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Associations in Sagittal Length Observed between the Neurocranium and the Thoracic Vertebrae: Toward the Solution of the Brachycephalization Problem

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Abstract Toward elucidating the causes of brachycephalization, the correlations between the measurements of the neurocranium and the thoracic vertebrae were examined by means of principal component analysis (PCA) and Kaiser's normal varimax rotation method. In most of the direct results of the PCAs, the first principal component was significantly correlated both with the cranial length and/or basi-bregmatic height and with the sagittal and/or transverse diameters of the vertebral body; and, in one third of the rotated solutions for males, the factor correlated with the cranial length always had significant correlations with the sagittal diameters of the vertebral body. The concrete causes for these associations should be examined in the future.
Key words: Brachycephalization, Neurocranium, Thoracic vertebrae, Principal component analysis, Bootstrap method.

Although Mizoguchi (1992) suggested that some neurocranial measurements were relatively highly correlated not only with the size of the jaws but also with some postcranial measurements such as the body diameters of the third lumbar vertebra, iliac breadth, *etc*., he has since not been able to confirm any consistent correlations between the cranial length or breadth and the measurements of the lumbar and the cervical vertebrae (Mizoguchi, 1994, 1995, 1996). All he found is that the basi-bregmatic height is relatively highly correlated with the size of the vertebral foramen in the above-mentioned vertebrae.

The present study is an attempt to examine whether or not the previous findings regarding the cervical and lumbar vertebrae are also the case with the thoracic vertebrae. The final goal is the same as in the above studies, *i.e.*, the solution of the brachycephalization problem.

Materials and Methods

The data used are the measurements of the neurocranium and the thoracic vertebrae published by Miyamoto (1924) and Okamoto (1930), respectively. These data are of the same individuals, *i.e.*, 30 male and 20 female Japanese from the Kinai dis-

Table 1. Means and standard deviations for the measurements

Variable[2]	Th. v. I			Th. v. II			Th. v. III			Th. v. IV			Th. v. V		
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
1 Ventral height of vertebral body	30	15.7	1.0	30	16.8	1.4	29	17.3	1.5	30	17.8	1.3	30	18.2	1.3
3 Central height of vertebral body	30	13.7	1.3	30	14.4	1.7	29	14.4	1.5	30	14.9	1.5	30	15.6	1.4
2 Dorsal height of vertebral body	30	16.5	1.0	30	16.9	1.6	29	17.5	1.5	30	18.3	1.3	30	19.2	1.3
4 Superior sagittal diam. of vert. body	30	16.4	1.3	30	17.0	1.3	29	18.8	1.8	30	20.7	2.0	30	21.9	1.7
6 Middle sagittal diam. of vert. body	30	16.3	1.4	29	17.3	1.2	29	19.0	1.5	30	20.3	1.6	30	21.6	1.6
5 Inferior sagittal diam. of vert. body	30	16.9	1.1	30	18.4	1.7	29	20.3	1.8	30	21.5	1.6	30	23.1	1.8
7 Superior transverse diam. of vert. body	30	29.3	2.2	30	27.4	2.1	29	27.7	1.5	30	27.3	1.8	30	28.0	1.6
9 Middle transverse diam. of vert. body	30	29.8	1.7	30	29.0	1.5	29	26.7	1.3	30	25.7	1.6	30	26.2	1.8
8 Inferior transverse diam. of vert. body	30	33.0	2.2	30	32.9	1.9	29	31.8	2.2	30	31.1	2.1	30	31.2	2.1
10 Sagittal diameter of vertebral foramen	30	13.4	1.1	30	13.8	1.1	29	14.1	1.1	30	14.3	1.3	30	14.5	1.3
11 Transverse diameter of vertebral foramen	30	20.0	1.4	30	17.0	1.3	29	15.9	1.2	30	15.4	1.1	30	15.3	1.1
K12 Max. width between transverse processes	30	74.9	3.6	30	69.3	3.2	30	62.5	4.2	30	61.6	3.7	30	61.9	3.2
K13 Max. width between sup. articular proc.	30	47.0	3.1	30	39.2	2.6	30	34.0	2.5	30	31.7	2.2	30	30.5	2.3

[1] The estimates of basic statistics listed here were recalculated by the present author on the basis of the raw data published

[2] Variable number according to Martin and Saller (1957) except for K12 and K13, which are Nos. 12 and 13, respectively.

Table 2. Means and standard deviations for the measurements

Variable[2]	Th. v. I			Th. v. II			Th. v. III			Th. v. IV			Th. v. V		
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
1 Ventral height of vertebral body	19	14.4	0.8	19	15.2	0.9	19	15.8	0.7	19	15.9	0.8	19	16.2	0.6
3 Central height of vertebral body	19	11.9	1.1	20	12.5	1.1	19	12.8	0.6	19	13.1	0.7	20	13.6	0.8
2 Dorsal height of vertebral body	18	14.6	1.2	19	15.4	1.2	18	16.1	0.9	18	16.6	1.0	19	17.4	0.5
4 Superior sagittal diam. of vert. body	19	14.9	1.0	19	15.5	1.2	19	16.9	1.6	19	18.5	1.3	19	20.0	1.2
6 Middle sagittal diam. of vert. body	20	15.1	1.4	19	15.7	1.4	20	17.0	1.6	20	18.2	1.4	20	19.8	1.6
5 Inferior sagittal diam. of vert. body	19	15.5	1.2	19	16.7	1.2	19	18.3	1.5	19	19.6	1.3	19	20.8	1.4
7 Superior transverse diam. of vert. body	20	28.6	2.4	19	26.1	2.1	19	25.5	2.0	19	25.6	1.8	19	25.8	1.9
9 Middle transverse diam. of vert. body	20	27.7	1.7	20	25.6	1.7	20	23.4	1.5	20	22.7	1.4	20	23.0	1.7
8 Inferior transverse diam. of vert. body	19	29.4	1.5	19	29.6	1.8	19	28.2	1.9	18	27.9	2.0	19	28.6	1.8
10 Sagittal diameter of vertebral foramen	20	12.9	0.9	19	13.5	1.0	20	13.6	1.2	20	14.0	1.2	20	14.4	1.3
11 Transverse diameter of vertebral foramen	20	18.8	0.8	20	16.5	0.9	20	15.3	1.1	20	14.7	1.0	20	14.4	0.9
K12 Max. width between transverse processes	20	65.8	3.4	20	61.7	3.8	20	56.6	4.0	20	55.1	4.1	20	55.0	3.8
K13 Max. width between sup. articular proc.	20	44.9	2.2	20	35.9	2.2	20	30.9	2.0	20	28.7	1.8	20	27.1	1.9

[1] and [2] See the footnotes to Table 1.

trict. The basic statistics for the measurements of the thoracic vertebrae are listed in Tables 1 and 2, and those for the neurocranium are presented in Mizoguchi (1994).

For examining the overall relationships between the measurements of the neurocranium and the thoracic vertebrae, principal component analysis (Lawley and Maxwell, 1963; Okuno *et al.*, 1971, 1976; Takeuchi and Yanai, 1972) was applied to the correlation matrices. In the present study, the number of principal components of the thoracic vertebrae in Japanese males.[1)]

Th. v. VI			Th. v. VII			Th. v. VIII			Th. v. IX			Th. v. X			Th. v. XI			Th. v. XII		
n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
29	18.4	1.3	29	18.8	0.9	29	19.3	1.4	29	20.3	1.4	29	21.1	1.3	30	21.5	1.5	30	22.4	2.3
29	16.2	1.5	29	16.7	1.3	29	16.7	1.3	29	17.2	1.5	29	18.3	1.5	30	19.6	1.9	30	21.3	2.0
29	19.9	1.3	30	20.4	1.4	29	20.4	1.3	30	20.7	1.3	29	22.0	1.6	30	24.1	1.8	30	25.9	1.6
30	23.5	1.8	30	25.2	2.1	30	26.4	2.0	30	27.3	2.2	30	27.7	2.0	30	28.3	2.0	30	28.8	1.8
30	23.3	1.6	30	24.8	2.1	30	25.9	1.9	30	26.7	1.9	30	27.2	1.8	30	27.4	1.5	30	27.2	1.5
30	24.6	1.9	30	26.1	1.9	30	27.0	2.2	30	27.8	2.1	30	28.1	1.7	30	28.6	2.3	30	29.1	1.8
30	28.7	2.0	30	30.2	2.2	30	31.6	2.5	30	32.4	2.5	30	33.8	2.6	30	37.1	2.7	30	40.4	2.5
30	26.9	1.9	30	28.6	2.3	30	29.6	2.0	30	30.9	2.3	30	32.9	2.3	30	35.4	1.9	30	37.0	2.1
30	31.8	2.4	30	32.6	2.6	30	33.7	2.3	30	35.2	2.5	30	38.3	3.1	30	40.6	2.6	30	42.7	2.8
30	14.5	1.3	30	14.4	1.1	30	14.3	1.4	30	13.8	1.1	30	13.9	1.0	30	14.3	1.1	30	15.5	1.1
30	15.1	1.1	30	15.3	1.1	30	15.1	1.3	30	15.5	1.1	30	15.4	1.0	30	16.3	1.3	30	19.7	2.1
30	61.7	3.0	30	60.9	3.0	30	60.4	3.0	29	58.9	3.4	30	56.7	2.6	30	53.5	2.6	30	49.4	4.5
30	29.6	2.1	30	29.5	2.0	30	30.7	2.1	29	31.8	2.2	30	33.8	2.7	30	34.4	2.3	30	34.5	2.2

by Okamoto (1930).
of Kiyono's (1929) measurement system.

of the thoracic vertebrae in Japanese females.[1)]

Th. v. VI			Th. v. VII			Th. v. VIII			Th. v. IX			Th. v. X			Th. v. XI			Th. v. XII		
n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
19	16.5	1.0	19	16.5	0.8	19	17.3	1.1	19	18.4	0.8	19	19.2	1.0	19	19.7	1.0	19	21.7	1.1
20	14.3	0.9	20	14.5	0.8	20	14.9	0.8	20	15.4	0.9	20	16.6	0.9	20	17.8	1.1	20	19.9	1.7
19	17.8	0.6	19	18.2	0.8	19	18.3	0.9	19	18.9	0.9	19	20.2	1.0	19	22.1	1.1	19	23.7	1.2
19	21.2	1.4	19	22.6	1.5	19	23.8	1.9	19	24.4	2.2	19	24.3	1.9	19	24.8	1.9	19	25.1	1.9
20	20.8	1.3	20	22.1	1.5	20	22.9	1.9	20	23.5	2.0	20	23.9	2.1	20	24.0	1.8	20	24.1	1.8
19	22.2	1.3	19	23.5	1.7	19	24.3	2.1	19	24.6	2.0	19	24.7	2.0	19	24.7	1.7	19	24.7	1.9
19	26.5	1.7	19	27.1	1.7	19	28.3	1.5	19	29.2	1.8	19	30.7	1.9	19	33.3	1.8	19	36.3	1.7
20	24.0	1.5	20	25.1	1.8	20	26.3	1.8	20	27.6	2.0	20	29.3	2.1	20	31.9	1.9	20	33.2	1.9
19	28.7	1.9	19	29.9	1.8	19	31.5	1.8	19	32.6	2.1	19	34.5	2.0	19	36.7	1.9	19	38.4	2.1
20	14.4	1.5	20	14.3	1.3	20	13.8	0.9	20	13.6	1.1	20	13.5	1.1	20	14.2	1.1	20	15.6	1.1
20	14.3	1.2	20	14.5	1.3	20	14.6	1.4	20	14.8	1.4	20	15.2	1.5	20	16.2	1.7	20	18.7	1.9
20	55.8	4.3	20	54.8	3.4	20	53.6	3.4	20	52.8	3.1	20	51.0	2.7	20	47.3	3.2	20	45.0	3.7
20	26.8	1.9	20	27.3	2.2	20	27.6	2.3	20	29.1	2.7	20	31.6	2.4	20	30.8	2.1	20	32.9	2.6

was so determined that the cumulative proportion of the variances of the principal components exceeded 80%. The principal components obtaind in such a way were then transformed by Kaiser's normal varimax rotation method (Asano, 1971; Okuno *et al.*, 1971) into different factors, which may suggest some other associations hidden behind the measurements dealt with.

The significance of factor loadings was tested by the bootstrap method (Efron, 1979 a, b, 1982; Diaconis and Efron, 1983; Mizoguchi, 1993). In order to estimate the bootstrap standard deviation of a factor loading, 1,000 bootstrap replications including the observed sample were used. The estimation of a bootstrap standard deviation was made by directly counting the cumulative frequency for the standard deviation in the bootstrap distribution.

Further, the reality of common factors as represented by principal components or rotated factors was examined indirectly by finding similarities between the factors obtained from different thoracic vertebrae, *i.e.*, by estimating a Spearman's rank correlation coefficient (Siegel, 1956) between the variation patterns of the factor loadings.

The statistical calculations were executed with the mainframe, HITACHI MP5800 System, of the Computer Centre, the University of Tokyo. The programs used are BSFMD for calculating basic statistics, BTPCA for the principal component analysis and Kaiser's normal varimax rotation, and RKCNCT for rank correlation coefficients. All of these have been written in FORTRAN by the present author.

Results

The direct results of the principal component analyses (PCAs) for males are shown in Tables 3 to 14, and those for females are in Tables 15 to 26. Although the first principal component (PC) is usually called a "general size factor," it is found in 75% of these tables that the first PC is particulary strongly correlated with the cranial length and/or basi-bregmatic height and, simultaneously, with the sagittal and/or transverse diameters of the vertebral body. And the first PCs which are significantly correlated with the diameters of the vertebral foramen (in 7 of the 24 tables) always have significant correlations with the basi-bregmatic height.

The rotated solutions for males and females are shown in Tables 27 to 38 and in Tables 39 to 50, respectively. In one third of the rotated solutions for males, it can be found that the factor significantly correlated with the cranial length always has significant correlations with the sagittal diameters of the vertebral body. Further, one fifth of the 24 rotated solutions for both sexes shows that there is the factor which is significantly correlated with both the basi-bregmatic height and the sagittal or transverse diameters of the vertebral foramen.

In Tables 51 and 52, highly significant Spearman's rank correlation coefficients between the PCs and between the rotated factors are shown, respectively.

Discussion

Mizoguchi (1994, 1995, 1996) carried out the PCAs for the measurements of the neurocranium and the lumbar and cervical vertebrae. In his results, the basi-bregmatic height was relatively highly correlated with the size of the vertebral foramen. In

Table 3. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the first thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings PC I	II	III	IV	V	VI	Total variance (%)
1 Cranial length	.53*	.16	−.17	−.26	.09	.46	62.04
8 Cranial breadth	.41	−.17	−.44	.35	.04	.48	74.79
17 Basi-bregmatic height	.46*	.09	−.03	−.49	.56	.18	81.21
1 Vent. height of v. body	.50	−.58	.47	.02	.05	.12	81.92
3 Cent. height of v. body	.40	−.60	.54	.24	.08	−.15	89.48
2 Dors. height of v. body	.37	−.53	.53	.32	.24	−.08	86.77
4 Sup. sag. d. of v. body	.55	.58	.46	−.02	−.07	.06	86.25
6 Mid. sag. d. of v. body	.48	.63	.50	.00	−.22	.07	92.29
5 Inf. sag. d. of v. body	.43	.70	.46	−.04	−.03	−.14	90.88
7 Sup. trans. d. of v. b.	.09	.38	−.53	.50	.31	−.20	82.01
9 Mid. trans. d. of v. b.	.68***	.09	−.45	.18	.01	−.07	70.04
8 Inf. trans. d. of v. b.	.47	.32	−.13	.53	.34	−.14	75.63
10 Sagit. d. of v. foramen	.57	−.52	−.22	−.17	.00	−.06	67.92
11 Trans. d. of v. foramen	.49	−.08	−.41	−.54	.11	−.40	87.31
K12 Max. wid. trans. proc.	.75**	−.11	−.19	−.17	−.29	−.23	78.26
K13 Max. wid. s. art. proc.	.52	−.16	−.32	.21	−.65	.05	86.62
Total contribution (%)	25.08	17.68	15.93	9.65	7.33	5.16	80.84
Cumulative proportion (%)	25.08	42.77	58.70	68.35	75.67	80.84	80.84

[1)] The sample size is 30. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.

[2)] See the second footnote to Table 1.

*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 4. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the second thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings PC I	II	III	IV	V	VI	Total variance (%)
1 Cranial length	.62**	−.03	−.13	−.24	−.26	−.05	52.72
8 Cranial breadth	.37	−.19	.15	.12	.75	−.02	76.54
17 Basi-bregmatic height	.60**	−.13	.22	−.27	−.18	−.22	58.13
1 Vent. height of v. body	.14	.49	.71	−.07	−.25	−.07	83.65
3 Cent. height of v. body	−.12	.58	.43	.33	−.19	−.34	79.98
2 Dors. height of v. body	−.01	.53	.42	.46	.09	.29	76.62
4 Sup. sag. d. of v. body	.70	.49	−.17	−.13	.19	.12	82.26
6 Mid. sag. d. of v. body	.63	.52	−.21	−.37	.18	.08	89.05
5 Inf. sag. d. of v. body	.70*	.44	.08	−.46	.09	−.02	91.67
7 Sup. trans. d. of v. b.	.65	−.23	−.34	.31	−.31	.14	80.42
9 Mid. trans. d. of v. b.	.64	−.03	−.48	.49	−.08	.13	91.09
8 Inf. trans. d. of v. b.	.57	.27	−.21	.54	−.10	−.27	81.22
10 Sagit. d. of v. foramen	.32	−.17	.53	.17	.02	.65*	86.52
11 Trans. d. of v. foramen	.36	−.61	.33	−.26	−.33	.19	82.11
K12 Max. wid. trans. proc.	.65*	−.43	.35	.19	−.02	−.20	81.12
K13 Max. wid. s. art. proc.	.44	−.56	.37	.13	.32	−.35	88.69
Total contribution (%)	26.90	16.55	12.99	10.06	7.29	6.32	80.11
Cumulative proportion (%)	26.90	43.45	56.44	66.50	73.79	80.11	80.11

[1)] The sample size is 29. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.

[2)] See the second footnote to Table 1.

*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 5. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the third thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.41	.21	−.29	−.45	−.21	.19	58.71
8 Cranial breadth	.30	.16	.12	−.21	.77	.33	87.66
17 Basi-bregmatic height	.52	.12	.03	−.48	−.28	.44	79.63
1 Vent. height of v. body	.55	−.62	.32	.09	−.16	−.16	84.85
3 Cent. height of v. body	.41	−.72	.15	.38	.00	.02	85.72
2 Dors. height of v. body	.52*	−.49	.23	.50	−.06	.29	89.77
4 Sup. sag. d. of v. body	.74***	−.37	−.44	−.19	.01	−.09	93.04
6 Mid. sag. d. of v. body	.69***	−.16	−.57	.01	.16	−.21	89.88
5 Inf. sag. d. of v. body	.86***	−.29	−.28	−.13	.09	.00	91.64
7 Sup. trans. d. of v. b.	.23	.50	−.19	.48	−.41	.27	81.40
9 Mid. trans. d. of v. b.	.60	.53	−.00	.14	−.26	−.05	72.58
8 Inf. trans. d. of v. b.	.39	.71	−.17	.40	.13	−.04	85.90
10 Sagit. d. of v. foramen	.42	.02	.71	−.06	.02	.25	74.23
11 Trans. d. of v. foramen	.38	.17	.50	−.58	−.21	−.35	91.77
K12 Max. wid. trans. proc.	.59	.42	.33	.17	.07	−.37	81.17
K13 Max. wid. s. art. proc.	.56	.56	.19	.13	.27	−.06	75.12
Total contribution (%)	28.63	18.84	11.48	10.82	7.23	5.69	82.69
Cumulative proportion (%)	28.63	47.47	58.95	69.77	77.00	82.69	82.69

1) The sample size is 29. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 6. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the fourth thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.44*	.45	−.17	−.27	−.04	.34	61.43
8 Cranial breadth	.24	.04	−.13	−.29	.88*	.03	93.72
17 Basi-bregmatic height	.50*	.10	−.13	−.31	−.10	.59	73.31
1 Vent. height of v. body	.59*	−.63	−.10	.29	−.01	.07	84.62
3 Cent. height of v. body	.55**	−.59	−.15	.45	.05	.07	87.92
2 Dors. height of v. body	.63**	−.62	−.02	.27	.12	.15	89.00
4 Sup. sag. d. of v. body	.84***	.04	−.37	−.14	−.07	−.29*	94.90
6 Mid. sag. d. of v. body	.81***	.10	−.20	−.20	−.08	−.44*	95.44
5 Inf. sag. d. of v. body	.86***	−.10	−.24	−.21	−.23	−.16	93.09
7 Sup. trans. d. of v. b.	.33	.71	−.17	.32	.01	.13	76.22
9 Mid. trans. d. of v. b.	.43	.66	.04	.19	−.11	.16	70.36
8 Inf. trans. d. of v. b.	.65*	.60	−.02	.31	.13	−.03	88.65
10 Sagit. d. of v. foramen	.43	−.41	.26	−.51	.11	.07	69.58
11 Trans. d. of v. foramen	.49*	−.23	.63	−.20	−.31	.16	84.78
K12 Max. wid. trans. proc.	.58**	.05	.63	.29	.22	.06	87.76
K13 Max. wid. s. art. proc.	.38	.38	.69	−.05	.07	−.30	86.97
Total contribution (%)	32.87	19.05	10.71	8.31	6.59	6.09	83.61
Cumulative proportion (%)	32.87	51.92	62.62	70.93	77.52	83.61	83.61

1) The sample size is 30. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 7. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the fifth thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.48**	.49	−.20	−.17	−.05	−.07	54.82
8 Cranial breadth	.19	.06	−.28	−.00	.79	−.46	95.02
17 Basi-bregmatic height	.45	.30	−.25	−.54	.22	.35	81.63
1 Vent. height of v. body	.60**	−.44	.29	−.02	.16	.28	74.75
3 Cent. height of v. body	.44	−.65	.43	−.13	.16	.01	84.36
2 Dors. height of v. body	.63**	−.59	.37	.02	.15	−.03	91.21
4 Sup. sag. d. of v. body	.85***	−.13	−.15	−.22	−.28	−.21	93.30
6 Mid. sag. d. of v. body	.84***	−.01	−.09	−.18	−.32	−.21	88.48
5 Inf. sag. d. of v. body	.84***	−.16	−.24	−.25	−.19	−.15	90.72
7 Sup. trans. d. of v. b.	.61*	.54	.39	−.02	.16	−.06	83.96
9 Mid. trans. d. of v. b.	.46	.67	.22	.18	.13	.23	81.46
8 Inf. trans. d. of v. b.	.63*	.38	.42	.29	.15	.04	83.26
10 Sagit. d. of v. foramen	.16	−.43	−.66	.30	.22	−.04	78.38
11 Trans. d. of v. foramen	.32	.01	−.73	−.04	.12	.43	83.90
K12 Max. wid. trans. proc.	.59**	−.26	−.11	.60	−.09	.28	87.01
K13 Max. wid. s. art. proc.	.50*	.29	−.26	.56	−.19	−.22	79.82
Total contribution (%)	32.89	16.09	13.10	8.51	7.02	5.64	83.26
Cumulative proportion (%)	32.89	48.98	62.08	70.60	77.62	83.26	83.26

[1)] The sample size is 30. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
**P*<0.05; ***P*<0.01; ****P*<0.001, by the two-tailed bootstrap test.

Table 8. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the sixth thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.54**	−.21	.35	.29	.01	.55	84.58
8 Cranial breadth	.29	−.13	.03	.77	−.25	−.40	91.51
17 Basi-bregmatic height	.53	−.06	.06	.37	.55	−.11	74.48
1 Vent. height of v. body	.60*	.50	−.23	.00	.25	.04	72.24
3 Cent. height of v. body	.28	.76	−.41	−.19	.06	−.13	87.20
2 Dors. height of v. body	.53	.61	−.42	−.02	−.23	.05	87.98
4 Sup. sag. d. of v. body	.91***	−.01	−.18	−.03	.01	.14	88.60
6 Mid. sag. d. of v. body	.88***	.02	−.16	.04	.06	.14	83.26
5 Inf. sag. d. of v. body	.89***	−.17	−.16	−.04	−.07	.12	87.54
7 Sup. trans. d. of v. b.	.59*	.26	.60	−.08	−.21	−.10	83.58
9 Mid. trans. d. of v. b.	.57*	−.16	.64	−.17	−.07	−.22	84.39
8 Inf. trans. d. of v. b.	.55*	.20	.65	−.21	−.10	−.29	90.99
10 Sagit. d. of v. foramen	.26	−.39	−.65	.17	−.34	−.17	81.80
11 Trans. d. of v. foramen	.30	−.57	−.16	−.19	.58	−.26	88.09
K12 Max. wid. trans. proc.	.40	−.40	−.40	−.33	−.14	−.29	69.99
K13 Max. wid. s. art. proc.	.35	−.72	−.04	−.26	−.22	.23	80.48
Total contribution (%)	32.51	16.10	15.07	7.34	6.71	5.82	83.54
Cumulative proportion (%)	32.51	48.61	63.68	71.02	77.73	83.54	83.54

[1)] The sample size is 29. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
**P*<0.05; ***P*<0.01; ****P*<0.001, by the two-tailed bootstrap test.

Table 9. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the seventh thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.55***	−.29	.16	−.14	−.04	−.55	73.58
8 Cranial breadth	.35	−.30	−.25	−.46	−.56	.20	84.55
17 Basi-bregmatic height	.55**	−.06	−.06	.16	−.40	−.42	66.30
1 Vent. height of v. body	.16	.79	.38	.12	.04	.06	81.01
3 Cent. height of v. body	.30	.81	−.00	.19	−.22	−.14	85.39
2 Dors. height of v. body	.47	.80	−.07	−.03	.07	.01	87.50
4 Sup. sag. d. of v. body	.91***	.09	−.16	−.12	.09	.05	88.75
6 Mid. sag. d. of v. body	.88***	.09	−.16	−.12	.06	−.13	84.15
5 Inf. sag. d. of v. body	.92***	−.00	−.15	−.15	.11	−.07	90.70
7 Sup. trans. d. of v. b.	.72***	−.05	.55	−.10	−.07	.22	89.13
9 Mid. trans. d. of v. b.	.51**	−.41	.64	.16	.04	.16	89.38
8 Inf. trans. d. of v. b.	.65***	−.10	.58	−.03	.03	.23	82.35
10 Sagit. d. of v. foramen	.40*	.11	−.51	.17	−.30	.42	72.78
11 Trans. d. of v. foramen	.44*	−.31	−.26	.70	−.13	.10	87.25
K12 Max. wid. trans. proc.	.44**	.02	−.48	−.26	.47	.14	72.92
K13 Max. wid. s. art. proc.	.58***	−.36	−.25	.33	.37	−.07	76.80
Total contribution (%)	34.98	15.83	12.42	6.89	6.37	5.57	82.06
Cumulative proportion (%)	34.98	50.81	63.23	70.12	76.49	82.06	82.06

[1)] The sample size is 29. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 10. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the eighth thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.71***	.03	−.33	−.20	−.19	.24	75.59
8 Cranial breadth	.42	−.31	.21	.09	.56	.08	64.22
17 Basi-bregmatic height	.54**	.02	.16	−.17	.34	.47	67.45
1 Vent. height of v. body	−.01	.86*	.17	.05	−.08	−.02	77.60
3 Cent. height of v. body	.05	.74	.49	.02	−.03	−.09	80.90
2 Dors. height of v. body	.27	.81	.42	−.02	.08	.01	91.60
4 Sup. sag. d. of v. body	.87***	−.13	.13	−.30	−.20	−.20	96.25
6 Mid. sag. d. of v. body	.78***	−.15	.17	−.47	−.08	−.25	95.16
5 Inf. sag. d. of v. body	.86***	−.17	.19	−.33	−.18	−.14	96.02
7 Sup. trans. d. of v. b.	.71***	.30	−.47	.23	.15	.01	89.49
9 Mid. trans. d. of v. b.	.59**	.22	−.62	.24	.08	.13	85.79
8 Inf. trans. d. of v. b.	.69***	.20	−.40	.31	.15	−.31	89.33
10 Sagit. d. of v. foramen	.46*	−.13	.45	.12	−.23	.54	74.82
11 Trans. d. of v. foramen	.31	−.24	.51	.26	.54	−.21	82.51
K12 Max. wid. trans. proc.	.25	−.38	.44	.62	−.32	−.11	90.14
K13 Max. wid. s. art. proc.	.47*	−.07	.05	.65	−.30	.04	74.42
Total contribution (%)	31.73	15.71	13.40	9.95	7.18	5.47	83.43
Cumulative proportion (%)	31.73	47.44	60.83	70.78	77.96	83.43	83.43

[1)] The sample size is 29. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 11. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the ninth thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.59**	−.23	−.08	.02	−.20	.37	58.66
8 Cranial breadth	.41	.07	−.10	−.16	.64	−.33	73.14
17 Basi-bregmatic height	.56**	.12	−.21	−.03	.16	.65*	82.60
1 Vent. height of v. body	−.10	.76	.40	.14	−.16	−.08	79.72
3 Cent. height of v. body	.04	.92**	−.03	−.01	−.04	.07	86.47
2 Dors. height of v. body	.26	.88**	.13	−.15	−.09	.06	89.78
4 Sup. sag. d. of v. body	.81***	.02	−.44	−.05	−.24	−.23	95.70
6 Mid. sag. d. of v. body	.74***	−.04	−.54	−.24	−.05	−.09	90.61
5 Inf. sag. d. of v. body	.76***	.06	−.44	.04	−.34	−.20	94.11
7 Sup. trans. d. of v. b.	.77***	−.04	.49	−.32	−.04	−.06	94.03
9 Mid. trans. d. of v. b.	.60**	−.41	.61	−.15	.01	.04	92.50
8 Inf. trans. d. of v. b.	.64***	−.04	.63	−.32	.02	−.09	91.14
10 Sagit. d. of v. foramen	.71***	.28	.04	.29	.14	−.02	68.30
11 Trans. d. of v. foramen	.52**	.03	−.03	.39	.57	.12	75.91
K12 Max. wid. trans. proc.	.32	.02	.12	.75	.07	−.18	71.11
K13 Max. wid. s. art. proc.	.37	−.27	.31	.55	−.38	.02	75.07
Total contribution (%)	31.64	16.25	12.75	9.08	7.43	5.29	82.43
Cumulative proportion (%)	31.64	47.89	60.64	69.71	77.14	82.43	82.43

1) The sample size is 27. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
2) See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 12. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the tenth thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.58**	.42	−.04	−.16	−.40	.02	69.58
8 Cranial breadth	.25	.28	.58	.01	−.28	.38	70.24
17 Basi-bregmatic height	.49	.07	.45	−.06	−.08	−.40	61.48
1 Vent. height of v. body	.68*	−.61	.01	.09	.02	.19	88.77
3 Cent. height of v. body	.52	−.69	−.10	.29	.12	.20	89.51
2 Dors. height of v. body	.54	−.67	−.11	.35	.13	.14	91.72
4 Sup. sag. d. of v. body	.86***	−.07	−.07	−.21	−.21	−.09	85.31
6 Mid. sag. d. of v. body	.84***	−.11	−.24	−.26	−.15	−.19	90.44
5 Inf. sag. d. of v. body	.83***	−.13	−.21	−.39	−.14	.02	91.39
7 Sup. trans. d. of v. b.	.69***	.48	.01	.46	.07	−.05	92.99
9 Mid. trans. d. of v. b.	.47	.76	−.06	.30	.19	.01	93.28
8 Inf. trans. d. of v. b.	.54*	.55	−.22	.45	.10	.03	86.59
10 Sagit. d. of v. foramen	.33	−.10	.81	.02	.13	.14	80.60
11 Trans. d. of v. foramen	.33	−.11	.56	−.19	.47	−.37	83.22
K12 Max. wid. trans. proc.	.19	.38	.03	−.52	.32	.57	88.54
K13 Max. wid. s. art. proc.	.31	.18	−.42	−.33	.52	−.07	68.67
Total contribution (%)	32.12	18.30	11.62	9.05	6.39	5.79	83.27
Cumulative proportion (%)	32.12	50.42	62.04	71.09	77.48	83.27	83.27

1) The sample size is 28. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
2) See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 13. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the eleventh thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings							Total variance (%)
	PC I	II	III	IV	V	VI	VII	
1 Cranial length	.51**	.19	−.15	.08	.70*	−.00	.01	82.22
8 Cranial breadth	.34	.11	−.20	.47	−.19	.63	−.22	86.02
17 Basi-bregmatic height	.47*	−.14	−.14	.09	.50	.19	.09	56.70
1 Vent. height of v. body	.55	−.62	−.39	−.22	−.13	.04	.02	90.50
3 Cent. height of v. body	.49*	−.60	−.40	−.17	−.08	−.04	−.36	92.29
2 Dors. height of v. body	.79***	.23	−.21	−.18	−.21	−.07	−.23	85.03
4 Sup. sag. d. of v. body	.56	−.50	.56	.22	−.00	−.11	.13	95.77
6 Mid. sag. d. of v. body	.63***	.33	.40	−.11	.36	.03	−.02	80.39
5 Inf. sag. d. of v. body	.32	−.54	.66	.17	−.14	−.13	−.05	89.71
7 Sup. trans. d. of v. b.	.69*	.64	.04	−.24	−.08	−.04	.01	95.33
9 Mid. trans. d. of v. b.	.67*	.63	.12	−.08	−.05	−.03	.03	86.40
8 Inf. trans. d. of v. b.	.57	.68	.03	−.22	−.04	−.08	−.13	85.19
10 Sagit. d. of v. foramen	.42	−.25	−.49	.04	−.16	.06	.67*	95.85
11 Trans. d. of v. foramen	.52	.25	−.13	.29	−.24	−.51	.10	75.93
K12 Max. wid. trans. proc.	.39	.24	−.00	.72	−.12	.03	−.05	74.19
K13 Max. wid. s. art. proc.	.31	.13	.50	−.35	−.27	.49	.19	84.62
Total contribution (%)	28.22	18.61	11.67	7.96	7.35	6.12	4.84	84.76
Cumulative proportion (%)	28.22	46.83	58.49	66.46	73.80	79.92	84.76	84.76

[1)] The sample size is 30. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
*P<0.05; **P<0.01; ***P<0.001, by the two-tailed bootstrap test.

Table 14. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the twelfth thoracic vertebra for Japanese males.[1)]

Variable[2)]	Factor loadings						Total variance (%)
	PC I	II	III	IV	V	VI	
1 Cranial length	.56**	.01	.28	−.36	.39	.17	71.00
8 Cranial breadth	.26	−.21	.24	.64	.47	−.24	84.74
17 Basi-bregmatic height	.41	−.07	.17	−.33	.60	−.19	70.66
1 Vent. height of v. body	.48	.62	−.41	.03	.07	−.02	78.10
3 Cent. height of v. body	.19	.81	−.38	.15	.05	−.06	86.32
2 Dors. height of v. body	.35	.74	−.39	.07	.20	−.06	86.15
4 Sup. sag. d. of v. body	.78***	.14	.31	−.05	−.30	−.01	82.55
6 Mid. sag. d. of v. body	.52	.31	.67	−.09	−.08	−.06	84.73
5 Inf. sag. d. of v. body	.84***	.29	.15	−.05	−.35*	−.03	93.42
7 Sup. trans. d. of v. b.	.71	−.49	−.27	.00	.03	.16	83.83
9 Mid. trans. d. of v. b.	.57	−.60	−.32	.01	.03	.28	87.26
8 Inf. trans. d. of v. b.	.55	−.61	−.44	.06	−.03	.22	91.37
10 Sagit. d. of v. foramen	.15	.30	−.71	.11	−.02	−.03	62.96
11 Trans. d. of v. foramen	−.08	−.54	−.47	−.08	.02	−.44	71.94
K12 Max. wid. trans. proc.	.13	−.02	.31	.81	.02	.22	82.11
K13 Max. wid. s. art. proc.	.53	−.40	.06	.12	−.27	−.57	85.09
Total contribution (%)	24.85	20.88	15.01	8.61	6.74	5.31	81.39
Cumulative proportion (%)	24.85	45.73	60.74	69.34	76.08	81.39	81.39

[1)] The sample size is 30. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
*P<0.05; **P<0.01; ***P<0.001, by the two-tailed bootstrap test.

Table 15. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the first thoracic vertebra for Japanese females.[1]

Variable[2]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.38	−.21	−.27	−.60	.12	63.12
8 Cranial breadth	.15	.26	.14	.89	−.11	90.79
17 Basi-bregmatic height	.50	.66	.24	.14	.19	79.40
1 Vent. height of v. body	.18	.64	.57	−.20	.07	81.64
3 Cent. height of v. body	−.13	.40	.80	−.15	−.20	88.75
2 Dors. height of v. body	.46	.35	.59	−.07	−.39	84.84
4 Sup. sag. d. of v. body	.12	.62	−.73	.09	.10	93.90
6 Mid. sag. d. of v. body	.27	.72	−.58	−.03	−.20	95.79
5 Inf. sag. d. of v. body	.28	.76	−.53	−.14	−.11	96.63
7 Sup. trans. d. of v. b.	.70	−.45	−.20	.14	−.27	82.78
9 Mid. trans. d. of v. b.	.91***	−.24	.04	.16	.09	92.45
8 Inf. trans. d. of v. b.	.67	−.41	.06	.24	−.40	83.47
10 Sagit. d. of v. foramen	.54	.03	.62	−.07	.48	90.91
11 Trans. d. of v. foramen	.69**	−.08	−.17	.31	.49	85.76
K12 Max. wid. trans. proc.	.77*	.08	−.00	−.34	−.09	72.28
K13 Max. wid. s. art. proc.	.69*	−.29	−.11	−.32	−.10	68.65
Total contribution (%)	27.89	20.19	19.29	10.46	6.63	84.45
Cumulative proportion (%)	27.89	48.08	67.36	77.82	84.45	84.45

[1] The sample size is 18. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 16. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the second thoracic vertebra for Japanese females.[1]

Variable[2]	Factor loadings				Total variance (%)
	PC I	II	III	IV	
1 Cranial length	.41	−.29	−.14	−.61	65.00
8 Cranial breadth	.15	.15	−.00	.94*	92.53
17 Basi-bregmatic height	.55	.61	−.00	.26	74.43
1 Vent. height of v. body	.02	.61	.58	−.33	82.64
3 Cent. height of v. body	.07	.64	.60	−.17	81.25
2 Dors. height of v. body	.47	.43	.68	.03	87.49
4 Sup. sag. d. of v. body	.45	.60	−.58	−.00	90.34
6 Mid. sag. d. of v. body	.52	.60	−.54	−.07	93.37
5 Inf. sag. d. of v. body	.42	.61	−.51	−.33	91.64
7 Sup. trans. d. of v. b.	.66*	−.52	.12	−.15	74.50
9 Mid. trans. d. of v. b.	.89***	−.23	−.21	−.00	89.11
8 Inf. trans. d. of v. b.	.76**	−.39	.04	.30	81.84
10 Sagit. d. of v. foramen	.76***	.04	.28	.01	65.82
11 Trans. d. of v. foramen	.83***	−.01	.15	.36	83.49
K12 Max. wid. trans. proc.	.78***	−.31	.21	−.32	85.86
K13 Max. wid. s. art. proc.	.73**	−.38	.03	−.04	68.48
Total contribution (%)	34.94	20.46	14.28	12.06	81.74
Cumulative proportion (%)	34.94	55.40	69.68	81.74	81.74

[1] The sample size is 18. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 17. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the third thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.47	.15	−.55	.33	−.31	75.13
8 Cranial breadth	−.03	−.48	.47	−.70	−.13	94.76
17 Basi-bregmatic height	.61*	.11	.58	−.19	−.33	87.60
1 Vent. height of v. body	.33	.09	.17	.74	−.36	81.97
3 Cent. height of v. body	.43	.45	.41	.16	.56	89.24
2 Dors. height of v. body	.69**	−.10	.40	.14	.45	86.73
4 Sup. sag. d. of v. body	.50	.68	−.10	−.48	−.04	95.63
6 Mid. sag. d. of v. body	.62	.64	−.10	−.34	−.23	96.97
5 Inf. sag. d. of v. body	.61	.69	−.06	−.20	.03	89.44
7 Sup. trans. d. of v. b.	.74	−.28	−.45	−.04	.14	84.91
9 Mid. trans. d. of v. b.	.64*	−.57	−.36	−.20	.03	89.53
8 Inf. trans. d. of v. b.	.43	−.51	−.43	−.39	.02	78.46
10 Sagit. d. of v. foramen	.55	−.35	.47	.24	−.18	72.93
11 Trans. d. of v. foramen	.57*	−.43	.56	−.04	−.15	85.50
K12 Max. wid. trans. proc.	.76**	.03	−.06	.27	.02	65.28
K13 Max. wid. s. art. proc.	.70*	−.36	−.33	.17	.13	77.56
Total contribution (%)	32.41	18.35	15.08	12.26	6.37	84.48
Cumulative proportion (%)	32.41	50.76	65.84	78.11	84.48	84.48

[1)] The sample size is 18. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
$*P<0.05$; $**P<0.01$; $***P<0.001$, by the two-tailed bootstrap test.

Table 18. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the fourth thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.47	−.51	.14	.36	−.15	65.53
8 Cranial breadth	−.14	.87	−.14	−.12	−.09	81.10
17 Basi-bregmatic height	.51	.43	−.60	−.03	.12	82.28
1 Vent. height of v. body	.30	−.64	−.23	.46	.31	86.26
3 Cent. height of v. body	.39	−.19	−.26	.01	.81**	90.76
2 Dors. height of v. body	.50	.47	−.44	−.16	.26	75.74
4 Sup. sag. d. of v. body	.81	−.21	−.12	−.44	−.18	95.03
6 Mid. sag. d. of v. body	.72	−.36	.02	−.50	−.22	93.54
5 Inf. sag. d. of v. body	.80	−.45	−.19	−.24	−.13	94.76
7 Sup. trans. d. of v. b.	.60	.41	.61	.04	.09	90.86
9 Mid. trans. d. of v. b.	.58	.34	.64	−.04	.11	87.72
8 Inf. trans. d. of v. b.	.41	.60	.52	.21	.08	84.53
10 Sagit. d. of v. foramen	.41	.31	−.71	.30	−.25	92.60
11 Trans. d. of v. foramen	.37	.76	−.22	.20	−.11	81.51
K12 Max. wid. trans. proc.	.50	−.13	−.06	.54	−.40	72.56
K13 Max. wid. s. art. proc.	.75	−.10	.40	.14	.10	75.87
Total contribution (%)	29.92	22.37	15.86	8.58	7.69	84.42
Cumulative proportion (%)	29.92	52.29	68.15	76.73	84.42	84.42

[1)] The sample size is 17. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
$*P<0.05$; $**P<0.01$; $***P<0.001$, by the two-tailed bootstrap test.

Table 19. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the fifth thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.29	.52	−.22	.57	−.10	74.95
8 Cranial breadth	.13	−.66	.55	−.27	.09	83.70
17 Basi-bregmatic height	.65*	.05	.64	.02	.27	89.88
1 Vent. height of v. body	−.11	.48	−.32	.30	.65*	85.58
3 Cent. height of v. body	.64	.16	−.29	−.04	.41	70.10
2 Dors. height of v. body	.63*	.17	−.22	−.22	.41	69.10
4 Sup. sag. d. of v. body	.41	.71	.07	−.46	−.24	95.11
6 Mid. sag. d. of v. body	.62	.42	.26	−.33	−.01	73.56
5 Inf. sag. d. of v. body	.40	.70	.11	−.28	−.20	77.85
7 Sup. trans. d. of v. b.	.66*	−.23	−.48	−.34	−.19	87.27
9 Mid. trans. d. of v. b.	.73**	−.21	−.44	−.01	−.13	78.12
8 Inf. trans. d. of v. b.	.59	−.63	−.36	.07	−.12	89.06
10 Sagit. d. of v. foramen	.48	.22	.69	.39	−.00	89.93
11 Trans. d. of v. foramen	.54	−.63	.21	−.04	.31	83.66
K12 Max. wid. trans. proc.	.61*	.03	.11	.50	−.36	75.93
K13 Max. wid. s. art. proc.	.82**	−.23	−.02	.35	−.10	86.13
Total contribution (%)	30.85	19.76	13.55	9.90	7.82	81.87
Cumulative proportion (%)	30.85	50.61	64.16	74.05	81.87	81.87

[1)] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 20. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the sixth thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.39	−.29	−.01	.67	.28	76.22
8 Cranial breadth	−.14	.78	.11	−.34	−.24	82.04
17 Basi-bregmatic height	.52	.59	.50	.05	.11	88.19
1 Vent. height of v. body	.32	−.50	.19	−.49	.07	63.88
3 Cent. height of v. body	.43	−.05	.50	−.49	.07	68.58
2 Dors. height of v. body	.20	.03	.62	−.26	.59	84.03
4 Sup. sag. d. of v. body	.85**	−.40	.16	−.11	−.18	94.74
6 Mid. sag. d. of v. body	.78*	−.46	.11	.00	−.35	94.42
5 Inf. sag. d. of v. body	.73*	−.56	.12	−.01	−.30	94.67
7 Sup. trans. d. of v. b.	.79***	.07	−.49	−.28	.04	96.18
9 Mid. trans. d. of v. b.	.63**	.14	−.67	−.23	.06	92.69
8 Inf. trans. d. of v. b.	.65**	.30	−.41	−.25	.32	84.47
10 Sagit. d. of v. foramen	.40	.54	.52	.31	−.33	91.88
11 Trans. d. of v. foramen	.27	.86	−.13	−.18	−.22	90.38
K12 Max. wid. trans. proc.	.63	.19	−.06	.66	.05	86.61
K13 Max. wid. s. art. proc.	.76*	.36	−.01	.32	.19	85.06
Total contribution (%)	32.97	20.58	13.28	12.47	6.58	85.88
Cumulative proportion (%)	32.97	53.55	66.83	79.30	85.88	85.88

[1)] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 21. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the seventh thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.35	−.21	−.44	.46	.46	77.43
8 Cranial breadth	−.11	.81	.16	−.26	−.22	80.42
17 Basi-bregmatic height	.51*	.63	−.26	.23	−.39	92.95
1 Vent. height of v. body	.05	−.39	.39	.34	.42	59.08
3 Cent. height of v. body	.43	−.08	.36	.65	−.34	85.59
2 Dors. height of v. body	.55*	.04	.18	.50	−.38	72.22
4 Sup. sag. d. of v. body	.79**	−.45	−.21	−.15	−.15	90.55
6 Mid. sag. d. of v. body	.75**	−.43	−.38	−.13	−.08	92.11
5 Inf. sag. d. of v. body	.73**	−.44	−.34	−.20	−.24	94.41
7 Sup. trans. d. of v. b.	.71**	.13	.53	−.31	−.00	89.43
9 Mid. trans. d. of v. b.	.77***	.05	.43	−.38	.19	95.32
8 Inf. trans. d. of v. b.	.79**	−.14	.40	−.13	.06	82.66
10 Sagit. d. of v. foramen	.28	.58	−.62	.01	−.12	81.88
11 Trans. d. of v. foramen	.42	.75	.12	−.06	.20	80.64
K12 Max. wid. trans. proc.	.50	.28	−.41	−.12	.56	83.15
K13 Max. wid. s. art. proc.	.44	.53	.11	.44	.39	83.34
Total contribution (%)	31.34	19.61	13.14	10.38	9.35	83.82
Cumulative proportion (%)	31.34	50.96	64.10	74.47	83.82	83.82

[1)] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 22. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the eighth thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.61*	−.39	.01	.18	.43	74.71
8 Cranial breadth	−.18	.76	.28	−.35	−.21	86.10
17 Basi-bregmatic height	.44	.49	.37	−.45	.26	83.98
1 Vent. height of v. body	.33	−.38	.64	−.10	−.29	76.39
3 Cent. height of v. body	.22	−.27	.70	.03	.42	78.23
2 Dors. height of v. body	.14	−.24	.67	−.30	−.01	60.93
4 Sup. sag. d. of v. body	.77***	−.34	−.29	−.39	−.04	94.58
6 Mid. sag. d. of v. body	.81**	−.34	−.33	−.28	.05	96.67
5 Inf. sag. d. of v. body	.77***	−.30	−.27	−.44	−.08	94.80
7 Sup. trans. d. of v. b.	.77**	.29	−.09	.11	−.32	80.45
9 Mid. trans. d. of v. b.	.81***	.31	.04	.22	−.40	95.78
8 Inf. trans. d. of v. b.	.74*	.08	.37	.37	−.24	88.46
10 Sagit. d. of v. foramen	.38	.66	−.08	−.43	.35	90.04
11 Trans. d. of v. foramen	.17	.94	−.04	.05	.10	91.92
K12 Max. wid. trans. proc.	.53*	.18	−.42	.43	.26	75.46
K13 Max. wid. s. art. proc.	.51	.20	.31	.65	.20	85.88
Total contribution (%)	32.07	19.66	14.11	11.74	7.07	84.65
Cumulative proportion (%)	32.07	51.73	65.83	77.57	84.65	84.65

[1)] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 23. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the ninth thoracic vertebra for Japanese females.[1]

Variable[2]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.39	−.26	.22	−.40	.63	83.03
8 Cranial breadth	−.21	.68	−.02	.62	−.05	89.02
17 Basi-bregmatic height	.24	.57	.38	.29	.37	74.99
1 Vent. height of v. body	.30	−.43	−.28	.47	.57*	90.53
3 Cent. height of v. body	.71*	−.05	−.49	−.09	.00	74.76
2 Dors. height of v. body	.68**	−.21	−.36	.31	−.07	73.27
4 Sup. sag. d. of v. body	.68*	−.32	.60	.15	−.10	95.13
6 Mid. sag. d. of v. body	.65*	−.53	.50	.08	−.09	96.41
5 Inf. sag. d. of v. body	.69**	−.35	.53	.13	−.24	96.38
7 Sup. trans. d. of v. b.	.88***	.09	−.23	.18	−.10	86.69
9 Mid. trans. d. of v. b.	.85***	.29	−.14	−.07	−.13	84.60
8 Inf. trans. d. of v. b.	.87***	.17	−.35	−.04	−.01	89.94
10 Sagit. d. of v. foramen	.06	.69	.52	.09	.34	86.58
11 Trans. d. of v. foramen	.32	.86	−.05	.03	−.18	88.77
K12 Max. wid. trans. proc.	.45	.52	.46	−.43	−.11	88.16
K13 Max. wid. s. art. proc.	.53	.37	−.42	−.37	.23	78.08
Total contribution (%)	34.31	20.82	14.86	8.63	7.40	86.02
Cumulative proportion (%)	34.31	55.13	69.99	78.62	86.02	86.02

[1] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 24. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the tenth thoracic vertebra for Japanese females.[1]

Variable[2]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.33	−.41	.24	.60	.44	88.40
8 Cranial breadth	−.09	.69	.28	−.49	−.11	81.66
17 Basi-bregmatic height	.55***	.41	.22	−.15	.15	56.03
1 Vent. height of v. body	.64*	−.12	−.59	−.18	.21	85.94
3 Cent. height of v. body	.64***	.17	−.52	.29	−.08	80.01
2 Dors. height of v. body	.76***	.34	−.34	.24	.11	87.45
4 Sup. sag. d. of v. body	.67*	−.58	.13	−.37	−.07	94.97
6 Mid. sag. d. of v. body	.70*	−.62	.10	−.25	−.06	94.16
5 Inf. sag. d. of v. body	.65*	−.61	.12	−.30	−.02	90.43
7 Sup. trans. d. of v. b.	.80***	.18	.06	.10	−.16	71.76
9 Mid. trans. d. of v. b.	.88***	.18	.08	.09	−.32	92.53
8 Inf. trans. d. of v. b.	.79***	.02	.11	.33	−.32	85.41
10 Sagit. d. of v. foramen	.40	.52	.02	−.15	.63	84.93
11 Trans. d. of v. foramen	.39	.71	.42	.14	−.18	89.21
K12 Max. wid. trans. proc.	.33	−.19	.80	.13	.23	86.14
K13 Max. wid. s. art. proc.	.66*	.25	−.13	−.38	.16	68.84
Total contribution (%)	38.11	18.81	11.42	8.83	6.45	83.62
Cumulative proportion (%)	38.11	56.92	68.34	77.16	83.62	83.62

[1] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 25. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the eleventh thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.38	−.46	.05	−.45	.36	68.15
8 Cranial breadth	−.22	.51	.57	.31	−.40	89.22
17 Basi-bregmatic height	.38*	.35	.48	.32	.08	60.91
1 Vent. height of v. body	.69**	.23	−.38	.34	.10	79.72
3 Cent. height of v. body	.48	.59	−.45	.02	.12	79.52
2 Dors. height of v. body	.53*	.11	−.66	.17	−.33	85.85
4 Sup. sag. d. of v. body	.75**	−.52	.03	.38	.05	97.41
6 Mid. sag. d. of v. body	.69*	−.63	.01	.27	−.02	94.37
5 Inf. sag. d. of v. body	.63**	−.56	.30	.38	.06	95.35
7 Sup. trans. d. of v. b.	.89***	.06	−.15	−.24	−.13	88.59
9 Mid. trans. d. of v. b.	.82***	.06	−.07	−.33	−.28	87.65
8 Inf. trans. d. of v. b.	.88***	.06	−.10	−.24	−.22	90.43
10 Sagit. d. of v. foramen	.51*	.51	.07	.12	.54	83.20
11 Trans. d. of v. foramen	.59**	.66	.19	−.01	.16	83.79
K12 Max. wid. trans. proc.	.58*	.03	.60	−.16	−.29	81.38
K13 Max. wid. s. art. proc.	.60*	.01	.53	−.34	.14	77.47
Total contribution (%)	39.49	16.71	13.45	8.03	6.26	83.94
Cumulative proportion (%)	39.49	56.20	69.66	77.68	83.94	83.94

[1)] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 26. Principal component analysis of the correlation matrix on the measurements of the neurocranium and the twelfth thoracic vertebra for Japanese females.[1)]

Variable[2)]	Factor loadings					Total variance (%)
	PC I	II	III	IV	V	
1 Cranial length	.41*	−.38	−.36	−.25	.49	74.71
8 Cranial breadth	−.22	.55	.60	−.16	−.10	75.25
17 Basi-bregmatic height	.38*	.42	.35	−.60	.16	82.79
1 Vent. height of v. body	.64	.31	−.35	.24	.11	69.74
3 Cent. height of v. body	.24	.79	−.21	−.08	−.26	80.68
2 Dors. height of v. body	.38	.65	−.43	.01	−.35	88.57
4 Sup. sag. d. of v. body	.76***	−.41	−.01	−.41	−.14	92.42
6 Mid. sag. d. of v. body	.77***	−.42	.18	−.25	−.17	90.05
5 Inf. sag. d. of v. body	.79***	−.26	.06	−.39	−.28	92.69
7 Sup. trans. d. of v. b.	.80***	−.23	−.13	.27	−.09	78.43
9 Mid. trans. d. of v. b.	.77**	−.06	.35	.24	.20	82.67
8 Inf. trans. d. of v. b.	.84***	.07	−.23	.12	.17	81.44
10 Sagit. d. of v. foramen	.55	.54	.12	.06	.38	76.27
11 Trans. d. of v. foramen	.69*	.57	.11	.06	.11	82.48
K12 Max. wid. trans. proc.	.36	−.11	.61	.46	−.02	72.64
K13 Max. wid. s. art. proc.	.63*	−.27	.09	.36	−.33	72.03
Total contribution (%)	37.69	18.50	10.06	8.66	5.89	80.80
Cumulative proportion (%)	37.69	56.19	66.25	74.91	80.80	80.80

[1)] The sample size is 19. The number of the principal components shown here was so determined that the cumulative proportion of the variances of the principal components exceeded 80%.
[2)] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 27. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the first thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	−.05	.23	−.21	.02	−.15	.71
8 Cranial breadth	.11	−.22	.08	.38	−.47	.57
17 Basi-bregmatic height	.09	.17	−.46*	.05	.40	.63*
1 Vent. height of v. body	.84***	.06	−.11	−.20	−.11	.20
3 Cent. height of v. body	.93***	.04	−.06	−.04	−.07	−.11
2 Dors. height of v. body	.92***	.03	.04	.09	.04	−.03
4 Sup. sag. d. of v. body	.10	.90	−.03	.08	−.03	.17
6 Mid. sag. d. of v. body	.03	.95	.06	.00	−.11	.08
5 Inf. sag. d. of v. body	−.02	.94*	−.07	.13	.10	−.02
7 Sup. trans. d. of v. b.	−.30	−.06	−.01	.85	−.02	−.03
9 Mid. trans. d. of v. b.	.02	.11	−.42	.52	−.41	.27
8 Inf. trans. d. of v. b.	.13	.28	−.04	.81*	−.04	.09
10 Sagit. d. of v. foramen	.40	−.22	−.56	−.01	−.30	.26
11 Trans. d. of v. foramen	−.08	−.03	−.92***	.05	−.02	.13
K12 Max. wid. trans. proc.	.17	.23	−.66**	.06	−.50	.10
K13 Max. wid. s. art. proc.	.06	.05	−.19	.06	−.90*	.05

1) The sample size is 30. The cumulative proportion of the variances of the six principal components is 80.84%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 28. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the second thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	.43	−.49*	−.10	.29	−.08	−.06
8 Cranial breadth	.20	.09	−.13	.02	.82	.16
17 Basi-bregmatic height	.33	−.66**	.09	.09	.16	−.05
1 Vent. height of v. body	.23	−.24	.79	−.23	−.09	.21
3 Cent. height of v. body	−.04	.13	.87*	.01	−.07	−.12
2 Dors. height of v. body	.06	.38	.62	.09	.05	.47
4 Sup. sag. d. of v. body	.84	.04	.07	.31	.09	.08
6 Mid. sag. d. of v. body	.93	.01	−.01	.14	−.00	−.02
5 Inf. sag. d. of v. body	.91*	−.27	.15	.00	.07	.01
7 Sup. trans. d. of v. b.	.10	−.33	−.22	.79*	−.04	.13
9 Mid. trans. d. of v. b.	.20	.00	−.17	.91*	.08	.09
8 Inf. trans. d. of v. b.	.21	.01	.32	.78	.15	−.17
10 Sagit. d. of v. foramen	.02	−.21	.08	.04	.16	.89**
11 Trans. d. of v. foramen	−.09	−.80	−.23	−.04	.03	.35
K12 Max. wid. trans. proc.	−.01	−.63	.10	.32	.52*	.14
K13 Max. wid. s. art. proc.	−.13	−.49	−.01	.08	.79***	−.00

1) The sample size is 29. The cumulative proportion of the variances of the six principal components is 80.11%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 29. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the third thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	.35	.12	−.20	−.08	.01	.64
8 Cranial breadth	.12	.08	−.02	−.01	.92*	.09
17 Basi-bregmatic height	.14	.09	.09	−.18	.12	.85*
1 Vent. height of v. body	.31	−.10	.78*	−.35	−.11	−.00
3 Cent. height of v. body	.29	−.14	.85	.04	−.03	−.16
2 Dors. height of v. body	.12	.13	.91*	.16	.05	.04
4 Sup. sag. d. of v. body	.89	−.01	.26	−.06	.01	.25
6 Mid. sag. d. of v. body	.92*	.21	.10	.07	.05	.03
5 Inf. sag. d. of v. body	.80	.13	.37	−.10	.17	.29
7 Sup. trans. d. of v. b.	−.12	.70	.04	.38	−.29	.27
9 Mid. trans. d. of v. b.	.16	.76	.03	−.17	−.10	.30
8 Inf. trans. d. of v. b.	.11	.88	−.17	.15	.13	−.04
10 Sagit. d. of v. foramen	−.28	.18	.50	−.42	.35	.28
11 Trans. d. of v. foramen	.02	.08	−.03	−.91*	.00	.29
K12 Max. wid. trans. proc.	.12	.71	.14	−.49	.12	−.11
K13 Max. wid. s. art. proc.	.09	.73	.01	−.24	.40	.04

[1)] The sample size is 29. The cumulative proportion of the variances of the six principal components is 82.69%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 30. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the fourth thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	−.14	.40	.02	−.25	.11	.60
8 Cranial breadth	.04	.02	.02	−.10	.96*	.11
17 Basi-bregmatic height	.14	.16	.04	−.15	.05	.81
1 Vent. height of v. body	.88	−.11	.06	−.25	−.03	.06
3 Cent. height of v. body	.92*	.01	−.00	−.18	−.01	−.03
2 Dors. height of v. body	.90	−.09	.16	−.17	.10	.12
4 Sup. sag. d. of v. body	.28	.24	.02	−.88***	.11	.17
6 Mid. sag. d. of v. body	.15	.19	.18	−.92***	.09	.06
5 Inf. sag. d. of v. body	.34	.09	.12	−.83***	−.05	.31
7 Sup. trans. d. of v. b.	−.09	.85	−.03	−.10	.02	.12
9 Mid. trans. d. of v. b.	−.10	.75	.20	−.14	−.08	.24
8 Inf. trans. d. of v. b.	.10	.83	.24	−.32	.15	.06
10 Sagit. d. of v. foramen	.21	−.46	.42	−.28	.23	.37
11 Trans. d. of v. foramen	.22	−.19	.74	−.13	−.26	.35
K12 Max. wid. trans. proc.	.37	.33	.78	.02	.14	−.00
K13 Max. wid. s. art. proc.	−.22	.26	.83	−.19	.07	−.13

[1)] The sample size is 30. The cumulative proportion of the variances of the six principal components is 83.61%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 31. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the fifth thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	−.22	.42	−.48*	−.01	.10	.28
8 Cranial breadth	.03	.09	−.03	.03	.96*	.10
17 Basi-bregmatic height	.04	.27	−.28	−.23	.09	.77**
1 Vent. height of v. body	.81*	.15	−.15	.13	−.06	.17
3 Cent. height of v. body	.90	−.06	−.15	−.06	.03	−.10
2 Dors. height of v. body	.89*	.07	−.27	.13	.08	−.11
4 Sup. sag. d. of v. body	.30	.12	−.89***	.14	.01	.13
6 Mid. sag. d. of v. body	.23	.22	−.87***	.13	−.03	.08
5 Inf. sag. d. of v. body	.31	.06	−.85***	.16	.07	.24
7 Sup. trans. d. of v. b.	.12	.85	−.27	−.11	.10	.02
9 Mid. trans. d. of v. b.	−.08	.87	−.04	.10	−.04	.19
8 Inf. trans. d. of v. b.	.25	.84	−.14	.18	.04	−.08
10 Sagit. d. of v. foramen	.09	−.43	−.08	.62	.39	.22
11 Trans. d. of v. foramen	−.09	−.12	−.17	.42	.08	.78**
K12 Max. wid. trans. proc.	.39	.18	−.14	.80	−.14	.08
K13 Max. wid. s. art. proc.	−.22	.37	−.40	.65	.10	−.14

[1)] The sample size is 30. The cumulative proportion of the variances of the six principal components is 83.26%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 32. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the sixth thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	−.05	−.06	.23	.09	.08	.88**
8 Cranial breadth	.06	−.02	.12	.94*	.07	.09
17 Basi-bregmatic height	−.09	.20	.14	.29	.71*	.31
1 Vent. height of v. body	−.04	.78	.12	−.01	.25	.19
3 Cent. height of v. body	−.06	.89	.00	−.09	−.04	−.25
2 Dors. height of v. body	.13	.89*	.04	.11	−.22	.11
4 Sup. sag. d. of v. body	.42	.53*	.27	.08	.23	.54**
6 Mid. sag. d. of v. body	.35	.54**	.24	.11	.26	.53**
5 Inf. sag. d. of v. body	.54	.40	.27	.10	.20	.55**
7 Sup. trans. d. of v. b.	−.08	.21	.85	.08	−.08	.24
9 Mid. trans. d. of v. b.	.15	−.11	.86	.04	.17	.20
8 Inf. trans. d. of v. b.	−.04	.14	.94*	.02	.05	.05
10 Sagit. d. of v. foramen	.72**	.12	−.33	.41	−.03	.04
11 Trans. d. of v. foramen	.44	−.15	−.00	−.13	.80*	−.01
K12 Max. wid. trans. proc.	.81***	.11	.06	−.00	.16	−.08
K13 Max. wid. s. art. proc.	.69**	−.32	.09	−.15	.01	.43

[1)] The sample size is 29. The cumulative proportion of the variances of the six principal components is 83.54%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 33. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the seventh thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	.22	−.12	.28	−.05	.03	−.77*
8 Cranial breadth	.14	−.21	.11	−.03	−.85	−.21
17 Basi-bregmatic height	.04	.17	.10	.30	−.20	−.70*
1 Vent. height of v. body	−.08	.83	.22	−.13	.20	.12
3 Cent. height of v. body	.00	.90	−.07	.08	−.04	−.16
2 Dors. height of v. body	.38	.85	.03	−.04	−.03	−.03
4 Sup. sag. d. of v. body	.71	.28	.35	.19	−.25	−.29
6 Mid. sag. d. of v. body	.65	.28	.28	.16	−.20	−.44
5 Inf. sag. d. of v. body	.72	.19	.35	.17	−.21	−.41
7 Sup. trans. d. of v. b.	.17	.18	.88	−.00	−.17	−.18
9 Mid. trans. d. of v. b.	−.01	−.18	.89	.18	.10	−.16
8 Inf. trans. d. of v. b.	.16	.13	.88	.03	−.05	−.12
10 Sagit. d. of v. foramen	.27	.23	−.07	.53	−.55	.14
11 Trans. d. of v. foramen	.09	−.07	.13	.90*	−.04	−.16
K12 Max. wid. trans. proc.	.84*	−.02	−.07	.02	−.07	.08
K13 Max. wid. s. art. proc.	.56	−.21	.18	.54	.20	−.23

[1)] The sample size is 29. The cumulative proportion of the variances of the six principal components is 82.06%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 34. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the eighth thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	.54*	−.09	.52	−.03	−.20	.38
8 Cranial breadth	.14	−.15	.15	.02	.72	.25
17 Basi-bregmatic height	.21	.09	.25	−.15	.35	.65
1 Vent. height of v. body	.12	.84	−.12	−.06	−.20	−.03
3 Cent. height of v. body	−.10	.89	.02	.04	.02	−.01
2 Dors. height of v. body	.10	.93	.12	−.03	.10	.15
4 Sup. sag. d. of v. body	.24	.02	.93***	.15	.11	.12
6 Mid. sag. d. of v. body	.11	.01	.95***	−.02	.18	.08
5 Inf. sag. d. of v. body	.17	.01	.92***	.15	.13	.19
7 Sup. trans. d. of v. b.	.91**	.12	.19	.03	.07	.09
9 Mid. trans. d. of v. b.	.91*	−.04	.07	.01	−.07	.14
8 Inf. trans. d. of v. b.	.85**	.09	.27	.15	.19	−.21
10 Sagit. d. of v. foramen	−.08	.09	.24	.46	.06	.71
11 Trans. d. of v. foramen	−.06	.06	.12	.23	.86*	−.01
K12 Max. wid. trans. proc.	−.12	−.09	10	.91*	.21	−.01
K13 Max. wid. s. art. proc.	.38	.02	.07	.76	.03	.11

[1)] The sample size is 29. The cumulative proportion of the variances of the six principal components is 83.43%.
[2)] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 35. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the ninth thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	.39	−.16	.29	.15	−.16	.53
8 Cranial breadth	.20	−.00	.17	−.05	.81	−.03
17 Basi-bregmatic height	.24	.11	.10	−.01	.14	.85*
1 Vent. height of v. body	−.22	.82	.06	.16	−.11	−.19
3 Cent. height of v. body	.06	.90	−.18	−.06	.06	.09
2 Dors. height of v. body	.14	.91	−.13	−.09	.06	.12
4 Sup. sag. d. of v. body	.94*	.02	.16	.13	.12	.12
6 Mid. sag. d. of v. body	.87	−.08	.12	−.10	.24	.26
5 Inf. sag. d. of v. body	.93*	.07	.09	.20	.01	.12
7 Sup. trans. d. of v. b.	.28	.11	.90	.05	.12	.12
9 Mid. trans. d. of v. b.	.02	−.24	.90	.19	.03	.15
8 Inf. trans. d. of v. b.	.10	.13	.93	.04	.13	.04
10 Sagit. d. of v. foramen	.35	.31	.25	.46	.33	.28
11 Trans. d. of v. foramen	.06	−.01	.07	.45	.61	.42
K12 Max. wid. trans. proc.	.07	.04	−.01	.82	.16	−.01
K13 Max. wid. s. art. proc.	.12	−.14	.30	.72	−.33	.06

1) The sample size is 27. The cumulative proportion of the variances of the six principal components is 82.43%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 36. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the tenth thoracic vertebra in Japanese males.[1)]

Variable[2)]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	−.16	.37	−.06	−.68*	.07	.25
8 Cranial breadth	−.07	.18	.14	−.12	.16	.78*
17 Basi-bregmatic height	−.02	.17	.60	−.39	−.20	.19
1 Vent. height of v. body	.85	−.03	.14	−.37	.02	.09
3 Cent. height of v. body	.93	−.02	.03	−.14	−.06	−.03
2 Dors. height of v. body	.94*	.05	.06	−.13	−.11	−.06
4 Sup. sag. d. of v. body	.30	.20	.17	−.83***	.04	.05
6 Mid. sag. d. of v. body	.30	.17	.13	−.86***	.03	−.15
5 Inf. sag. d. of v. body	.33	.07	.08	−.86***	.23	−.06
7 Sup. trans. d. of v. b.	.14	.90*	.15	−.24	−.04	.12
9 Mid. trans. d. of v. b.	−.17	.92	.07	−.12	.18	.04
8 Inf. trans. d. of v. b.	.07	.91	−.07	−.17	.04	−.03
10 Sagit. d. of v. foramen	.24	.02	.63	.03	.12	.58*
11 Trans. d. of v. foramen	.09	−.01	.90*	−.06	.09	−.04
K12 Max. wid. trans. proc.	−.13	.08	.01	−.13	.91*	.14
K13 Max. wid. s. art. proc.	.01	.22	.11	−.23	.49	−.58

1) The sample size is 28. The cumulative proportion of the variances of the six principal components is 83.27%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 37. Solution obtained through the normal varimax rotation of the first seven principal components for the correlation matrix on the measurements of the neurocranium and the eleventh thoracic vertebra in Japanese males.[1]

Variable[2]	Factor loadings						
	Fac I	II	III	IV	V	VI	VII
1 Cranial length	.03	.30	−.02	.04	.84**	−.15	.00
8 Cranial breadth	.17	.07	−.08	.88	.10	.17	.03
17 Basi-bregmatic height	.18	.04	.11	.14	.69	.04	.15
1 Vent. height of v. body	.85	−.07	.16	−.02	.13	.06	.37*
3 Cent. height of v. body	.94*	−.09	.11	.04	.12	−.09	.02
2 Dors. height of v. body	.78**	.40	.23	.11	.09	−.03	.11
4 Sup. sag. d. of v. body	.16	.02	.94	.07	.15	.01	.13
6 Mid. sag. d. of v. body	.26	.16	.64	−.09	.50*	.18	−.05
5 Inf. sag. d. of v. body	.14	−.11	.92	.02	−.10	.04	−.09
7 Sup. trans. d. of v. b.	.07	.95*	−.03	.06	.14	.10	.06
9 Mid. trans. d. of v. b.	−.04	.90	.07	.15	.16	.05	.04
8 Inf. trans. d. of v. b.	.04	.90	−.10	.05	.12	.03	−.10
10 Sagit. d. of v. foramen	.30	.03	−.02	.08	.14	−.02	.92*
11 Trans. d. of v. foramen	.09	.55*	.18	.14	−.07	−.56*	.27
K12 Max. wid. trans. proc.	−.12	.26	.21	.69	.08	−.36	.09
K13 Max. wid. s. art. proc.	−.06	.37	.30	.06	−.12	.77**	.09

[1] The sample size is 30. The cumulative proportion of the variances of the six principal components is 84.76%.
[2] See the second footnote to Table 1.
*P<0.05; **P<0.01; ***P<0.001, by the two-tailed bootstrap test.

Table 38. Solution obtained through the normal varimax rotation of the first six principal components for the correlation matrix on the measurements of the neurocranium and the twelfth thoracic vertebra in Japanese males.[1]

Variable[2]	Factor loadings					
	Fac I	II	III	IV	V	VI
1 Cranial length	.22	−.01	.36	−.03	.70*	.20
8 Cranial breadth	.07	−.03	−.02	.85	.27	−.22
17 Basi-bregmatic height	.09	.02	.09	.03	.82	−.12
1 Vent. height of v. body	.07	.84	.24	−.04	.09	.05
3 Cent. height of v. body	−.22	.89	.11	.01	−.06	.11
2 Dors. height of v. body	−.09	.90	.13	.02	.14	.08
4 Sup. sag. d. of v. body	.21	.10	.87	.05	.11	−.05
6 Mid. sag. d. of v. body	−.22	−.05	.82*	.14	.31	.09
5 Inf. sag. d. of v. body	.22	.31	.88*	−.01	.06	−.07
7 Sup. trans. d. of v. b.	.86	.03	.20	.06	.18	−.16
9 Mid. trans. d. of v. b.	.92*	−.07	.05	.04	.11	−.08
8 Inf. trans. d. of v. b.	.94	.00	−.01	.03	.01	−.17
10 Sagit. d. of v. foramen	.21	.71	−.18	−.11	−.18	−.09
11 Trans. d. of v. foramen	.31	−.08	−.42	−.15	−.01	−.65*
K12 Max. wid. trans. proc.	.06	−.06	.16	.82	−.25	.21
K13 Max. wid. s. art. proc.	.29	−.12	.42	.15	.01	−.75*

[1] The sample size is 30. The cumulative proportion of the variances of the six principal components is 81.39%.
[2] See the second footnote to Table 1.
*P<0.05; **P<0.01; ***P<0.001, by the two-tailed bootstrap test.

Table 39. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the first thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.26	.11	−.11	−.72	.12
8 Cranial breadth	.18	.13	.10	.90	.20
17 Basi-bregmatic height	.05	.42	.58	.18	.50
1 Vent. height of v. body	−.20	.14	.85	−.01	.20
3 Cent. height of v. body	−.24	−.23	.86	.11	−.16
2 Dors. height of v. body	.36	.03	.84	.09	−.03
4 Sup. sag. d. of v. body	−.13	.93	−.22	.05	.12
6 Mid. sag. d. of v. body	.06	.97	*	.07	.01
−.06					
5 Inf. sag. d. of v. body	.00	.97	.14	−.09	.01
7 Sup. trans. d. of v. b.	.88	−.01	−.20	−.04	.11
9 Mid. trans. d. of v. b.	.78	.01	.06	−.04	.55
8 Inf. trans. d. of v. b.	.89	−.14	.01	.12	.04
10 Sagit. d. of v. foramen	.13	−.30	.51	−.13	.72
11 Trans. d. of v. foramen	.40	.16	−.18	.06	.80
K12 Max. wid. trans. proc.	.58	.25	.32	−.40	.24
K13 Max. wid. s. art. proc.	.67	.04	.02	−.46	.17

[1)] The sample size is 18. The cumulative proportion of the variances of the six principal components is 84.45%.
[2)] See the second footnote to Table 1.

Table 40. Solution obtained through the normal varimax rotation of the first four principal components for the correlation matrix on the measurements of the neurocranium and the second thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings			
	Fac I	II	III	IV
1 Cranial length	.45	.14	−.10	−.65
8 Cranial breadth	.10	.07	−.07	.95*
17 Basi-bregmatic height	.24	.60	.41	.40
1 Vent. height of v. body	.16	.07	.88	−.16
3 Cent. height of v. body	.13	.09	.89	.0
2 Dors. height of v. body	.34	.04	.85	.19
4 Sup. sag. d. of v. body	.06	.94	−.00	.09
6 Mid. sag. d. of v. body	.12	.96	.05	.03
5 Inf. sag. d. of v. body	.03	.92	.11	−.22
7 Sup. trans. d. of v. b.	.83	−.12	−.08	−.21
9 Mid. trans. d. of v. b.	.86**	.36	−.15	−.02
8 Inf. trans. d. of v. b.	.86*	.01	−.14	.26
10 Sagit. d. of v. foramen	.70*	.16	.36	.07
11 Trans. d. of v. foramen	.78*	.21	.18	.40
K12 Max. wid. trans. proc.	.85*	.03	.16	−.32
K13 Max. wid. s. art. proc.	.82*	.05	−.08	−.07

[1)] The sample size is 18. The cumulative proportion of the variances of the six principal components is 81.74%.
[2)] See the second footnote to Table 1.
$*P<0.05$; $**P<0.01$; $***P<0.001$, by the two-tailed bootstrap test.

Table 41. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the third thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.41	.29	−.08	.68	−.18
8 Cranial breadth	.07	−.06	.51	−.80	−.21
17 Basi-bregmatic height	−.03	.47	.80**	−.03	.10
1 Vent. height of v. body	−.11	−.06	.41	.80	.07
3 Cent. height of v. body	−.14	.31	.12	.08	.87
2 Dors. height of v. body	.30	.07	.46	.03	.75
4 Sup. sag. d. of v. body	.07	.97*	−.05	−.07	.10
6 Mid. sag. d. of v. body	.11	.96	.11	.12	.02
5 Inf. sag. d. of v. body	.07	.88	.01	.16	.28
7 Sup. trans. d. of v. b.	.87*	.18	.06	.17	.14
9 Mid. trans. d. of v. b.	.92	.01	.21	−.05	−.04
8 Inf. trans. d. of v. b.	.83	.05	.04	−.23	−.18
10 Sagit. d. of v. foramen	.19	−.11	.78	.19	.19
11 Trans. d. of v. foramen	.25	−.05	.87*	−.09	.17
K12 Max. wid. trans. proc.	.44	.27	.31	.44	.32
K13 Max. wid. s. art. proc.	.79	.00	.17	.29	.20

1) The sample size is 18. The cumulative proportion of the variances of the six principal components is 84.48%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 42. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the fourth thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.28	−.17	.12	.72	.11
8 Cranial breadth	−.29	.57	.18	−.50	−.33
17 Basi-bregmatic height	.21	.85	.03	−.04	.22
1 Vent. height of v. body	.08	−.09	−.20	.66	.61
3 Cent. height of v. body	.14	.16	.05	.01	.93***
2 Dors. height of v. body	.23	.74	.16	−.20	.30
4 Sup. sag. d. of v. body	.93*	.20	.15	.12	.07
6 Mid. sag. d. of v. body	.95	−.02	.13	.11	.02
5 Inf. sag. d. of v. body	.87	.12	.02	.36	.21
7 Sup. trans. d. of v. b.	.14	.09	.94*	.03	−.01
9 Mid. trans. d. of v. b.	.19	.00	.92	−.02	.00
8 Inf. trans. d. of v. b.	−.15	.22	.88*	.01	−.09
10 Sagit. d. of v. foramen	.09	.88	−.18	.34	−.06
11 Trans. d. of v. foramen	−.12	.80	.37	−.01	−.17
K12 Max. wid. trans. proc.	.13	.25	.14	.77	−.16
K13 Max. wid. s. art. proc.	.37	−.03	.65	.39	.21

1) The sample size is 17. The cumulative proportion of the variances of the six principal components is 84.42%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 43. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the fifth thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.11	.74*	.40	−.10	.16
8 Cranial breadth	.06	−.87**	.19	.14	−.16
17 Basi-bregmatic height	.02	−.43	.73	−.32	.29
1 Vent. height of v. body	−.29	.46	−.06	.12	.73*
3 Cent. height of v. body	.43	.05	.13	−.24	.67
2 Dors. height of v. body	.38	−.07	.05	−.35	.64
4 Sup. sag. d. of v. body	.03	.16	.02	−.96***	.04
6 Mid. sag. d. of v. body	.13	−.12	.30	−.76**	.20
5 Inf. sag. d. of v. body	−.01	.22	.15	−.84***	.07
7 Sup. trans. d. of v. b.	.87	−.09	−.16	−.28	.09
9 Mid. trans. d. of v. b.	.86	.05	.09	−.12	.15
8 Inf. trans. d. of v. b.	.89	−.18	.09	.24	.01
10 Sagit. d. of v. foramen	−.14	−.07	.91	−.22	.02
11 Trans. d. of v. foramen	.45	−.65	.33	.20	.24
K12 Max. wid. trans. proc.	.43	.26	.69	−.07	−.16
K13 Max. wid. s. art. proc.	.69*	−.00	.61	.00	.10

1) The sample size is 19. The cumulative proportion of the variances of the six principal components is 81.87%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 44. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the sixth thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings				
	FacI	II	III	IV	V
1 Cranial length	.17	−.12	.00	.85*	.00
8 Cranial breadth	−.34	.65	−.11	−.52	.00
17 Basi-bregmatic height	.05	.78	−.14	.21	.46
1 Vent. height of v. body	.57	−.30	−.10	−.21	.41
3 Cent. height of v. body	.45	.20	−.09	−.23	.62
2 Dors. height of v. body	.01	.08	.05	.07	.91
4 Sup. sag. d. of v. body	.89*	.07	−.26	.20	.19
6 Mid. sag. d. of v. body	.93*	.06	−.16	.21	−.02
5 Inf. sag. d. of v. body	.94*	−.05	−.11	.22	.02
7 Sup. trans. d. of v. b.	.38	.06	−.90***	.07	−.01
9 Mid. trans. d. of v. b.	.18	−.01	−.93***	.05	−.15
8 Inf. trans. d. of v. b.	.04	.13	−.88***	.11	.19
10 Sagit. d. of v. foramen	.17	.90*	.15	.22	.06
11 Trans. d. of v. foramen	−.21	.75	−.48	−.24	−.10
K12 Max. wid. trans. proc.	.15	.39	−.25	.78	−.13
K13 Max. wid. s. art. proc.	.14	.49	−.48	.58	.15

1) The sample size is 19. The cumulative proportion of the variances of the six principal components is 85.88%.
2) See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 45. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the seventh thoracic vertebra in Japanese females.[1]

Variable[2]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.37	−.21	−.23	.13	.72
8 Cranial breadth	−.53	.66	.27	−.06	−.12
17 Basi-bregmatic height	.09	.78	.11	.48	.25
1 Vent. height of v. body	−.07	−.70**	.11	.19	.21
3 Cent. height of v. body	.08	−.13	.13	.90*	.00
2 Dors. height of v. body	.20	.10	.17	.80	.06
4 Sup. sag. d. of v. body	.89	−.01	.30	.16	.06
6 Mid. sag. d. of v. body	.92	.04	.18	.07	.16
5 Inf. sag. d. of v. body	.94	.10	.19	.10	−.00
7 Sup. trans. d. of v. b.	.15	.05	.91*	.18	−.02
9 Mid. trans. d. of v. b.	.25	−.02	.93*	.03	.13
8 Inf. trans. d. of v. b.	.38	−.14	.76*	.27	.09
10 Sagit. d. of v. foramen	.15	.79	−.13	.00	.40
11 Trans. d. of v. foramen	−.28	.49	.53	.08	.45
K12 Max. wid. trans. proc.	.24	.23	.25	−.27	.76
K13 Max. wid. s. art. proc.	−.26	.14	.30	.37	.72*

[1] The sample size is 19. The cumulative proportion of the variances of the six principal components is 83.82%.
[2] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 46. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the eighth thoracic vertebra in Japanese females.[1]

Variable[2]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.45	−.10	.14	.14	.71
8 Cranial breadth	−.34	.68	.07	.09	−.52
17 Basi-bregmatic height	.17	.83	.33	.14	.07
1 Vent. height of v. body	.16	−.19	.79	.29	−.04
3 Cent. height of v. body	−.06	.08	.70	−.03	.53
2 Dors. height of v. body	.06	.07	.77	−.02	.00
4 Sup. sag. d. of v. body	.95	.03	.07	.16	.08
6 Mid. sag. d. of v. body	.94	.01	−.00	.19	.22
5 Inf. sag. d. of v. body	.95	.06	.09	.18	.02
7 Sup. trans. d. of v. b.	.39	.22	−.10	.77*	−.00
9 Mid. trans. d. of v. b.	.29	.18	−.02	.92**	.00
8 Inf. trans. d. of v. b.	.12	.03	.29	.85*	.25
10 Sagit. d. of v. foramen	.23	.91	−.15	.04	.06
11 Trans. d. of v. foramen	−.26	.77	−.36	.35	−.03
K12 Max. wid. trans. proc.	.23	.09	−.51	.40	.52
K13 Max. wid. s. art. proc.	−.20	.10	.06	.64	.62*

[1] The sample size is 19. The cumulative proportion of the variances of the six principal components is 84.65%.
[2] See the second footnote to Table 1.
$^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$, by the two-tailed bootstrap test.

Table 47. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the ninth thoracic vertebra in Japanese females.[1]

Variable[2]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.12	.11	.22	.12	.86
8 Cranial breadth	−.03	.62	−.27	.09	−.65
17 Basi-bregmatic height	.09	.85	.10	.03	.02
1 Vent. height of v. body	.23	.01	.12	.89	.20
3 Cent. height of v. body	.83*	−.18	.07	.12	.13
2 Dors. height of v. body	.68	−.15	.30	.38	−.12
4 Sup. sag. d. of v. body	.16	.12	.95	.01	.14
6 Mid. sag. d. of v. body	.14	−.09	.94	.09	.21
5 Inf. sag. d. of v. body	.21	.00	.96	−.04	.06
7 Sup. trans. d. of v. b.	.85*	.09	.35	.10	−.08
9 Mid. trans. d. of v. b.	.84*	.18	.26	−.19	.02
8 Inf. trans. d. of v. b.	.93*	.07	.16	.01	.08
10 Sagit. d. of v. foramen	−.10	.90	.01	−.21	.08
11 Trans. d. of v. foramen	.50	.57	−.17	−.44	−.31
K12 Max. wid. trans. proc.	.27	.44	.25	−.70	.24
K13 Max. wid. s. art. proc.	.74	.14	−.28	−.16	.33

[1] The sample size is 19. The cumulative proportion of the variances of the six principal components is 86.02%.
[2] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 48. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the tenth thoracic vertebra in Japanese females.[1]

Variable[2]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.13	−.16	.07	.91*	.06
8 Cranial breadth	.10	.22	.32	−.67	.45
17 Basi-bregmatic height	.42	−.12	.04	−.08	.60
1 Vent. height of v. body	.11	−.44	−.75	.06	.29
3 Cent. height of v. body	.54	−.04	−.69	.13	.10
2 Dors. height of v. body	.61	−.02	−.56	.17	.41
4 Sup. sag. d. of v. body	.17	−.96	−.04	.07	.04
6 Mid. sag. d. of v. body	.21	−.93	−.08	.18	−.00
5 Inf. sag. d. of v. body	.14	−.93	−.05	.16	.02
7 Sup. trans. d. of v. b.	.73	−.29	−.16	.06	.26
9 Mid. trans. d. of v. b.	.86*	−.35	−.15	−.02	.18
8 Inf. trans. d. of v. b.	.84*	−.29	−.11	.21	−.00
10 Sagit. d. of v. foramen	.09	.08	−.14	.07	.90*
11 Trans. d. of v. foramen	.74	.26	.29	−.17	.41
K12 Max. wid. trans. proc.	.24	−.33	.65	.45	.27
K13 Max. wid. s. art. proc.	.29	−.36	−.30	−.20	.58

[1] The sample size is 19. The cumulative proportion of the variances of the six principal components is 83.62%.
[2] See the second footnote to Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$, by the two-tailed bootstrap test.

Table 49. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the eleventh thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.25	−.12	−.69*	−.36	.03
8 Cranial breadth	−.18	−.23	.88*	−.14	.11
17 Basi-bregmatic height	.25	−.06	.42	−.26	.54
1 Vent. height of v. body	.33	.68	−.02	.02	.47
3 Cent. height of v. body	−.19	.68	−.04	−.02	.54*
2 Dors. height of v. body	.16	.91***	−.01	.03	−.03
4 Sup. sag. d. of v. body	.92*	.25	−.14	−.18	.09
6 Mid. sag. d. of v. body	.89*	.22	−.21	−.21	−.06
5 Inf. sag. d. of v. body	.94*	−.02	−.05	−.24	.08
7 Sup. trans. d. of v. b.	.24	.62*	−.22	−.60*	.21
9 Mid. trans. d. of v. b.	.16	.57*	−.14	−.70**	.08
8 Inf. trans. d. of v. b.	.24	.61*	−.15	−.66*	.15
10 Sagit. d. of v. foramen	.05	.16	−.06	−.11	.89*
11 Trans. d. of v. foramen	−.08	.27	.18	−.41	.75**
K12 Max. wid. trans. proc.	.27	−.04	.25	−.81*	.12
K13 Max. wid. s. art. proc.	.20	−.15	−.14	−.76	.34

1) The sample size is 19. The cumulative proportion of the variances of the six principal components is 83.94%.
2) See the second footnote to Table 1.
$*P<0.05$; $**P<0.01$; $***P<0.001$, by the two-tailed bootstrap test.

Table 50. Solution obtained through the normal varimax rotation of the first five principal components for the correlation matrix on the measurements of the neurocranium and the twelfth thoracic vertebra in Japanese females.[1)]

Variable[2)]	Factor loadings				
	Fac I	II	III	IV	V
1 Cranial length	.30	−.09	−.80*	−.05	.06
8 Cranial breadth	−.21	.03	.61	.04	.57
17 Basi-bregmatic height	.30	.19	.03	−.03	.84**
1 Vent. height of v. body	.10	.66	−.39	.31	−.00
3 Cent. height of v. body	−.04	.83	.21	−.12	.25
2 Dors. height of v. body	.09	.93	.07	−.10	.00
4 Sup. sag. d. of v. body	.91	.02	−.29	.11	.09
6 Mid. sag. d. of v. body	.87*	−.05	−.17	.32	.08
5 Inf. sag. d. of v. body	.92*	.15	−.12	.14	.12
7 Sup. trans. d. of v. b.	.51	.30	−.34	.52	−.23
9 Mid. trans. d. of v. b.	.34	.11	−.23	.77*	.23
8 Inf. trans. d. of v. b.	.36	.50	−.51	.41	.07
10 Sagit. d. of v. foramen	−.06	.48	−.25	.41	.55*
11 Trans. d. of v. foramen	.13	.64	−.10	.44	.45
K12 Max. wid. trans. proc.	.11	−.14	.20	.81	.05
K13 Max. wid. s. art. proc.	.50	.17	.01	.58	−.32

1) The sample size is 19. The cumulative proportion of the variances of the six principal components is 80.80%.
2) See the second footnote to Table 1.
$*P<0.05$; $**P<0.01$; $***P<0.001$, by the two-tailed bootstrap test.

Table 51. Principal components from the measurements of the neurocranium and thoracic vertebrae which show significantly similar loading variation patterns at the 0.1% level.[1]

Principal components compared (Sex, Vert.)	Spearman's rank corr.	Principal components compared (Sex, Vert.)	Spearman's rank corr.
VI (M, 1)–IV (M, 6)	0.78	V (M, 5)–V (M, 7)	0.82
I (F, 1)–I (F, 2)	0.89	–II (F, 11)	0.81
II (F, 1)–II (F, 2)	0.89	II (F, 5)–II (F, 6)	0.81
IV (F, 1)–IV (F, 2)	0.80	–II (F, 7)	0.77
–IV (F, 3)	0.75	–II (F, 8)	0.76
–II (F, 4)	0.75	I (M, 6)–II (F, 7)	0.77
–V (M, 8)	0.80	–II (F, 9)	0.76
I (M, 2)–I (M, 7)	0.76	–I (M, 10)	0.82
–I (M, 8)	0.74	–I (M, 12)	0.80
–I (F, 8)	0.79	VI (M, 6)–V (M, 9)	0.86
IV (M,2)–IV (M, 3)	0.79	I (F, 6)–I (M, 7)	0.80
V (M, 2)–V (M, 3)	0.76	–I (F, 8)	0.85
II (F, 2)–II (M, 10)	0.75	II (F, 6)–II (F, 7)	0.93
IV (F, 2)–II (F, 4)	0.89	–II (F, 8)	0.90
–II (F, 6)	0.75	–V (M, 9)	0.76
I (M, 3)–V (M, 7)	0.74	–II (F, 9)	0.96
V (M, 3)–VI (M, 4)	0.84	–I (M, 10)	0.80
III (F, 3)–III (F, 4)	0.87	–II (F, 10)	0.86
–III (M, 8)	0.79	I (M, 7)–I (F, 7)	0.76
–I (M, 12)	0.75	–I (M, 8)	0.91
I (M, 4)–I (M, 5)	0.74	–I (F, 8)	0.77
–II (F, 7)	0.76	–I (M, 9)	0.78
II (M, 4)–III (F, 4)	0.83	–II (F, 11)	0.83
–II (M, 5)	0.91	–I (M, 12)	0.78
–III (M, 8)	0.80	I (F, 7)–I (F, 9)	0.76
–II (M, 10)	0.89	–I (F, 10)	0.78
V (M, 4)–IV (M, 12)	0.79	II (F, 7)–II (F, 8)	0.90
VI (M, 4)–VI (M, 9)	0.76	–II (F, 9)	0.93
I (F, 4)–I (F, 6)	0.83	–I (M, 10)	0.85
–I (M, 7)	0.84	–II (F, 10)	0.89
–II (F, 11)	0.77	I (M, 8)–I (F, 8)	0.77
II (F, 4)–II (F, 5)	0.82	–I (M, 9)	0.90
–II (F, 6)	0.83	–I (M, 12)	0.79
–II (F, 8)	0.82	III (M, 8)–I (M, 12)	0.79
–II (F, 10)	0.79	I (F, 8)–II (F, 11)	0.76
III (F, 4)–III (M, 8)	0.75	II (F, 8)–V (M, 9)	0.76
–II (M, 10)	0.76	–II (F, 9)	0.92
I (M, 5)–I (M, 6)	0.84	–II (F, 10)	0.86
–II (F, 7)	0.79	V (M, 9)–II (F, 9)	0.76
–II (F, 9)	0.78	I (F, 9)–I (F, 10)	0.80
–I (M, 10)	0.75	II (F, 9)–I (M, 10)	0.85
–II (F, 10)	0.75	–II (F, 10)	0.84
–II (F, 11)	0.79	I (F, 10)–I (F, 11)	0.82
II (M, 5)–III (M, 8)	0.78	II (F, 10)–II (F, 11)	0.82
–II (M, 10)	0.85	I (M, 11)–III (F, 11)	0.79
IV (M, 5)–IV (M, 12)	0.74	I (F, 11)–I (F, 12)	0.88
–IV (F, 12)	0.84		

[1] The similarity in the variation patterns of factor loadings between two principal components (PC's) was assessed by using the Spearman's rank correlation coefficient. The signs of rank correlations are removed because the signs of factor loadings are reversible. The PC's compared are those from the principal component analyses for all thoracic vertebrae of both sexes (Tables 3 to 26). The first PC and those PCs which are most highly correlated with one of the three main cranial measurements are listed.

Table 52. Rotated factors for the measurements of the neurocranium and thoracic vertebrae which show significantly similar loading variation patterns at the 0.1% level.[1)]

Rotated factors compared (Sex, Vert.)	Spearman's rank corr.	Rotated factors compared (Sex, Vert.)	Spearman's rank corr.
IV (F, 1)–IV (F, 2)	0.82	II (F, 4)–II (F, 6)	0.80
–IV (F, 3)	0.78	–II (F, 7)	0.75
–IV (F, 4)	0.81	IV (F, 4)–II (F, 5)	0.76
V (M, 2)–V (M, 3)	0.81	–V (F, 9)	0.84
IV (F, 2)–IV (F, 3)	0.83	III (M, 5)–IV (M, 10)	0.80
–IV (F, 4)	0.79	VI (M, 6)–VI (M, 7)	0.78
–II (F, 5)	0.83	–IV (M, 10)	0.78
VI (M, 3)–VI (M, 4)	0.92	II (F, 6)–II (F, 7)	0.81
–VI (M, 5)	0.77	–II (F, 8)	0.80
–VI (M, 9)	0.76	II (F, 7)–II (F, 8)	0.82
III (F, 3)–V (F, 10)	0.82	V (M, 8)–V (M, 9)	0.77
–III (F, 11)	0.78	V (F, 8)–V (F, 9)	0.76
IV (F, 3)–IV (F, 4)	0.81	III (F, 11)–III (F, 12)	0.76
VI (M, 4)–VI (M, 5)	0.83		
–VI (M, 9)	0.81		

[1)]The similarity in the variation patterns of factor loadings between two rotated factors was assessed by using the Spearman's rank correlation coefficient. The signs of rank correlations are removed because the signs of factor loadings are reversible. The rotated factors compared are those from the solutions for all thoracic vertebrae of both sexes (Tables 27 to 50). Only those factors which are most highly correlated with one of the three main cranial measurements are listed.

the present study, this was again confirmed with the significant factor loadings at least in one fifth of the 24 rotated solutions for the thoracic vertebrae of both sexes (Tables 27, 31, 32, 41 and 50). Such a repeatedly-shown association, though not for all the vertebrae, strongly supports the hypothesis offered by Mizoguchi (1994) that the vertebral foramen is an extension of the cranial cavity.

In the previous investigations of the lumbar and cervical vertebrae (Mizoguchi, 1994, 1995, 1996), no consistent association was found between the cranial length or breadth and vertebral measurements. But, in the present study, significant correlations were regularly recognized between the cranial length and the sagittal diameters of the vertebral body in the rotated solutions for at least four thoracic vertebrae of males (Tables 31, 32, 36 and 37). The reality of the common factor controlling both the cranial length and the sagittal body size of the thoracic vertebrae is also supported by the significantly high rank correlations between the variation patterns in the factor loadings (Table 52). Taking such similarity in factor loading variation patterns into account, the factor VI in Table 33 may also be regarded as the same kind of factor.

Because of the above findings, the previous results on the lumbar and cervical vertebrae were re-examined. In result, at least two factors were found to be associated with both the cranial length and the sagittal diameters of the vertebral body in the rotated solutions for lumbar vertebrae: the factor IV from the analysis for the second lumbar of males and the factor I for the fourth lumbar of females (Table 14 in Mizoguchi, 1994). Similarly, the rotated factor I from the analysis for the seventh cervical vertebra of males is also identified as such (Table 7 in Mizoguchi, 1996).

After all, it is probable that there is some strong association in sagittal length between the neurocranium and the vertebral body, especially of the thoracic vertebrae. The fact that any similar association was not found in females seems to result from the small size of the present female sample. To determine whether the concrete causes for this association are genetical, biomechanical or accidental, further investigations must be conducted in the future.

Summary and Conclusions

The principal component analyses on the neurocranium and the thoracic vertebrae revealed that the cranial length and/or basi-bregmatic height were strongly associated with the sagittal and/or transverse diameters of the vertebral body. Some rotated factors obtained from the principal components showed that the cranial length was significantly correlated with the sagittal diameters of the vertebral body, and that the basi-bregmatic height and the sagittal or transverse diameters of the vertebral foramen were significantly correlated with each other.

These results suggest that the shape of the thoracic vertebrae has some kind of connection with that of the neurocranium, though the concrete causes for it are unknown for the present.

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