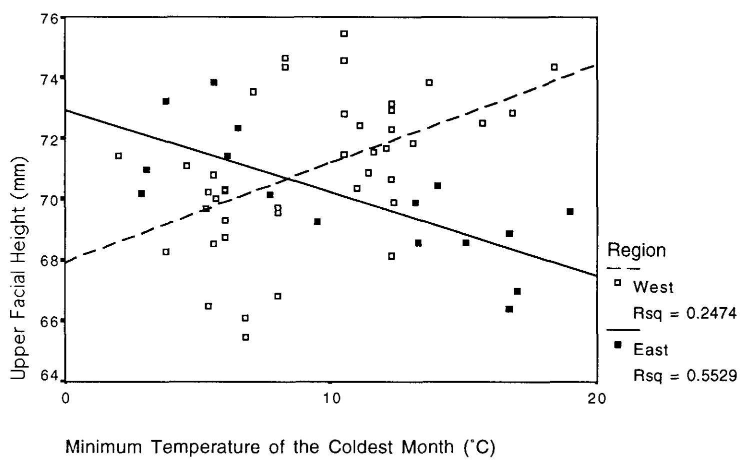

Figure 7.56: Bivariate Scatterplot of Male Upper Facial Height vs Minimum Temperature of the Coldest Month: East/West sub-samples

When the partial correlations are calculated it is found that in males, variation in age has the effect of increasing some correlations, but all remain below 0.45. Variation in weight has had very little effect, but when stature is controlled for a very weak, negative correlation appears with Hottest Month, and a weak, positive correlation appears with Most Humid Month, a similar pattern to that seen for total facial height. In females, accounting for age increases some correlations, with a weak, negative correlation appearing with Least Humid Month. Correcting for either weight or stature has relatively little effect.

7.2.5.9 Nose Height

Given that climate has been argued to be of importance in the evolution of nasal morphology, the results of this analysis are interesting. In the total samples of males and females there is little evidence of any meaningful relationship between climate and nasal height. The single significant correlation above 0.45 is the positive Spearman's coefficient with Annual Temperature. MSR analysis reveals that in males only 9% of variance in nose height is explained by Humidity Range (as in upper facial height) and in females Annual Temperature and Humidity Range together account for 21% of variation.

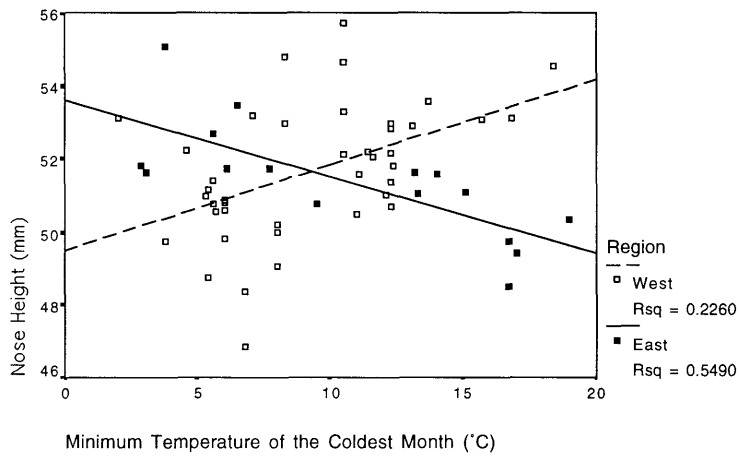

Figure 7.57: Bivariate Scatterplot of Male Nose Height vs Minimum Temperature of the Coldest Month: East/West sub-samples

In the eastern and western sub-samples the pattern of correlations is similar to that of facial height. In eastern males there are strong, negative correlations with Coldest Month (Figure 7.57), Annual Temperature and Annual Rainfall and moderately strong, positive correlations with Temperature Range and Humidity Range. In eastern females, however, no correlation attains significance. In the west, male and female nasal height has weak to moderately strong, positive correlations with Coldest Month and Annual Rainfall and in females there is also a moderately strong, negative correlation with Temperature Range.

In the partial correlations it can be seen that in males, variation in age and weight have had some influence on the size of correlations, however none reach the 0.45 level. As with facial height, the removal of stature has a greater effect. When variation in stature is accounted for very weak correlations appear with Hottest Month (negative) and Least Humid Month (positive), and a moderately strong positive correlation appears with Most Humid Month. In females, accounting for age has the effect of increasing some correlations and when variation in weight is removed, the positive correlations with Coldest Month and Annual Temperature increase above 0.45. In contrast to the situation in males, variation in stature has only a minor effect.

7.2.5.10 Nose Breadth

Whereas nasal height showed little relationship with climate on an Australia-wide basis, nose breadth has a number of moderate and significant correlations in both the male and female samples. In males, there are moderately strong, positive correlations with Hottest Month (Figure 7.58) and Annual Temperature and weak to moderately strong, negative correlations with Least Humid Month and Most Humid Month. There is also a moderately strong, negative correlation with longitude and very weak, negative correlation with latitude. The results of the MSR reveal that Hottest Month is the primary correlate (38% of variance alone) and this variable combined with Annual Temperature explains a total of 46% of variance in male nose breadth. In females there are weak to moderately strong, positive correlations with Hottest Month and Annual Temperature, and a very weak, negative correlation with Least Humid Month (Pearson's only). The correlations with latitude and longitude are also repeated. MSR analysis reveals that Annual Temperature is the primary correlate, with Humidity Range being subsidiary. Overall, 36% of variation in female nose breadth is explained by climate. Thus populations in cooler and/or drier areas have narrower noses than those living in warmer and/or wetter climates.

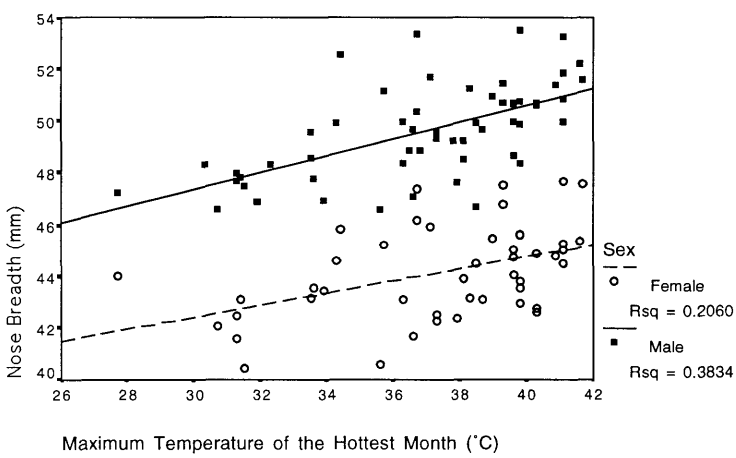

Figure 7.58: Bivariate Scatterplot of Male and Female Nose Breadth vs Maximum Temperature of the Hottest Month

In contrast to nasal height there are no significant correlations with climate in either the eastern males or females. In western males there are weak to moderately strong, positive correlations with Hottest Month, Coldest Month and Annual Temperature (Figure 7.59) and very weak correlations with Annual Rainfall (positive) and Most Humid Month (negative). Western females have fewer significant correlations, with moderately strong to weak, positive correlations with Coldest Month, and Annual Temperature and Annual Rainfall.

In the partial correlations, accounting for variation in either male age or weight has only minor effects. When variation in stature is removed, however, all significant correlations reduce below 0.45, indicating that some of the relationship between climate and nose breadth is due to its relationship with body size.

In females, variation in average age between groups has a more marked effect on the size of correlations. With age removed all significant correlations increase in size and those with humidity rise above 0.45. When weight is removed, meanwhile, there are increases in the size of correlations with temperature, but not with humidity. When stature is accounted for all significant correlations are lost, except that with Annual Temperature, which is much reduced in size. This would suggest that most of the variation in nasal breadth in the female sample is also due to variation in body size.

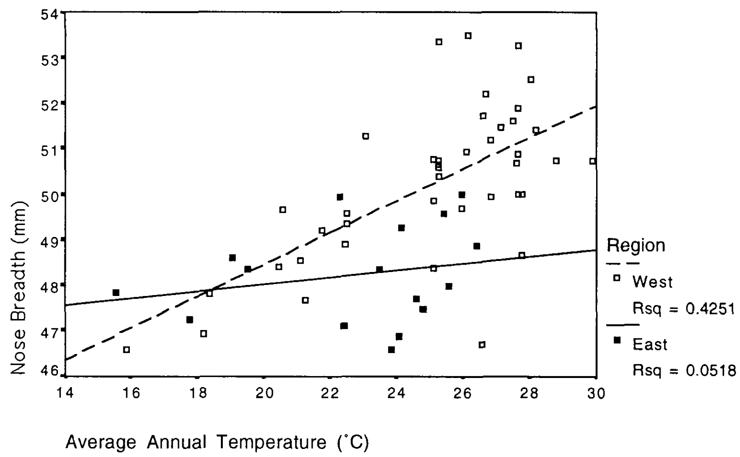

Figure 7.59: Bivariate Scatterplot of Male Nose Breadth vs Average Annual Temperature: East/West sub-samples

7.2.5.11 Nose Depth

In neither the male or female Australia-wide samples does any correlation reach the 0.45 level. However, of the significant correlations MSR analysis reveals that Coldest Month explains 9% of variation in male nose depth and Humidity Range 17% of variation in females.

In eastern males there are strong negative correlations with temperature (Figure 7.60) and moisture variables and a positive correlation with Temperature Range. This pattern is similar in eastern females, however none of the correlations attain significance. In western males and females there are significant positive correlations with humidity variables, but they do not reach the 0.45 level. It would appear that in the east and in males particularly, more protrusive noses are found in cooler areas.

When partial correlations are examined, it is seen that accounting for variation in average male age and weight have relatively little effect. When variation in stature is removed, however, a moderately strong, negative correlation is revealed with Annual Temperature. A similar situation is seen in the female sample. This indicates that in both males and females, nasal protrusion is greater relative to body size where average temperatures are cooler.

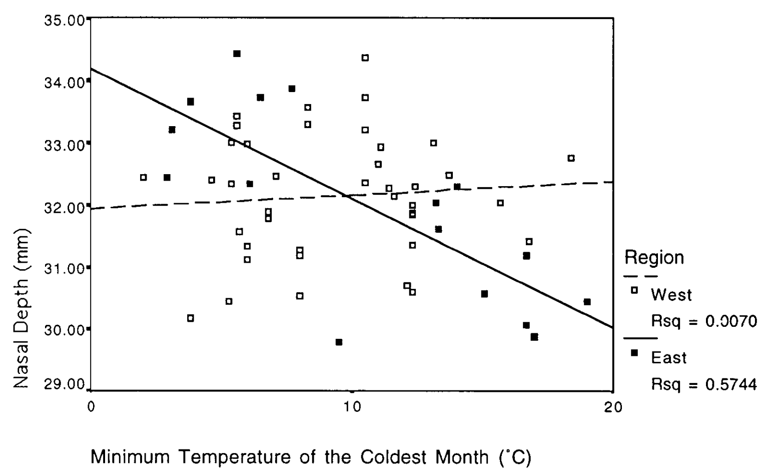

Figure 7.60: Bivariate Scatterplot of Male Nasal Depth vs Minimum Temperature of the Coldest Month: East/West sub-samples

7.2.5.12 Mandibular Depth

In males, there is a single significant correlation between mandibular depth and Annual Temperature, but this represents only about 7% shared variation. In females there are no significant correlations.

When the eastern male sub-sample is examined, it is seen that there is a moderately strong, negative correlation with Annual Rainfall (Figure 7.61), whilst in eastern females there is a strong, negative correlation with Coldest Month. In the west, males have a moderately strong, positive correlation with Annual Rainfall, but there are no significant correlations produced by the female sample. Both of these patterns of correlation suggest a link with body size.

In the partial correlations it can be seen that variation in age has a significant effect on the size of some correlations, with the positive correlation with Annual Temperature, for instance, rising above 0.45. When weight is accounted for some other significant correlations appear, however they are below 0.45. When stature is corrected for there is no relationship evident between climate and mandibular depth. In the female sample, accounting for variation in age, weight or stature has no effect on the size of correlations. This suggests that there is no relationship between mandibular depth and climate independent of body size.

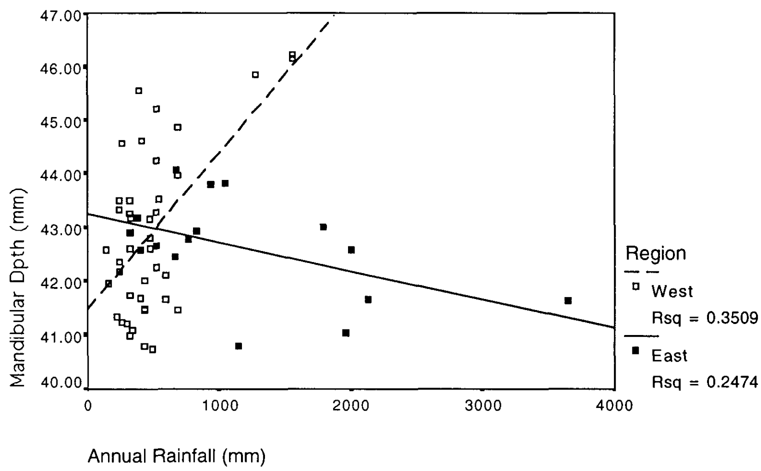

Figure 7.61: Bivariate Scatterplot of Male Mandibular Depth vs Annual Rainfall: East/West sub-samples

7.2.5.13 Summary: Cranio-facial size

Bivariate Correlations

Head

- In males the greatest effect of climate is seen in head length (25% shared variance with Temperature Range), and in the female sample in head breadth (24% with Most Humid Month and Annual Rainfall), closely followed by head height (22% with Most Humid Month). Moisture is apparently responsible for a greater degree of variance in head size than is temperature.

Face

- Overall, humidity appears to be the more influential factor than temperature in facial variation.

- In both males and females the greatest effect of climate is seen in nose breadth, but the effect is stronger in males (46% vs 36%); in both cases temperature is the major correlate.
- Breadth of both the mid- and lower face is associated with humidity.
- Male upper facial height is most closely associated with Annual Temperature, closely followed by Humidity Range; in females the relationship is solely with Humidity Range.
- Not unexpectedly a similar pattern is seen in nose height with Humidity Range being the major correlate of the male sample and Annual Temperature and Humidity Range for the female sample.
- Mandibular depth at symphysis has only a very weak relationship with Temperature Range in males and no relationship with climate in females.
- In the east there is a general trend towards longer, broader and higher crania were temperatures are lower. These populations are also distinguished by longer and somewhat narrower faces, and higher and more protrusive noses.
- The cranio-facial variables of the western sub-groups have few significant correlations with climate and those that exist are primarily associated with body size.
- Partial correlations reveal that Australia-wide ecogeographic clines do exist in some cranio-facial variables independent of body size. These include real increases in head length, head breadth, total and upper facial height, nose height, and depth, and a decrease in nose breath where temperatures are cooler.

MSR

- Climate clearly has relatively little effect on the absolute measurements on the cranium and face. In only 4 out 12 variables of the male sample does climate explain more than 20% of variance, and total facial height exhibits no association.
- In the female sample only 4 out of 12 variables share 20% of variance with climate, and 4 variables exhibit no relationship at all.
- It is apparent that climate has had more effect on the absolute measurements of the head and face in males than in females, and in males temperature is the more influential factor, whilst in females it is humidity.

7.2.6 Cranio-facial shape and climate in adult male and female Australian Aborigines

The bivariate, multivariate and partial correlations between cranio-facial indices and climate are presented in Tables 7.31 to 7.38.

7.2.6.1 Nasal Breadth Index

Measured on the fleshy nose, this index compares the breadth of the nose relative to its height. A high index indicates a relatively broad and/or short nose and a low index, a relatively narrow and/or high nose.

In the continent-wide male sample there are moderately strong negative correlations with Most Humid Month (Figure 7.62) and Least Humid Month (Spearman's only), and a weak positive correlation with Hottest Month, suggesting that in males relatively broader, or shorter noses are found in dry and/or hot areas (Table 7.31). MSR analysis reveals that Most Humid Month is the primary correlate, accounting for 37% of variance. There are no significant correlations in the female sample (Table 7.32).

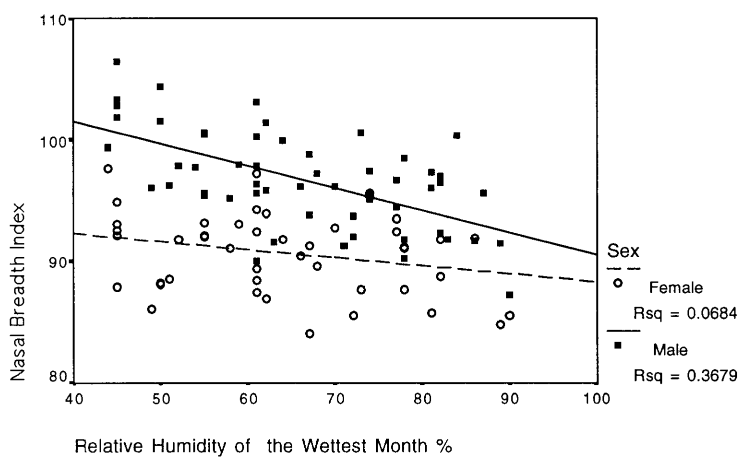

Figure 7.62: Bivariate Scatterplot of Male and Female Nasal Breadth Index vs Relative Humidity of the Wettest Month

As with many of the absolute measurements there are some differences between the eastern and western sub-samples. In eastern males there are strong, positive correlations with Coldest Month and Annual Temperature, and moderately strong, negative correlations with Temperature Range and Humidity Range. In eastern females there are no significant correlations. In the west, the male sample has weak to moderately strong, negative correlations with Most Humid Month, Least Humid Month (Figure 7.63) and

Humidity Range. Again, the female sample produces no significant correlations.

When partial correlations are calculated it can be seen that variation in age between groups has had some effect on the size of correlations, but controlling for weight and stature has little or no effect. In females, the effect of age is far more pronounced, with a number of significant, but very weak correlations appearing in a pattern similar to that seen in males. As with males, variation in female weight or stature has had no apparent effect on the size of the correlations.

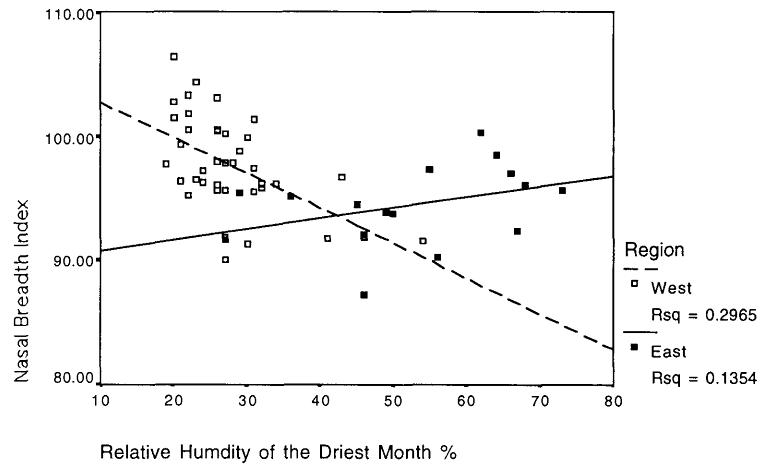

Figure 7.63: Bivariate Scatterplot of Male Nasal Breadth Index vs Relative Humidity of the Driest Month: East/West sub-samples

7.2.6.2 Nasal Depth Index

This index compares the protrusion of the nose relative to its breadth. A high index indicates a relatively protrusive nose and a low index, a relatively flat nose.

In the male sample there are moderately strong, negative correlations with Hottest Month and Annual Temperature (Figure 7.64) and a moderately strong, positive correlation with latitude and a weak, positive correlation with Most Humid Month. In females there are weak to strong, negative correlations with Hottest Month, Coldest Month and Annual Temperature. There are also positive correlations with humidity, but these do not reach the 0.45 level. The moderately strong, positive correlation with latitude is repeated. Results of the MSR analysis indicate that in both males and females Annual Temperature is the primary correlate with climate, explaining a total of 49% of variance in male nasal depth index and 51% in females. These results suggest that relatively protrusive noses are found in the cooler areas to the south.

Table 7.31: Pearson's and Spearman's correlation coefficients between mean cranio-facial indices and climate: males.

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
NIB	*r*	**0.48*** **	0.14	0.18	0.39**	**-0.61*** **	-0.40**	-0.21	-0.15	-0.26*	-0.42***
	ρ	**0.46*** **	0.15	0.30*	0.27*	**-0.55*** **	**-0.52*** **	-0.21	-0.30*	-0.10	-0.42***
NID	*r*	**-0.52*** **	-0.43**	0.01	**-0.67*** **	**0.47*** **	0.30*	0.18	-0.05	**0.62*** **	0.36**
	ρ	**-0.45*** **	-0.40**	-0.06	**-0.52*** **	0.42**	0.36**	0.21	-0.02	0.40**	0.37**
CI	*r*	-0.16	0.15	-0.22	-0.01	0.35**	0.20	0.17	-0.04	0.005	-0.08
	ρ	-0.20	0.13	-0.37**	0.09	0.33*	0.38**	0.23	0.20	-0.07	-0.14
CM	*r*	0.18	-0.21	0.28*	-0.01	-0.15	-0.34**	0.30*	-0.34**	0.20	-0.32*
	ρ	0.20	-0.15	0.05	0.15	-0.14	-0.16	0.26*	-0.04	0.12	-0.32*
CFI	*r*	**0.45*** **	-0.07	0.33*	0.31*	**-0.49*** **	**-0.47*** **	0.06	-0.09	-0.32*	-0.19
	ρ	0.41**	-0.10	**0.50*** **	0.13	**-0.45*** **	**-0.60*** **	0.08	-0.24	-0.14	-0.14
TFI	*r*	-0.42***	0.26*	**-0.47*** **	-0.03	**0.53*** **	**0.54*** **	-0.11	0.40**	-0.04	**0.49*** **
	ρ	-0.38**	0.26	**-0.51*** **	0.03	**0.50*** **	**0.62*** **	-0.13	**0.48*** **	-0.16	0.42***

Table 7.32: Pearson's and Spearman's correlation coefficients between mean cranio-facial indices and climate: females.

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Absolute Latitude	Absolute Longitude
NIB	*r*	0.27	-0.05	0.22	0.24	-0.26	-0.27	0.01	0.004	-0.19	-0.27
	ρ	0.26	-0.01	0.23	0.16	-0.25	-0.25	0.04	-0.05	-0.09	-0.25
NID	*r*	**-0.49*** **	-0.42**	0.01	**-0.71*** **	0.43**	0.33*	0.14	-0.12	**0.64*** **	0.25
	ρ	**-0.45** **	**-0.55*** **	0.05	**-0.66*** **	0.38**	0.21	0.10	-0.22	**0.50*** **	0.31*
CI	*r*	-0.42**	0.01	-0.28	-0.30*	**0.59*** **	0.43**	0.22	0.15	0.26	0.01
	ρ	-0.37*	-0.05	-0.41**	-0.14	**0.53*** **	**0.52*** **	0.27	0.15	0.11	-0.16
CM	*r*	-0.27	-0.12	-0.08	-0.23	0.24	0.13	0.15	-0.06	0.31*	0.10
	ρ	-0.08	-0.02	-0.29	0.06	0.17	0.11	0.27	0.07	0.12	-0.15
CFI	*r*	**0.53*** **	-0.12	0.44**	0.34*	**-0.59*** **	**-0.66*** **	0.09	-0.23	-0.26	-0.22
	ρ	0.41**	-0.07	**0.49*** **	0.19	**-0.51*** **	**-0.65*** **	0.06	-0.23	-0.08	-0.08
TFI	*r*	-0.07	0.17	-0.18	-0.03	0.29	0.16	0.18	0.05	0.05	0.06
	ρ	-0.01	0.29	-0.34*	0.20	0.18	0.23	0.17	0.24	-0.19	-0.06

Table 7.33: Pearson's correlation coefficients between mean cranio-facial indices and climate: male eastern and western sub-samples. (E: n = 16; W: n = 41).

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Abs Latitude
NIB	E	0.17	**0.70****	**-0.53***	**0.76*****	0.04	0.37	**-0.51***	0.37	**-0.80*****
	W	0.38*	-0.003	0.24	0.17	**-0.65*****	**-0.54*****	**-0.45****	-0.19	-0.03
NID	E	-0.15	**-0.76*****	**0.59***	**-0.75*****	-0.27	-0.47	0.43	-0.49	**0.88*****
	W	**-0.57*****	-0.35*	-0.01	**-0.59*****	**0.59*****	**0.52*****	0.39*	-0.07	**0.49****
CI	E	0.49	-0.18	0.36	0.02	-0.15	**-0.59***	**0.73*****	**-0.64****	0.15
	W	-0.26	0.26	-0.41**	0.04	0.41**	**0.50*****	0.15	0.36*	-0.06
CM	E	-0.17	**-0.74*****	**0.56***	**-0.76*****	-0.13	-0.34	0.38	**-0.58***	**0.79*****
	W	0.02	0.38*	-0.36*	0.30	0.09	0.10	0.04	**0.47****	-0.32*
CFI	E	0.17	**0.53***	-0.38	**0.59***	0.17	0.37	-0.38	**0.56***	**-0.66****
	W	0.28	-0.17	0.34*	0.15	**-0.44****	**-0.57*****	-0.12	0.03	-0.27
TFI	E	**-0.57***	-0.42	0.12	**-0.67****	0.19	0.11	0.02	0.06	**0.64****
	W	0.08	**0.48****	-0.41**	0.37*	0.36*	0.31	0.25	0.28	-0.34*

Table 7.34: Pearson's correlation coefficients between mean cranio-facial indices and climate: female eastern and western sub-samples. (E: n = 8; W: n = 37).

		Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Abs Latitude
NIB	E	-0.12	-0.30	0.23	-0.16	-0.31	-0.08	-0.13	-0.10	0.20
	W	0.20	0.05	0.08	0.24	-0.16	-0.15	-0.09	0.27	-0.29
NID	E	-0.39	-0.02	-0.11	-0.31	0.51	0.02	0.31	-0.13	0.20
	W	**-0.49****	**-0.58*****	0.23	**-0.76*****	0.37*	0.29	0.28	-0.38*	**0.75*****
CI	E	-0.23	-0.42	0.30	-0.51	0.25	-0.32	0.45	-0.48	0.53
	W	-0.39*	0.11	-0.36*	-0.19	**0.59*****	**0.57*****	0.35*	0.20	0.16
CM	E	-0.50	-0.57	0.34	-0.67	0.01	-0.25	0.24	-0.49	**0.72***
	W	-0.17	0.29	-0.38*	0.08	0.32	0.25	0.25	0.23	-0.09
CFI	E	0.26	-0.42	0.47	-0.10	-0.61	-0.35	-0.07	-0.31	0.12
	W	0.37*	-0.03	0.27	0.27	**-0.47****	**-0.64*****	-0.11	0.08	-0.31
TFI	E	0.24	-0.29	0.35	-0.42	0.53	-0.43	**0.73***	-0.34	0.33
	W	0.04	**0.45****	-0.40*	0.24	0.20	0.22	0.09	0.15	-0.17

Table 7.35: Multiple stepwise regression analysis on male cranio-facial indices.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
	Percent Shared Variance									
NIB	.	.	.	.	36.79***	.	.	.	0.61	0.37***
NID	.	.	.	45.38***	3.84*	.	.	.	0.70	0.49***
CI	.	.	.	.	11.92**	.	.	.	0.35	0.12**
CM	.	.	.	.	.	.	.	11.64**	0.34	0.12**
CFI	.	.	.	.	23.82***	.	.	.	0.49	0.24***
TFI	.	.			.	29.43***			0.54	0.29***

Table 7.36: Multiple stepwise regression analysis on female cranio-facial indices.

Variable	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain	Multi R	R Square
	Percent Shared Variance									
NIB	.	.	.	.	.	.	.	.	.	.
NID	.	.	.	50.98***	.	.	.	.	0.71	0.51***
CI	.	.	.	.	34.73***	.	.	.	0.59	0.35***
CM	.	.	.	.	.	.	.	.	.	.
CFI	.	.	.	.	.	43.43***	.	08.02*	0.72	0.51***
TFI	.	.	.	.	.	.	.	.	.	.

Table 7.37: Complete and partial correlations between mean cranio-facial indices and climate: males.

	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
NIB	**0.48*** **	0.14	0.18	0.39**	**-0.61*** **	-0.40**	-0.21	-0.15
age	0.34*	0.17	0.06	0.30*	**-0.50*** **	-0.26	-0.23	-0.05
weight	**0.52*** **	0.14	0.21	0.40**	**-0.63*** **	**-0.46*** **	-0.20	-0.18
stature	**0.51*** **	0.14	0.15	0.39**	**-0.63*** **	-0.41**	-0.25	-0.12
NID	**-0.52*** **	-0.43**	0.01	**-0.67*** **	**0.47*** **	0.30*	0.18	-0.05
age	-0.42***	**-0.47*** **	0.14	**-0.64*** **	0.35**	0.16	0.19	-0.15
weight	**-0.60*** **	-0.42**	-0.03	**-0.70*** **	**0.50*** **	0.38**	0.14	-0.004
stature	**-0.48*** **	-0.42***	0.10	**-0.66*** **	0.41**	0.19	0.26	-0.14
CI	-0.16	0.15	-0.22	-0.01	0.35**	0.20	0.17	-0.04
age	0.15	0.17	-0.06	0.20	0.09	-0.07	0.20	-0.12
weight	-0.32*	0.25	-0.40**	-0.05	**0.45*** **	0.41**	0.03	0.19
stature	-0.25	0.15	-0.25	-0.05	0.42***	0.28*	0.16	0.06
CM	0.18	-0.21	0.28*	-0.01	-0.15	-0.34**	0.30*	-0.34**
age	0.30*	-0.22	0.35**	0.04	-0.27*	**-0.46*** **	0.30*	-0.40**
weight	-0.06	-0.11	0.05	-0.11	-0.04	-0.09	0.06	-0.15
stature	-0.31*	-0.34**	0.11	**-0.54*** **	0.20	0.05	0.19	-0.18
CFI	**0.45*** **	-0.07	0.33*	0.31*	**-0.49*** **	**-0.47*** **	0.06	-0.09
age	0.26	-0.07	0.21	0.19	-0.31*	-0.31*	0.07	0.05
weight	**0.48*** **	-0.08	0.36**	0.32*	**-0.50*** **	**-0.53*** **	0.07	-0.10
stature	0.36**	-0.10	0.27*	0.19	**-0.49*** **	-0.39**	-0.02	0.01
TFI	-0.42***	0.26*	**-0.47*** **	-0.03	**0.53*** **	**0.54*** **	-0.11	0.40**
age	-0.20	0.32*	-0.37**	0.18	0.33*	0.39**	-0.14	0.32*
weight	**-0.49*** **	0.29*	**-0.54*** **	-0.05	**0.56*** **	**0.65*** **	-0.17	**0.47*** **
stature	**-0.46*** **	0.27*	**-0.46*** **	0.01	**0.55*** **	**0.61*** **	-0.09	0.39**

Table 7.38: Complete and partial correlations between mean cranio-facial indices and climate: females.

	Max Hot	Min Cold	Ann Temp Var	Av Ann Temp	RH Wet	RH Dry	Ann RH Var	Ann Rain
NIB	0.27	-0.05	0.22	0.24	-0.26	-0.27	0.01	0.004
age	0.39**	-0.06	0.30	0.28	-0.41**	-0.40**	0.01	-0.03
weight	0.28	-0.02	0.20	0.28	-0.28	-0.26	-0.03	0.04
stature	0.25	-0.07	0.20	0.21	-0.24	-0.25	-0.02	0.02
NID	**-0.49*** **	-0.42**	0.01	**-0.71*** **	0.43**	0.33*	0.14	-0.12
age	**-0.50*** **	-0.43**	0.06	**-0.71*** **	**0.45** **	0.32*	0.14	-0.15
weight	**-0.48*** **	-0.38*	-0.03	**-0.70*** **	0.42**	0.36*	0.07	-0.05
stature	-0.39**	-0.39**	0.08	**-0.67*** **	0.36*	0.19	0.26	-0.18
CI	-0.42**	0.01	-0.28	-0.30*	**0.59*** **	0.43**	0.22	0.15
age	-0.15	-0.04	-0.05	-0.18	0.37*	0.14	0.26	-0.04
weight	-0.42**	0.12	-0.37*	-0.23	**0.59*** **	**0.50*** **	0.13	0.28
stature	-0.44**	0.02	-0.27	-0.30*	**0.60*** **	**0.45** **	0.26	0.14
CM	-0.27	-0.12	-0.08	-0.23	0.24	0.13	0.15	-0.06
age	0.05	-0.20	0.20	-0.09	-0.15	-0.28	0.16	-0.29
weight	-0.34*	0.16	-0.35*	-0.05	0.23	0.33*	-0.14	0.29
stature	**-0.51*** **	-0.19	-0.15	**-0.46** **	0.36*	0.34*	0.07	-0.01
CFI	**0.53*** **	-0.12	0.44**	0.34*	**-0.59*** **	**-0.66*** **	0.09	-0.23
age	0.39**	-0.10	0.33*	0.26	**-0.46** **	**-0.56*** **	0.12	-0.13
weight	**0.54*** **	-0.11	0.44**	0.37*	**-0.61*** **	**-0.66*** **	0.08	-0.23
stature	0.42**	-0.21	0.41**	0.19	**-0.54*** **	**-0.59*** **	-0.01	-0.19
TFI	-0.07	0.17	-0.18	-0.03	0.29	0.16	0.18	0.05
age	0.07	0.16	-0.09	0.04	0.18	0.03	0.18	-0.02
weight	-0.06	0.24	-0.22	0.02	0.27	0.18	0.13	0.12
stature	-0.09	0.17	-0.19	-0.04	0.31*	0.19	0.19	0.05

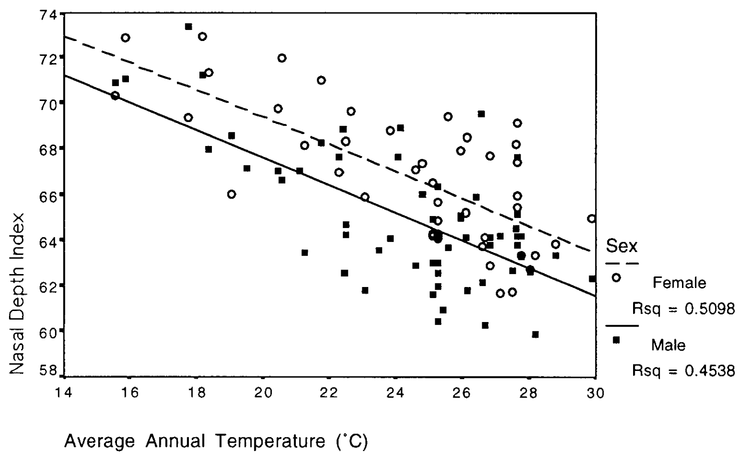

Figure 7.64: Bivariate Scatterplot of Male and Female Nasal Depth Index vs Average Annual Temperature

This Australia-wide cline is repeated in both the eastern and western sub-samples. In the eastern males there are strong, negative correlations with Coldest Month and Annual Temperature (Figure 7.65) and a moderately strong, positive correlation with Temperature Range. In eastern females, however, no correlation attains significance. In the west, the male sample has moderately strong, negative correlations with Hottest Month and Annual Temperature and moderately strong, positive correlations with Most Humid Month and Least Humid Month. The western female sample, meanwhile, exhibits weak to strong, negative correlations with Hottest Month, Coldest Month and Annual Temperature.

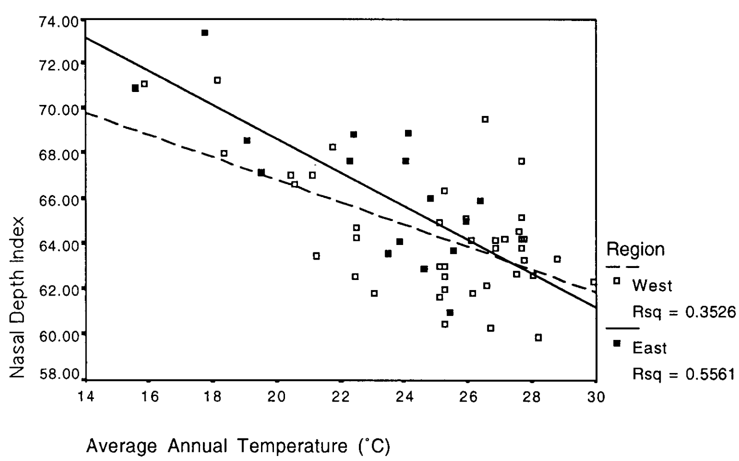

Figure 7.65: Bivariate Scatterplot of Male Nasal Depth Index vs Average Annual Temperature: East/West sub-samples

When partial correlations are calculated it is seen that removing variation in male age reduces the size of most of the significant correlations, except that with Coldest Month, which in contrast, rises above 0.45. Removing both weight and stature also has minor effects. In females, accounting for variation in age and weight has little effect on the size of correlations. Correcting for stature, however, reduces most significant correlations below 0.45, except that with Annual Temperature.

7.2.6.3 Cephalic Index

This index compares the maximum breadth of the cranium relative to it maximum length. It has generally been seen as a measure of cranial shape: a high index describing a relatively short and broad, or brachycephalic skull, and a low index, a relatively long and narrow, or dolichocephalic skull.

In the male sample no correlation with climate rises above the 0.45 level, although there are very weak, positive correlations with Most Humid Month (Figure 7.66) and Least Humid Month, and a negative correlation with Temperature Range. In the female sample there are moderately strong, positive correlations with Most Humid Month and Least Humid Month. MSR analysis reveals that in both the male and female samples Most Humid Month is the primary correlate, however in males it explains only 12% of variance, compared with 35% in females. Overall, these results indicate a trend towards relatively broader and/or shorter heads in areas with greater humidity, particularly in females.

In the eastern male sample there are moderately strong, negative correlations with Least Humid Month (Figure 7.67) and Annual Rainfall and a strong positive correlation with Humidity Range ($r^2 = 0.53$). There are no significant correlations in the eastern female sample. In western males there is a moderately strong, positive correlation with Least Humid Month: all other significant correlations are below 0.45. In western females CI also has a positive relationship with humidity, there being moderately strong, positive correlations with both Least Humid Month and Most Humid Month.

In the partial correlations, variation in male age has some effect in reducing the size and significance of correlations. Correcting for weight, on the other hand, has the effect of increasing a number of correlations: the weak, positive correlation with Most Humid Month rising above 0.45 and the negative correlations with Hottest Month and Temperature Range becoming significant. Accounting for stature has a similar effect to weight, however no correlation reaches 0.45. In females, correcting for age also has the effect of reducing the size of correlations. Weight and stature are seen to have only minor effects.

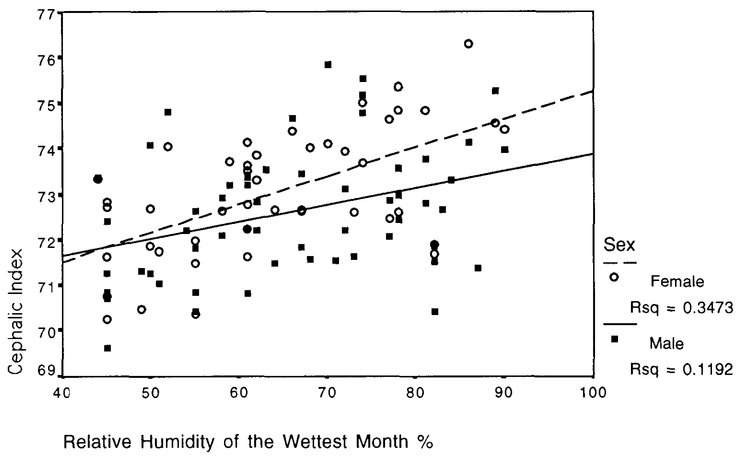

Figure 7.66: Bivariate Scatterplot of Male and Female Cephalic Index vs Relative Humidity of the Wettest Month

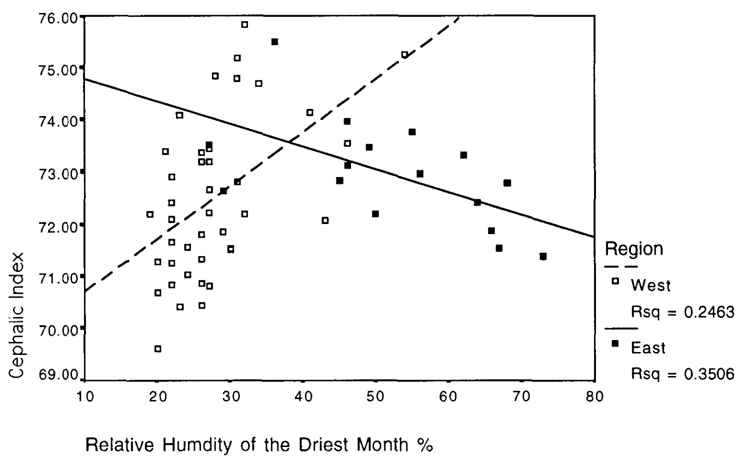

Figure 7.67: Bivariate Scatterplot of Male Cephalic Index vs Relative Humidity of the Driest Month: East/West sub-samples

7.2.6.4 Cranial Module

This index is the average of the three major dimensions of the skull: length, breadth and height. Measured on a living subject, cranial height is taken from porion to vertex. The index provides a rough approximation for total cranial size.

In the Australia-wide male and female samples no correlation reaches the 0.45 level. MSR analysis suggests that Annual Rainfall is the primary correlate, yet this explains only 12% of variance. In the eastern male sample, meanwhile, there are strong, negative correlations with Coldest Month (Figure 7.68), Annual Temperature and Annual Rainfall, and moderately strong positive correlation with Temperature Range. Correlations in the eastern female sample follow the same general pattern, but none attain significance. This suggests that in the east larger head sizes occur in populations inhabiting cooler and drier areas.

In the western male sample the only correlation above the 0.45 level is a weak, positive correlation with Annual Rainfall. In western females no correlation reaches the 0.45 level.

It is the partial correlations, which are, perhaps, the most interesting. Correcting for age has the effect of increasing some of the correlations in the male sample, whereas removing variation in weight reduces the size of all significant correlations. However, most significantly, when stature is controlled for, moderately strong negative correlations appear with temperature variables. A similar effect is seen in females. This suggests that in colder areas head size is larger relative to body size.

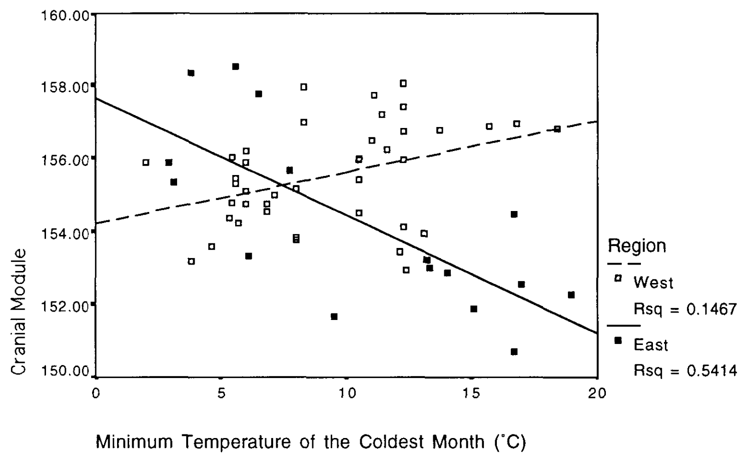

Figure 7.68: Bivariate Scatterplot of Male Cranial Module vs Minimum Temperature of the Coldest Month: East/West sub-samples

7.2.6.5 Cephalo-Facial Index (Breadth).

This index measures the relative proportions of cranial and facial breadth. A high value indicates a broad face relative to head breadth and a low value a relatively narrow face.

In the continent-wide sample both males and females have weak to moderately strong, positive correlations with Hottest Month (Figure 7.69) and Temperature Range (Spearman's only) and moderately strong, negative correlations with Most Humid Month and Least Humid Month. MSR analysis reveals that in males Most Humid Month is the primary correlate, explaining 24% of variance, and in females it is Least Humid Month, which along with Annual Rainfall, explains 51% of variance in female cephalo-facial index.

Therefore, populations in warmer, drier areas that have greater seasonal variation in temperature, have relatively broader faces (or narrower heads) than do populations in areas where summers are somewhat cooler and wetter.

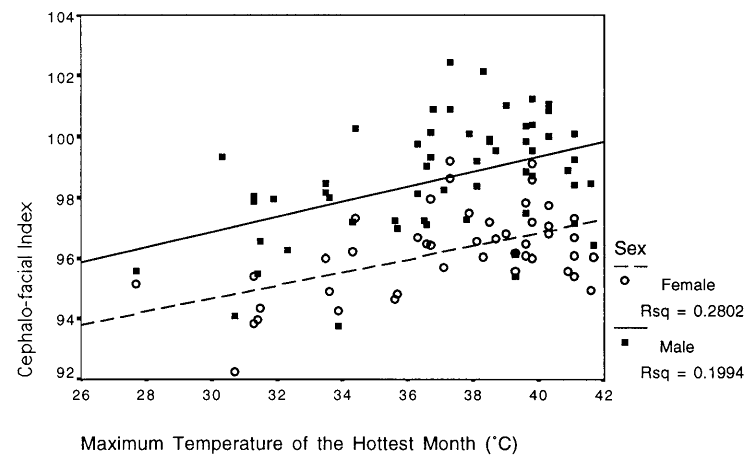

Figure 7.69: Bivariate Scatterplot of Male and Female Cephalo-facial Index vs Maximum Temperature of the Hottest Month

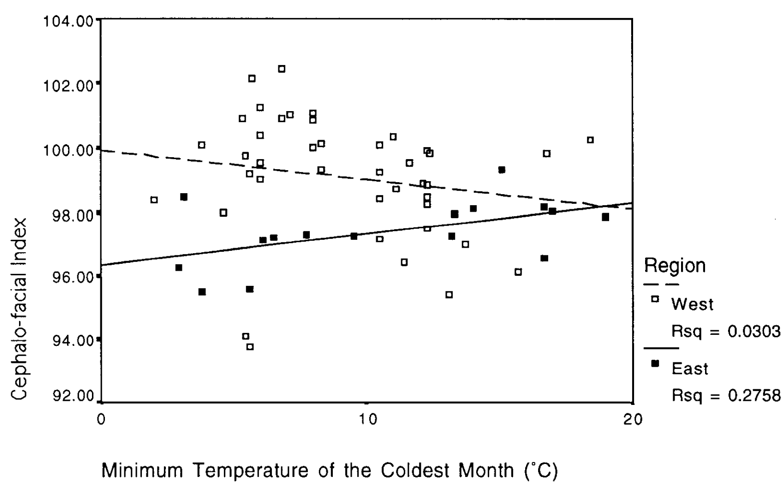

Figure 7.70: Bivariate Scatterplot of Male Cephalo-facial Index vs Minimum Temperature of the Coldest Month: East/West sub-samples

In the eastern male sub-sample there are moderately strong, positive correlations with Coldest Month (Figure 7.70), Annual Temperature and Annual Rainfall, however none of the correlations in the female sample attain significance. The western samples lack correlations with temperature, instead, in both males and females, there are weak to moderately strong, negative correlations with humidity variables (Figure 7.71).

The partial correlations reveal that variation in age has a significant effect on the size of correlations in the male sample. When age is controlled for all significant correlations are reduced in size, with all but the correlation with Most Humid Month falling below 0.45. Controlling for stature reduces some correlations and removing variation in weight has no effect. A similar pattern is seen in the female sample.

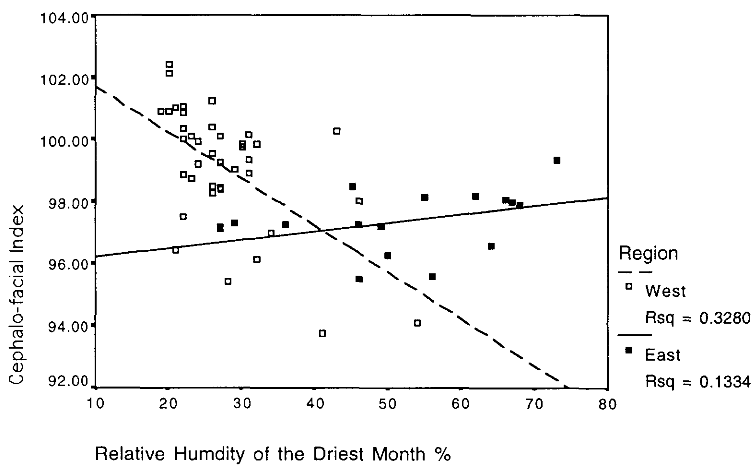

Figure 7.71: Bivariate Scatterplot of Male Cephalo-facial Index vs Relative Humidity of the Driest Month: East/West sub-samples

7.2.6.6 Total Facial Index

Total facial index compares facial height to facial breadth. A high index indicates a longer face relative to breadth and a low index a shorter face.

In the total male sample there are weak to moderately strong, positive correlations with Annual Rainfall, Most Humid Month, Least Humid Month (Figure 7.72) and longitude, and a weak to moderately strong, negative correlation with Temperature Range. MSR analysis indicates that Least Humid Month is the primary correlate, explaining 29% of variance in total facial index in males. In the female sample no correlation reaches the 0.45 level.

These results indicate that in males there is a tendency for shorter (or broader) faces were it is warmer and particularly drier, and where there is greater annual variation in temperature. The positive correlation with longitude places this morphological complex in the west.

Indeed, the pattern of correlations for this index is quite different in the east and the west. In the eastern male sample there are moderately strong, negative correlations with Hottest Month and Annual Temperature (Figure 7.73). In the eastern females, meanwhile, there is a strong, positive correlation with Humidity Range, which is not at all evident in eastern males. This indicates that in the east, longer faces are found in areas that cooler and, in females, where there is greater annual variation in humidity.

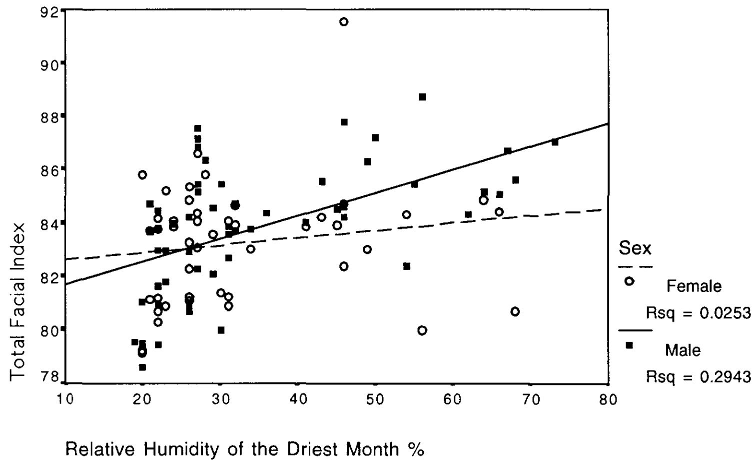

Figure 7.72: Bivariate Scatterplot of Male and Female Total Facial Index vs Relative Humidity of the Driest Month

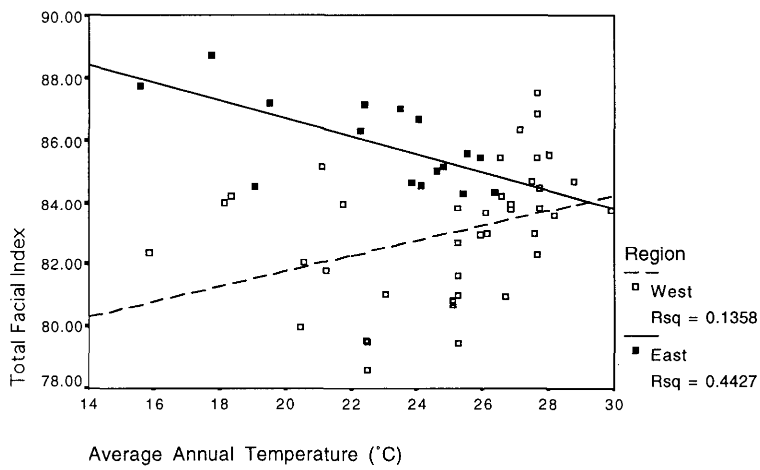

Figure 7.73: Bivariate Scatterplot of Male Total Facial Index vs Average Annual Temperature: East/West sub-samples

In the western males there is a weak, positive correlation with Coldest Month, but all other significant correlations are below 0.45. This result is repeated in the western female sample.

When co-variates are controlled for it can be seen that only variation in male age has any significant effect on the size of correlations. In the female sample, controlling for age and weight has no effect, and when stature is removed a very weak, but significant, positive correlation appears with Most Humid Month.

7.2.6.7 Summary: Cranio-facial shape

Bivariate Correlations.

- Overall, there appears to be a north-west to south-east cline in facial shape. Populations in the north and northwest tend to have a wider, shorter face, and broader, lower and flatter nose. In the southeast, longer, narrower faces with higher and more protrusive noses are more common. There is also sexual dimorphism evident in these clines: females having fewer significant ecogeographic correlations than do males.
- In eastern males there is a tendency for populations inhabiting cooler and/or drier areas to have larger heads, longer faces and more protrusive noses. On the whole these patterns are not evident in the small eastern female sample.
- In the west, many of the significant correlations are associated with moisture variables and, unlike in the east, similar patterns are shared by males and females.
- The common correlation between the east and west sub-samples is the negative relationship between temperature and the nasal depth index. This is a strong indication that nasal protrusion is greater in populations inhabiting cooler areas. The theory that relatively narrow noses are an adaptation to dry climates is not supported.

MSR

- In 4 out of 6 indices in the male sample climate explains more than 20% of variance, however all indices share some variance with climate.
- Only 3 out of the 6 indices in the female sample share more than 20% of variance with climate, and 3 indices exhibit no association at all.
- The strongest effect of climate on male facial shape is seen in the nasal depth index (49% shared variance, primarily with temperature), and in females, also the nasal depth index (51% variance shared with temperature), as well as the cephalo-facial

index (51% shared variance with moisture).

- Overall, moisture is seen to have a greater effect on facial shape than does temperature, and climate has a greater effect in males than in females (contra previous studies).