Bull. Natn. Sci. Mus., Tokyo, Ser. D, 21, pp. 37–50, December 22, 1995

Regional Variation in Mandibular Morphology of the Jomon People

By

Yousuke KAIFU

Department of Anthropology, National Science Museum
3–23–1 Hyakunincho, Shinjuku-ku, Tokyo, 169 Japan

Abstract Morphological variation among the mandibular samples of the Jomon period from five regions of Japan (Hokkaido, Tohoku, Kanto, Tokai and Kinki, and San'yo regions) was investigated. Although existence of some regional differences were suggested, it was revealed that the Jomon populations of these regions had common mandibular features compared to those of the Yayoi population from the northern Kyushu and Yamaguchi region.

Introduction

The Jomon people are prehistoric hunter-gatherers of Japan, ranging in time from ca. 10,000 B.P. to ca. 2,000 B.P. It has been shown that the skeletal materials of the Jomon period throughout Japan so far as known have basically common cranial, dental, and postcranial features, though there are some regional differences (BABA and ETOH, 1989; DODO, 1982, 1986; MATSUMURA, 1989; MOURI, 1986, 1988; NAITO and MATSUSHITA, 1977; YAMAGUCHI, 1981, 1982, 1989; but see YAMAGUCHI, 1995).

KAIFU (1995) investigated differences in mandibular morphology of the Jomon people from the Kanto region and the Yayoi people from the northern Kyushu and Yamaguchi region. However, it was not clear then whether the morphological features detected in the Kanto Jomon sample were applicable to the Jomon inhabitants of other regions.

The purpose of the present study is to investigate morphological variation in the mandibles of the Jomon populations from various regions of Japan.

Materials and Methods

The materials used in this study are the mandibles of male and female Jomon skeletal remains from the Hokkaido, Tohoku, Kanto, Tokai and Kinki (abbreviated Tokai+Kinki hereafter) and San'yo regions as shown in Table 1 and Fig. 1. These samples were from the collection in the Department of Anatomy, Sapporo Medical College; the Department of Anthropology and Prehistory,

Table 1. Derivation of the materials used in the present study[1].

Region	Site
Hokkaido	Irie (2F), Kitakogane (5M, 3F), Motowanishi[2] (4M, 2F), Funadomari (1M), Shimamaki (1F), Takasago (1M, 5F), Yakumokotan (1F)
Tohoku	Ebishima (1M, 4F), Nakazawahama (2M, 2F), Obora (1F), Sakai (1F), Sanganji (8M, 5F)
Kanto	Chidorikubo (1F), Higashi (1F), Horinouchi (2M, 1F), Kasori (11M, 1F), Kikumatenaga (2M, 6F), Kosaku (2M, 3F), Koyaba (1M), Kusakari (3M, 3F), Mitsusawa (2F), Moriyakaigan (1M), Saihiro (3M, 2F), Ubayama (22M, 8F), Yahagi (1M), Yoyama (2M, 1F)
Tokai, Kinki	Ikawazu (1M), Inariyama (3M, 1F), Kameyama (6M, 2F), Ko (3M, 2F), Yoshigo (7M, 5F)
San'yo	Hashima (2M, 1F), Hikosaki (8M, 2F), Ota (22M, 8F), Tsubue (3F), Tsugumo (5M), Yosekura (1M, 1F)

[1] The numbers in parentheses indicate the sample sizes for both sexes.

[2] Most of the Motowanishi specimens may belong to the Epi-Jomon Period (HASEBE, 1926; OBA, 1962).

Fig. 1. Geographical derivation of the Jomon samples used.

University Museum, University of Tokyo; the Department of Anthropology, National Science Museum, Tokyo; the Department of Anatomy, St. Marianna Medical College; Cultural Properties Center of Chiba Prefecture; and the Laboratory of Physical Anthropology, Kyoto University. In addition, the skeletal series of the Yayoi period (ca. 300 B.C.–A.D. 300) from the northern Kyushu and Yamaguchi region (abbreviated the NK-Y Yayoi sample hereafter) is used as a comparative sample. They are considered to be largely composed of immigrants from the Asian continent or their offspring (DODO, 1987; DODO and ISHIDA, 1988, 1990; HANIHARA, 1984, 1985; KANASEKI, 1955, 1976; KIM *et al.*, 1993; MATSUMURA, 1994, 1995; MIZOGUCHI, 1988; NAKAHASHI, 1990, 1993; NAKA-

HASHI *et al.*, 1985; YAMAGUCHI, 1984). The NK-Y Yayoi sample was from the collection in the Department of Anatomy, Kyushu University.

Selection criteria of the materials and definition of measurements have been described in detail elsewhere (KAIFU, 1995). Some basic points are outlined below.

As in the previous study, a major criterion used in restricting the materials was the presence of a full complement of lower alveoli including that of the third molar. This criterion was adopted in the previous study because congenital absence of M3 may indicate insufficient growth of the jaw bone in some individuals. To increase the sample size of the Tokai+Kinki, specimens with symmetrical ritual tooth ablation of lower canines were included (8/20 and 5/10 for males and females respectively). Sex was determined by the present author on the basis of morphological observations. The measurements used in the present study and their abbreviations are given in Table 2. Measurements were made by the present author with a digital sliding caliper (Mitutoyo, Japan) to an accuracy of 0.1 mm. The mean of the left and right sides was used for the analyses. If it was impossible to measure one side, the other side alone was used.

To begin with, significance tests of mean differences among the five regional Jomon samples were undertaken by one-way ANOVA. To the indices, a

Table 2. List of measurements.

Abbreviations	Measurements
1. BCoB	Bicondylar Breadth
2. BSnB	Bisigmoid-notch Breadth
3. LPRB	Least Posterior Ramus Breadth
4. BGoB	Bigonial Breadth
5. UML	Upper Mandibular Length
6. LML	Lower Mandibular Length
7. BM1B	Dental Arch Breadth (M1-M1)
8. BM2B	Dental Arch Breadth (M2-M2)
9. DAL	Dental Arch Length
10. CoH	Condyloid Height
11. LCrH	Least Coronial Height
12. LRB	Least Ramus Breadth
13. SnB	Sigmoid Notch Breadth
14. SnD	Sigmoid Notch Depth
15. TCor	Thickness of Coronoid Process
16. TAng	Thickness of Angle
17. SH	Symphyseal Height
18. CCH	Corpus Height at C_1
19. P3CH	Corpus Height at P_3
20. P4CH	Corpus Height at P_4
21. M1CH	Corpus Height at M_1
22. M2CH	Corpus Height at M_2

non-parametric statistical procedure (Kruskal-Wallis test) was also applied since the distribution of these may not be expected to be normal. When one of the above tests revealed significant differences, multiple comparisons were performed (Tukey's test). Then, mandibular morphology of the five Jomon samples was compared with that of the NK-Y Yayoi using the standardized deviations of the average measurements of the formers from the latter. The differences in each measurement were tested for statistical significance using least significant difference (LSD). Next, the corpus heights of these samples were compared by principal component analysis. All the above statistical procedures were performed using SYSTAT Macintosh 5.2.1 (SYSTAT Inc., 1992). For further data summary, Mahalanobis' generalized distances on a selected variable subset were calculated using pooled within-groups variances and covariances from all the samples compared. Calculation of these distances were performed using the program "Mahalanobis' D-square" written by Kiyotaka Koizumi (1985).

Results

Table 3 shows the descriptive statistics and results of statistical tests for the measurements and indices for the five Jomon regional samples. Differences among the samples are not statistically significant in most cases. There are significant differences, however, in some items, leading to the following interpretations. The Hokkaido Jomon males have broader ramus and deeper sigmoid notch as shown in LRB, SnD and SnD/SnB compared to the other samples. The corpus heights of the Tokai + Kinki Jomon males are lower as a whole. The same observations largely apply to the females.

Fig. 2 shows the standardized deviations of the average measurements of the five Jomon samples from the NK-Y Yayoi. The deviation patterns of the Jomon samples are similar to each other in both males and females. The results of significance tests between the NK-Y Yayoi and Jomon samples are given in Table 4. These results indicate that all of the Jomon samples largely have following common features which are different from the NK-Y Yayoi condition: a smaller overall mandibular size (most of the items related to mandibular size are smaller), a larger LML relative to UML, relatively large ramus heights (CoH, LCrH), a thinner angular region (TAng), a shallower sigmoid notch (SnD; except for the Hokkaido Jomon), and a lower symphysis (SH).

To examine corpus heights (SH to M2CH), which is one of the representative features differentiating the mandibles of the Kanto Jomon and NK-Y Yayoi (KAIFU, 1995), principal component analyses, using six corpus heights as variables, were applied to the correlation matrix of the pooled Jomon and NK-Y Yayoi sample. Taking side differences of corpus heights into consideration, specimens with no missing value for the six corpus heights on either side were used. The

Table 3. a) Comparisons of the mandibular measurements and indices (males)[1].

	1. BCoB			2. BSnB			3. LPRB		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	4	127.0	5.6	7	100.2	4.2	6	96.8	5.1
Tohoku	8	129.3	6.4	10	105.7	5.1	8	98.4	4.1
Kanto	18	127.3	6.0	32	103.0	4.1	30	98.1	6.3
Tokai+Kinki	8	129.6	5.6	8	103.1	3.8	8	101.2	4.0
San'yo	14	128.3	6.1	22	101.6	4.4	19	99.5	5.3
	$F=0.318$, $P=0.865$			$F=2.266$, $P=0.070$			$F=0.802$, $P=0.528$		
	4. BGoB			5. UML			6. LML		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	5	100.5	7.0	4	96.0	2.5	4	77.9	5.8 TK, S
Tohoku	9	99.2	3.9	5	90.7	2.4	8	72.3	2.6
Kanto	28	100.3	6.9	12	93.5	3.3	25	71.8	3.2
Tokai+Kinki	8	103.7	4.3	8	89.4	5.4	8	68.8	6.6 H
San'yo	19	101.1	6.1	11	92.1	4.0	19	69.5	4.0 H
	$F=0.670$, $P=0.615$			$F=2.582$, $P=0.054$			$F=4.454$, $P=0.003$		
	7. BM1B			8. BM2B			9. DAL		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	7	55.6	2.3	8	62.0	1.9	8	33.5	2.2
Tohoku	11	56.3	1.6	10	63.3	1.6	9	33.7	2.1
Kanto	40	56.1	1.9	40	63.2	2.2	35	34.4	1.9
Tokai+Kinki	13	56.2	2.8	12	64.1	2.6	11	33.5	1.5
San'yo	25	55.6	2.5	24	62.8	2.5	21	33.6	1.6
	$F=0.405$, $P=0.804$			$F=1.221$, $P=0.308$			$F=1.076$, $P=0.374$		
	10. CoH			11. LCrH			12. LRB		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	8	61.6	3.4	9	64.7	4.7	11	39.1	2.1 T, K, TK, S
Tohoku	9	64.0	2.0	10	67.8	4.6	10	34.1	3.1 H
Kanto	40	62.5	4.3	42	65.9	4.0	44	36.5	2.2 H
Tokai+Kinki	14	60.0	4.8	13	64.0	5.2	16	35.0	3.3 H
San'yo	27	62.4	4.3	33	64.9	3.9	33	35.2	2.2 H
	$F=1.485$, $P=0.213$			$F=1.506$, $P=0.206$			$F=7.835$, $P=0.000$		
	13. SnB			14. SnD			15. TCor		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	8	31.2	1.9	8	13.6	1.2 T, K, TK, S	10	5.6	0.7
Tohoku	8	30.5	3.2	8	11.4	1.2 H	10	5.4	0.7
Kanto	34	32.4	3.1 S	32	11.8	1.7 H	41	5.6	0.6
Tokai+Kinki	14	31.6	2.5	14	11.6	0.8 H	16	5.7	1.0
San'yo	31	30.1	2.8 K	31	11.4	1.7 H	33	5.8	1.2
	$F=2.790$, $P=0.031$			$F=3.446$, $P=0.012$			$F=0.475$, $P=0.754$		
	16. TAng			17. SH			18. CCH		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	11	6.1	1.9	9	31.7	1.4	9	31.0	1.4
Tohoku	11	5.9	1.3	8	30.3	2.9	11	30.5	2.4
Kanto	46	5.5	1.1 S	29	32.0	2.1 TK	41	31.7	2.1 TK
Tokai+Kinki	14	6.0	1.2	15	29.9	2.2 K	9	29.3	2.3 K
San'yo	33	6.5	1.1 K	27	30.8	1.7	37	30.8	1.9
	$F=3.438$, $P=0.011$			$F=3.243$, $P=0.016$			$F=3.264$, $P=0.015$		

Table 3. a) (continued).

	19. P3CH			20. P4CH			21. M1CH		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	9	31.3	1.4	10	30.9	1.8	10	30.0	2.3
Tohoku	11	31.2	2.4	11	31.6	2.3	11	30.4	2.1
Kanto	45	31.9	2.3 TK	46	31.4	2.2 TK	47	29.7	2.0
Tokai + Kinki	18	30.1	2.4 K	19	29.8	2.3 K	18	28.4	2.2
San'yo	37	30.8	1.9	38	30.5	2.0	36	29.2	2.0
	$F=2.711$, $P=0.033$			$F=2.617$, $P=0.038$			$F=2.291$, $P=0.064$		

	22. M2CH		
	N	mean	s.d.
Hokkaido	10	28.4	2.6
Tohoku	11	29.0	1.6 TK
Kanto	47	27.9	1.9
Tokai + Kinki	20	26.8	1.6 T
San'yo	38	27.7	2.0
	$F=2.563$, $P=0.042$		

	UML/BCoB			LML/BGoB			DAL/BM2B		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	4	75.7	2.8	4	76.3	9.0	8	54.0	3.9
Tohoku	5	70.1	4.8	8	72.8	4.9	9	53.3	3.5
Kanto	12	74.8	4.5 TK	25	72.2	7.3	35	54.6	3.5
Tokai + Kinki	8	69.1	5.1 K	8	66.3	5.2	11	52.5	3.1
San'yo	11	71.4	2.7	19	69.0	6.0	21	53.7	3.2
	$F=3.507$, $P=0.016$			$F=2.493$, $P=0.053$			$F=0.882$, $P=0.479$		
	$H=9.668$, $P=0.046$			$H=8.956$, $P=0.062$			$H=3.130$, $P=0.536$		

	SnD/SnB			CCH/SH			P3CH/SH		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	8	43.7	5.2 K, TK, S	9	97.9	2.2	9	99.0	4.4
Tohoku	8	37.8	5.0	8	100.5	4.0	8	103.5	5.3
Kanto	32	36.8	5.8 H	29	99.6	3.5	29	100.4	4.3
Tokai + Kinki	14	37.0	4.3 H	7	99.3	4.8	15	100.3	4.9
San'yo	31	37.9	4.5 H	27	100.2	2.6	27	100.5	3.4
	$F=3.080$, $P=0.020$			$F=0.999$, $P=0.414$			$F=1.242$, $P=0.299$		
	$H=10.519$, $P=0.033$			$H=5.405$, $P=0.248$			$H=2.727$, $P=0.604$		

	P4CH/SH			M1CH/SH			M2CH/SH		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	9	98.0	5.6	9	95.0	7.6	9	90.1	8.5
Tohoku	8	104.8	5.2 K	8	100.4	4.6 K	8	96.3	4.7 K
Kanto	29	98.9	5.0 T	29	93.6	5.5 T	29	87.8	6.2 T
Tokai + Kinki	15	99.3	5.3	15	94.2	5.0	15	89.7	5.1
San'yo	27	99.6	4.4	26	95.1	4.7	27	91.0	5.7
	$F=2.643$, $P=0.040$			$F=2.614$, $P=0.041$			$F=3.341$, $P=0.014$		
	$H=8.564$, $P=0.073$			$H=9.770$, $P=0.044$			$H=11.953$, $P=0.018$		

[1] Results of *F*-tests (raw measurements and indices) and Kruskal-Wallis tests (indices) are shown below the descriptive statistics. The letters such as TK, S, H, etc. indicate significant differences ($p<0.05$, Tukey's test) between the samples. H = Hokkaido Jomon, T = Tohoku Jomon, K = Kanto Jomon, TK = Tokai + Kinki Jomon, S = San'yo Jomon.

Table 3. b) Comparisons of the mandibular measurements and indices (females)[1)].

	1. BCoB			2. BSnB			3. LPRB			
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.	
Hokkaido	3	118.5	3.2	7	96.1	3.1	6	93.9	5.9	
Tohoku	9	119.6	5.8	12	97.3	3.4	11	90.7	4.4	
Kanto	7	115.7	4.9	19	95.7	3.4	12	92.1	3.5	
Tokai + Kinki	4	124.5	1.5	4	98.2	2.8	4	95.0	2.1	
San'yo	6	120.6	9.8	8	96.3	3.6	8	91.0	6.0	
	$F=1.367$, $P=0.275$			$F=0.692$, $P=0.602$			$F=0.956$, $P=0.444$			
	4. BGoB			5. UML			6. LML			
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.	
Hokkaido	6	94.9	6.1	2	87.9	0.7	6	69.2	1.6	
Tohoku	11	93.6	6.6	9	89.7	4.6	11	70.3	3.7	
Kanto	14	92.9	3.6	6	88.9	3.1	13	67.4	3.2	
Tokai + Kinki	4	95.8	1.1	3	84.4	0.6	4	67.6	2.9	
San'yo	9	91.5	6.5	4	88.8	3.0	9	70.1	6.3	
	$F=0.641$, $P=0.636$			$F=1.244$, $P=0.326$			$F=1.158$, $P=0.345$			
	7. BM1B			8. BM2B			9. DAL			
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.	
Hokkaido	7	53.5	2.2	8	59.8	1.8	7	32.3	1.7	
Tohoku	12	54.6	1.5	12	61.7	1.7	12	34.3	2.4	
Kanto	25	53.9	2.2	25	60.8	2.3	24	33.5	1.8	
Tokai + Kinki	7	55.5	1.9	6	61.8	1.3	5	32.6	1.4	
San'yo	10	54.2	2.5	7	60.6	1.6	7	33.0	1.4	
	$F=1.046$, $P=0.392$			$F=1.495$, $P=0.217$			$F=1.732$, $P=0.158$			
	10. CoH			11. LCrH			12. LRB			
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.	
Hokkaido	10	58.6	2.9	12	58.3	3.3	13	37.1	3.2	T, TK, S
Tohoku	12	56.6	4.1	13	58.8	4.2	13	33.6	2.3	H
Kanto	19	57.1	2.8	26	58.7	4.3	24	35.3	2.4	
Tokai + Kinki	7	56.7	3.7	8	58.9	4.0	10	32.8	2.2	H
San'yo	13	58.5	3.8	14	59.3	4.5	14	33.2	3.4	H
	$F=0.897$, $P=0.472$			$F=0.108$, $P=0.979$			$F=5.520$, $P=0.001$			
	13. SnB			14. SnD			15. TCor			
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.	
Hokkaido	10	32.5	3.3	S	10	11.7	2.4	12	6.6	0.9
Tohoku	13	30.1	3.1		13	10.1	0.8	13	5.8	0.8
Kanto	21	31.1	3.0		21	11.0	2.1	27	5.9	1.2
Tokai + Kinki	7	30.3	2.1		7	10.4	1.4	10	5.6	0.8
San'yo	13	28.2	3.0	H	13	10.6	1.2	14	5.7	0.8
	$F=3.355$, $P=0.015$			$F=1.415$, $P=0.240$			$F=2.102$, $P=0.090$			
	16. TAng			17. SH			18. CCH			
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.	
Hokkaido	12	6.1	0.8	11	28.8	2.5	12	28.5	2.5	
Tohoku	13	5.8	1.3	9	29.4	2.3	11	29.2	1.5	
Kanto	24	5.4	1.4	20	29.4	2.1	22	28.4	2.2	
Tokai + Kinki	10	6.6	1.4	7	27.9	2.4	4	27.2	2.6	
San'yo	14	6.1	1.0	12	28.1	1.9	12	27.6	2.3	
	$F=1.752$, $P=0.149$			$F=1.051$, $P=0.390$			$F=1.087$, $P=0.372$			

Table 3. b) (continued).

	19. P3CH			20. P4CH			21. M1CH		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	12	29.1	2.5	13	28.9	2.4	13	27.8	2.4
Tohoku	11	29.6	1.6	11	29.5	2.1	11	28.1	2.1
Kanto	25	28.6	1.9	28	28.5	2.0	29	27.4	1.8
Tokai+Kinki	10	27.4	2.0	10	27.3	1.7	10	25.6	1.8
San'yo	14	28.2	2.2	15	28.1	1.8	15	27.0	1.7
	$F=1.808$, $P=0.138$			$F=1.711$, $P=0.157$			$F=2.685$, $P=0.038$		

	22. M2CH			
	N	mean	s.d.	
Hokkaido	13	26.5	2.5	TK
Tohoku	13	26.2	2.0	TK
Kanto	28	26.0	1.8	TK
Tokai+Kinki	10	23.8	1.7	H, T, K
San'yo	13	25.8	1.8	
	$F=3.241$, $P=0.017$			

	UML/BCoB			LML/BGoB			DAL/BM2B		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	2	73.2	1.0	6	73.1	4.4	7	54.1	3.0
Tohoku	9	75.1	4.3	11	75.4	6.3	12	55.7	4.3
Kanto	6	76.2	2.7	13	72.3	5.3	24	55.0	3.4
Tokai+Kinki	3	67.8	1.3	4	70.6	3.6	5	52.9	2.1
San'yo	4	74.7	7.0	9	76.8	5.9	7	54.5	2.2
	$F=2.210$, $P=0.107$ $H=6.794$, $P=0.147$			$F=1.495$, $P=0.223$ $H=4.555$, $P=0.336$			$F=0.752$, $P=0.561$ $H=2.408$, $P=0.661$		

	SnD/SnB			CCH/SH			P3CH/SH		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	10	36.2	7.6	11	97.9	2.6	11	100.1	5.0
Tohoku	13	33.9	3.9	8	98.6	3.3	8	99.6	2.6
Kanto	21	25.4	6.5	17	98.1	2.1	18	99.0	3.2
Tokai+Kinki	7	34.2	3.5	3	95.5	3.1	7	97.0	4.0
San'yo	13	37.8	5.8	11	97.9	2.2	12	99.8	3.6
	$F=0.876$, $P=0.484$ $H=3.425$, $P=0.484$			$F=0.829$, $P=0.514$ $H=2.053$, $P=0.726$			$F=0.887$, $P=0.478$ $H=2.996$, $P=0.558$		

	P4CH/SH			M1CH/SH			M2CH/SH		
	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
Hokkaido	11	100.2	7.0	11	96.4	7.4	11	91.9	8.2
Tohoku	8	99.9	3.1	8	95.4	3.9	9	91.5	4.4
Kanto	19	99.8	4.4	20	95.3	5.3	19	91.3	6.7
Tokai+Kinki	7	97.0	3.6	7	89.9	4.6	7	83.0	7.8
San'yo	12	99.9	3.3	12	95.8	3.4	11	91.9	5.7
	$F=0.636$, $P=0.639$ $H=0.526$, $P=3.196$			$F=1.983$, $P=0.110$ $H=7.998$, $P=0.092$			$F=2.543$, $P=0.051$ $H=7.123$, $P=0.130$		

[1] See the footnote to Table 3. a).

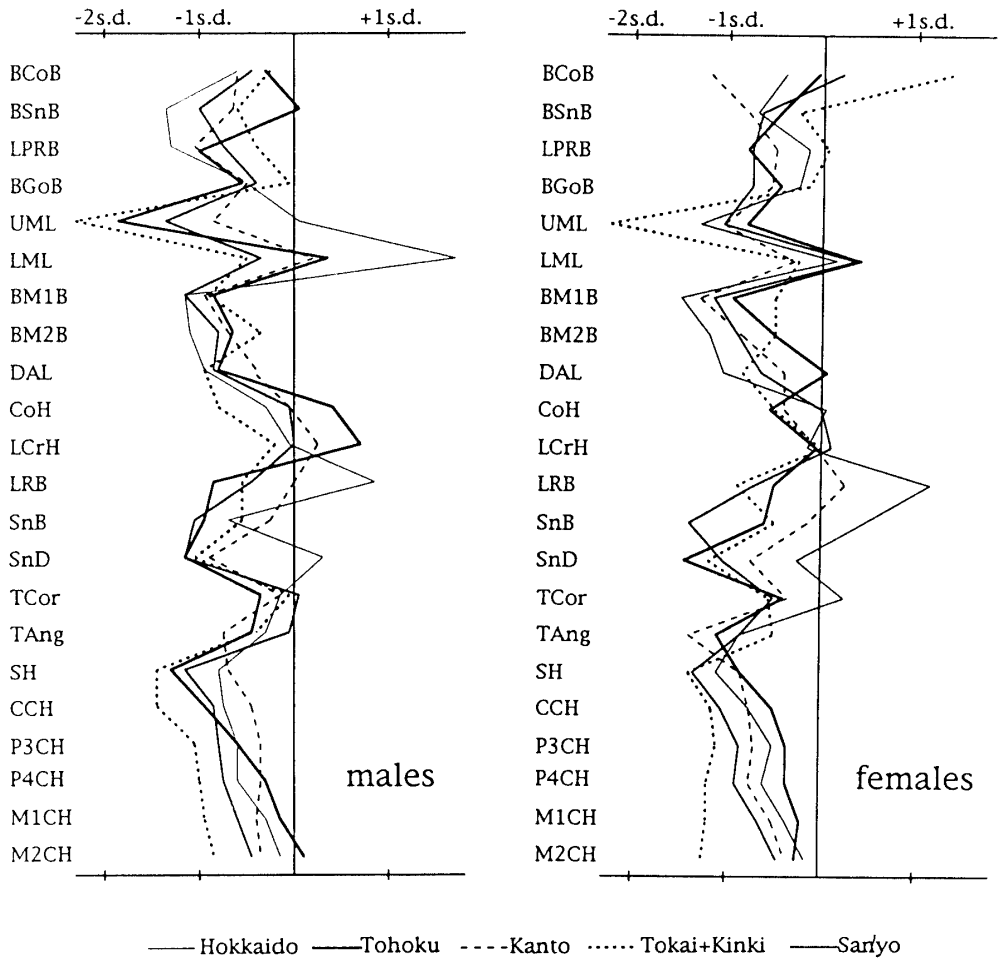

Fig. 2. Standardized deviations of the average measurements of the five Jomon samples from the NK-Y Yayoi.

results are given in Table 5 and Fig. 3. As seen in Table 5, in both males and females, the first principal components (PC I) represent overall size in corpus heights. The PC II give positive scores for those cases having relatively larger anterior corpus heights (SH to CCH) and lower posterior ones (M1CH to M2CH). The PC III give positive scores if P3CH and P4CH are relatively high and SH and M2CH are relatively low. As shown in Fig. 3, in both males and females, the Jomon samples tend to exhibit a similar trend (negative scores in PC I and PC II, positive scores in PC III) compared to the condition seen in the NK-Y Yayoi. The Tokai+Kinki Jomon female is somewhat close to the NK-Y Yayoi probably because of small sample size (3).

For further data summary, Mahalanobis' generalized distances between the male samples were calculated using BM2B, DAL, SH to M2CH as variables. For calculation of variances and covariances, corpus heights were arranged as in the

Table 4. Results of significance tests using LSD between the NK-Y Yayoi and Jomon[1)].

	Males					Females				
	H	T	K	TK	S	H	T	K	TK	S
BCoB			−							
BSnB	−		−		−			−		
LPRB	−	−	−		−		−			
BGoB			−							−
UML		−		−	−				−	
LML	+									
BM1B	−	−	−	−	−	−	−	−		−
BM2B	−	−	−		−	−	−	−		−
DAL	−	−		−	−	−				
CoH				−						
LCrH		+								
LRB	+	−		−	−	+				
SnB		−			−					−
SnD		−	−	−	−		−		−	−
TCor										
TAng			−			−	−	−		−
SH	−	−	−	−	−	−	−	−	−	−
CCH	−	−	−	−	−	−		−	−	−
P3CH		−		−	−			−	−	−
P4CH			−	−	−	−		−	−	−
M1CH			−	−	−			−	−	−
M2CH			−	−	−				−	

[1)] "+" indicates the Jomon sample is significantly ($p<0.05$) larger than the NK-Y Yayoi. "−" indicates the opposite. H=Hokkaido Jomon, T=Tohoku Jomon, K=Kanto Jomon, TK=Tokai+Kinki Jomon, S=San'yo Jomon.

Table 5. Component loadings from the principal component analysis of corpus heights.

Variables	Males			Females		
	PC I	PC II	PC III	PC I	PC II	PC III
SH	0.841	0.450	−0.284	0.886	0.405	−0.191
CCH	0.937	0.295	0.025	0.941	0.308	−0.038
P3CH	0.970	0.122	0.174	0.975	0.121	0.119
P4CH	0.967	−0.047	0.202	0.970	−0.058	0.204
M1CH	0.939	−0.307	0.017	0.938	−0.297	0.060
M2CH	0.801	−0.554	−0.206	0.824	−0.523	−0.200
Perc. disp.	83.1%	11.7%	3.3%	85.4%	10.6%	2.3%

case with the foregoing principal component analysis. Table 6 shows that the distances between the NK-Y Yayoi and five Jomon samples are largely greater than those between the Jomon samples.

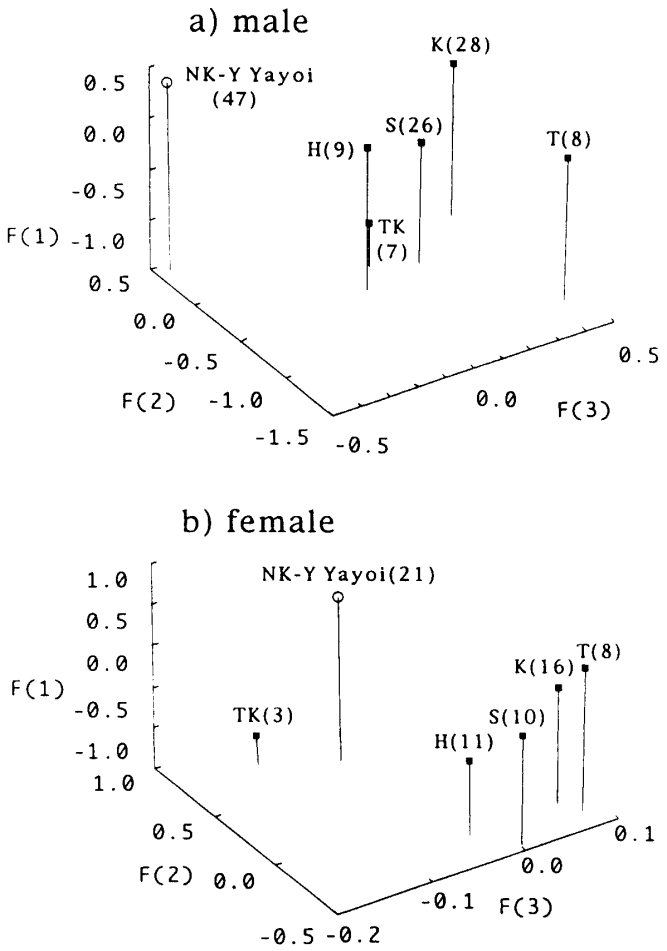

Fig. 3. Three dimensional plot of average principal component scores. The numbers in parentheses indicate the sample sizes.

Table 6. Mahalanobis' generalized distance matrix based on eight corpus dimensions (males).

	Hokkaido	Tohoku	Kanto	Tokai+Kinki	San'yo
Tohoku Jomon	1.292				
Kanto Jomon	1.592	1.481			
Tokai+Kinki Jomon	1.550	1.428	1.194		
San'yo Jomon	1.317	1.232	0.942	1.247	
NK-Y Yayoi	2.081	2.289	1.442	1.918	1.924

Discussion

From the above analyses, it can be said that the Jomon people of the Hokkaido and Honshu regions have common mandibular features which are different from those of the NK-Y Yayoi people. These are as follows: (1) a small overall size, (2) a low symphysis, (3) corpus heights at premolar region are

approximately equivalent to the symphyseal height (the NK-Y Yayoi is characterized by corpus heights decreasing posteriorly in a consistent manner), (4) a relatively larger height of ramus, (5) a shallower sigmoid notch (except for the Hokkaido Jomon), (6) a thinner angular region, and (7) a larger lower mandibular length relative to upper mandibular length. The first six features are largely consistent with those detected in the Kanto Jomon mandibles (KAIFU, 1995), and the last was newly documented in the present study.

The view that the Jomon inhabitants of various regions of Japan have common mandibular features is consistent with that drawn from the previous studies based on cranial, dental and postcranial traits. At the same time, this result confirms potential usefulness of the mandibles in discriminating between the Jomon and NK-Y Yayoi populations (KAIFU, 1995).

On the other hand, existence of some regional differences in mandibular morphology of the Jomon people was suggested. Among these, the difference seen in ramus breadth between the Hokkaido (larger) and other Jomon samples (smaller) is clear. This supports the observations put forward by previous researchers (DODO, 1981; YAMAGUCHI, 1984).

Acknowledgments

I would like to express my gratitude to the following persons for their permission to investigate the materials in their care: Dr. Kazumichi KATAYAMA, Laboratory of Physical Anthropology, Kyoto University; Dr. Gen MURAKAMI, Department of Anatomy, Supporo Medical College; Dr. Takeru AKAZAWA, Department of Anthropology and Prehistory, University Museum, University of Tokyo; Dr. Yosaburo SHIBATA, Department of Anatomy, Kyushu University; Dr. Bin YAMAGUCHI, Department of Anthropology, National Science Museum, Tokyo; Dr. Iwataro MORIMOTO, Department of Nursing, Japanese Red Cross College of Nursing; Mr. Hiroshi OKUNO, Cultural Properties Center of Chiba Prefecture. Thanks are also due to Drs. Yuji MIZOGUCHI, Hisao BABA and Bin YAMAGUCHI, Department of Anthropology, National Science Museum, Tokyo, for helpful comments.

References

BABA, H and M. ETOH., 1989. On the human skeletal remains of the Jomon people from eastern Japan. In: ETOH, M. (ed.), A study on the morphological variation of human skeletal remains of Jomon period from eastern Japan. A Report of the Research Supported by a Grant-in Aid for Scientific Research from the Ministry of Education, Science and Culture, Japan. (In Japanese.)

DODO, Y., 1981. On the human skeletal remains from the archeological sites in the Misawa River drainage. In: Archeological sites in the Misawa River drainage, IV, 455–477. Hokkaido,

Cultural Properties Center of Hokkaido Prefecture.

DODO, Y., 1982. A metrical analysis of Jomon Crania from the Tohoku district. *J. Anthrop. Soc. Nippon*, 90: 119–128. (In Japanese, with English summary.)

DODO, Y., 1986. Metrical and non-metrical analyses of Jomon crania from eastern Japan. In: AKAZAWA, T. and M. AIKENS (eds.), Prehistoric hunter-gatherers in Japan—New research method—, 137–161. *Univ. Mus. Univ. Tokyo, Bulletin*, 27.

DODO, Y., 1987. Supraorbital foramen and hypoglossal canal bridging: The two most suggestive nonmetric cranial traits in discriminating major groupings of man. *J. Anthrop. Soc. Nippon*, 95: 19–35.

DODO, Y. and H. ISHIDA, 1988. Nonmetric analyses of the Doigahama crania of the Aeneolithic Yayoi period in western Japan. In: The Genesis of the Japanese Population and Culture, 127–142. Tokyo, Rokko-shuppan. (In Japanese, with English summary.)

DODO, Y. and H. ISHIDA, 1990. Population history of Japan as viewed from cranial nonmetric variation. *J. Anthrop. Soc. Nippon*, 98: 269–287.

HANIHARA, K., 1984. Origins and affinities of Japanese viewed from cranial measurements. *Acta Anthropogenetica*, 8: 149–158.

HANIHARA, K., 1985. Origins and affinities of Japanese as viewed from cranial measurements. In: KIRK, R and E. SZATHMÁRY (eds.), Out of Asia: Peopling the Americas and the Pacific, 105–112. Canberra, The Journal of Pacific History.

HASEBE, K., 1926. Harpoon-heads of antler found from the shell-mounds of Motowanishi, Hokkaido. *J. Anthrop. Soc. Nippon*, 41: 471–475.

KAIFU, Y., 1995. Differences in mandibular morphology between the Jomon people from Kanto and Yayoi people from northern Kyushu and Yamaguchi. *Anthropol. Sci*, 103: 291–308.

KANASEKI, T., 1955. The problem of Yayoi people. In: Nihon Kokogaku-koza, 238–251. Tokyo, Kawade-shobo. (In Japanese.)

KANASEKI, T., 1976. The origin of the Japanese people. Tokyo, Hosei Univ. Press. (In Japanese.)

KIM, J. J., T. OGATA, K. MINE, M. TAKENAKA, M. SAKUMA and Y. N. SEO, 1993. Human skeletal remains from the Yean-ri site, Kimhae, Korea. *Mus. Rep. Pusan Univ*, 15: 281–334. (In Korean.)

MATSUMURA, H., 1989. Geographical variation of dental measurements in the Jomon population. *J. Anthrop. Soc. Nippon*, 97: 493–512.

MATSUMURA, H., 1994. A microevolutional history of the Japanese people from a dental characteristics perspective. *Anthropol. Sci*, 102: 93–118.

MATSUMURA, H., 1995. Dental characteristics affinities of the prehistoric to Modern Japanese with the east Asians, American natives and Australo-Melanesians. *Anthropol. Sci*, 103: 235–261.

MIZOGUCHI, Y., 1988. Affinities of the proto-historic Kofun people of Japan with pre- and proto-historic Asian populations. *J. Anthrop. Soc. Nippon*, 96: 71–109.

MOURI, T., 1986. Geographical and temporal variation of Japanese populations as viewed from nonmetric traits of the skull. Doctorial dissertation. Kyoto University. (In Japanese.)

MOURI, T., 1988. Incidences of cranial nonmetric characters in five Jomon populations from west Japan. *J. Anthrop. Soc. Nippon*, 96: 319–337.

NAKAHASHI, T., 1990. The problem of immigrants: Aspect of the physical anthropology. In: Ancient Korea and Japan, 117–174. Tokyo, Meicho-shuppan. (In Japanese.)

NAKAHASHI, T., 1993. Temporal craniometric changes from the Jomon to Modern period in western Japan. *Am. J. Phys. Anthropol*, 90: 409–425.

NAKAHASHI, T., N. DOI and M. NAGAI, 1985. Human skeletal remains of the Yayoi period from the Kanenokuma site. In: The Kanenokuma Site, 43–145. Fukushima, Fukuoka City Board of Education. (In Japanese.)

NAITO, Y. and T. MATSUSHITA., 1977. Anthropological study on the skeletons of Jomon period in Kyushu. *Acta Anatomica Nipponica*, 52: 117. (In Japanese.)

OBA, T., 1962. Summary of the Ponnai site. In: Muroran site, 122. Hokkaido, Hokkaido Muroran-shi Kyoiku-iinkai. (In Japanese.)

YAMAGUCHI, B., 1981. Human skeletal remains from Hokkaido. In: Ogata, T. (ed.) The Japanese, I, 137–156. Tokyo, Yuzankaku-shuppan. (In Japanese.)

YAMAGUCHI, B., 1982. A review of the osteological characteristics of the Jomon population in prehistoric Japan. *J. Anthrop. Soc. Nippon*, 90 (suppl.): 77–90.

YAMAGUCHI, B., 1984a. Human skeletal remains from the Kushiro-Midorigaoka site. In: TAKAKURA, S. *et al.* (eds.) KOUNO Hiromichi hakase botsugo 20 nen kinen ronbunshu, 401–417. Hokkaido, Hokkaido-shuppankikaku Senta.

YAMAGUCHI, B., 1984b. The formation and temporal change of Japanese. In Jinruigaku, 60–71. Tokyo, Nikkei-Saiensu-sha. (In Japanese.)

YAMAGUCHI, B., 1989. Limb segment proportions in human skeletal remains of the Jomon period. *Bull. Natn. Sci. Mus., Tokyo, Ser. D*, 15: 41–48.

YAMAGUCHI, B., 1995. A reflection on the Jomon people. Tokyo, Kokusaibunken-Insatsu-sha.