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Craniofacial Variation among the Common People of the Edo Period

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Abstract After the late 17th century, the Edo common people were buried in two kinds of coffins: a wooded coffin or "*hayaoke*" and a ceramic coffin or "*kamekan*." The townsman or samurai of the lower class were placed in the former type and the samurai of the lower-middle class in the latter. This paper investigates the morphological difference in skulls of those in *kamekan* and *hayaoke* coffins. Employing univariate and multivariate analyses, it statistically details the differences between the two groups. The "*Kamekan*" group is characterized by a short head, long face, high orbit, and weak prognathous, which make them quite similar to the specimens classified by Suzuki (1985) as Type II Edo common people. With principal component analysis, the morphological cline can be recognized from the "*Hayaoke*" group to "Daimyo (load of domain)" or "Ooku (wives of Shoguns) " groups in both sex.

Key words: Craniofacial morphology, Skull, Edo, Coffin type, Common people

Introduction

With urban development around Tokyo, many archeological sites of the Edo era have been unearthed. A large quantity of human skeletal material has been discovered in many burial sites, and now over 5000 individuals have been stored in the National Museum of Nature and Science.

Suzuki (1985) indicates that the skulls of the Edo people have three types of craniofacial morphology: Type I has the medieval Japanese characteristics of a long head (dolicocephaly), a round face, a flat nose, and a strong prognathous; type II displays the modern Japanese features of a long face, a relatively high-bridged nose, and a weak prognathous, and Type III has "super" modern features, such as a big and short head (brachycephaly), an extraordinary narrow face, a pyriform aperture, a high-bridged nose, a high orbit, and a narrow and weak maxilla, mandible, and malocculusion. Suzuki maintains that the last type exhibits "aristocratic characteristics," since these can be recognized only among the samurai of the higher class, such as shoguns and *daimyos* (territorial lords). He believed that these characteristics were basically caused by a remarkable reduction of masticatory force.

Although his classification is not statistically clarified, it has been confirmed by the study of the skeletal remains of the Makino family (the lords of the Nagaoka domain and of the wives, mothers, and daughters of the Tokugawa shoguns (Kato *et al.*, 1986: Baba and Sakaue, 2012). The later study, in particular, permits the statistical division of the Edo people into three groups: The first is a "lawful group" with "aristocratic characteristics" that is almost restricted to the lawful wives of the shoguns. The second is "mistress group" that is composed in part of the mistress wives of the shoguns and in part of townsmen. The members of this group show a variation in skull morphology, which is spreaded at the midway between the "lawful group" and "townsman group." The third is the "townsman group" what is composed partly of the mistress wives but mostly of townsmen.

However, it is not clear whether the townsmen samples can be statistically separated into two groups, such as the "Type I" and "Type II" of Suzuki (1985), or the "mistress group" and "townsman group" of Baba and Sakaue (2012). The "townsmen sample" of these studies may be mixed with the "lower-middle class of the samurai" and the "townsman class," composed of peasants, artisans, and merchants. It is possible that the grading of the townsmen samples may influence group variation in skull morphology, since hierarchical variance in skull morphology separates the high class of the Samurai and the rest of the sample population. Nevertheless, it is difficult to estimate the social status of buried persons, since the burial records of temples and tombstones do not exist, and burial accessories tend to be too plain to estimate status.

In archaeological studies, Tanigawa (1989, 1991) and Matsumoto (1990) demonstrate that the burial facilities, especially coffin types, indicate the social status of the persons contained in them. Although 14 types of burial containers have been identified (Tanigawa, 2004), the coffins that contain adult persons can be roughly classified as circular wooden coffins (*hayaoke*), square wooden coffins (*houkeimokkan*), and ceramic coffins (*kamekan*). The first type was utilized by the townsman or samurai of the lower class and the last by lower-middle class of samurai, as *hatamoto* or *hanshi*, after the late 17th century (Tanigawa, 2004). In one record, the cost of a ceramic coffin is given as two Ryo, which to about 400,000 of today's yen (Nakano, 1997). It is safe to say that people who could afford to buy a ceramic coffin were richer or of a higher social position those who bought circular wooden coffins. Square wooden coffins are thought to have been commonly used after the late 18th century (Tanigawa, 2004), but the relationship between this coffin and social status is still uncertain. In the excavation of a cemetery site of the Edo era, most of coffins have been *hayaoke* and secondly *kamekan* (Koizumi, 2004).

Thus assuming that *hayaoke* and *kamekan* coffins indicate the relative social status of skeletal remains, the purpose of this paper is to investigate statistically the morphological difference in the skulls of the *Hayaoke* group and the *Kamekan* group.

Material and Method

The materials of this study are composed of human skeletal remains excavated from ten cemetery sites located in Tokyo; these were in operation from the late 17th century to the 19th century (Table 1).

The selection criteria for these materials are as follows: 1) the complete closure of the sphenoocipitai synchondrosis; 2) the remains of at least one tooth or socket of the maxillary central incisors; 3) the remains of at least one tooth or socket of molars for each maxilla and mandible: 4) no contamination by another individual or, if

Table 1. Sites and sample size used in this study.

Site	Period	Male		Female	
		Hayaoke	Kamekan	Hayaoke	Kamekan
Ikenohata shichikencho	late 17th century–late 19th century	61	9	37	9
Sugenji	late 17th century–late 19th century	28	20	9	16
Shyokenji	late 17th century–late 19th century	15	4	12	10
Hoxtushyoji I and II	late 17th century–late 19th century	6	6	2	4
Enouji	late 17th century–late 19th century	4	0	1	2
Houkouji II	late 17th century–late 19th century	1	0	1	0
Shyugyoji	18th century–19th century	0	1	0	0
Hosenji I	18th century–19th century	0	1	0	0
Ikenohata shichikencho minami	late 17th century–late 19th century	16	7	8	5
Jishouin	middle 17the century–19th century	0	2	0	2
		131	50	70	48

Table 2 Summary statistics of all measurements and Indexes.

Martin No.	Variables	Male					Female				
		Hayaoke (N=131)			Kamekan (N=50)		Hayaoke (N=70)			Kamekan (N=48)	
		Mean	S.D.		Mean	S.D.	Mean	S.D.		Mean	S.D.
1	Maximum length	181.5	6.4	⩾	177.4	6.1	172.3	6.7	⩾	169.1	5.5
8	Maximum breadth	138.5	4.5	⩽	141.3	5.3	133.2	5.7	<	135.3	4.4
17	Basion-Bregma height	136.2	4.7	<	138.0	5.7	130.6	3.9		132.0	4.0
9	Least frontal breadth	93.5	4.2		94.4	4.9	89.3	4.8		89.5	3.3
10	Maximum frontal breadth	114.7	4.2	⩽	117.2	5.4	109.4	4.8		110.1	3.9
5	Basion-Nasion length	101.8	4.5	⩾	99.9	4.2	94.9	3.7		95.1	3.6
11	Biauricular breadth	126.0	4.3		125.0	4.3	119.2	4.4		118.8	4.6
12	Biasterionic breadth	108.5	4.6		108.2	5.2	104.4	4.0		104.2	3.8
13	Mastoid width	103.2	4.7		102.2	4.8	97.2	5.9		96.4	4.3
40	Basion-Prosthion length	99.3	4.9	⩾	96.0	6.0	94.4	5.3	>	92.7	3.8
14	Minimum cranial breadth	68.7	3.5		69.7	4.0	64.1	3.3		65.1	3.7
7	Foramen magnum length	35.8	2.2		35.3	2.4	33.7	2.0		33.7	2.0
16	Foramen magnum breadth	29.6	2.0		29.9	2.2	28.3	1.7		28.1	1.9
23	Horizontal circumference	518.2	13.9		514.9	13.0	494.6	14.0		491.1	11.9
24	Transverse arc	312.8	9.4	⩽	321.0	11.7	301.7	11.3		304.6	9.9
26	Frontal sagittal arc	125.9	5.7		126.9	5.3	121.3	5.9		119.8	5.7
27	Parietal sagittal arc	126.3	8.1		125.7	8.3	120.9	7.1		119.8	11.1
28	Occipital sagittal arc	118.2	8.3		117.7	5.4	115.1	8.1		113.9	6.6
25	Total sagittal arc	370.4	13.3		370.2	12.5	357.3	12.9		353.4	13.0
29	Frontal sagittal chord	110.6	4.4		110.8	4.4	106.3	4.2		105.6	4.2
30	Parietal sagittal chord	112.7	6.4		112.2	6.5	108.9	5.7		106.5	7.0
31	Occipital sagittal chord	98.4	5.3		99.3	4.1	96.8	5.4		97.6	4.2
43	Outer biorbital breadth	104.7	4.0		104.0	4.0	99.2	3.7		98.7	3.0
43a	Bifrontal breadth	97.3	4.0		96.8	3.7	92.3	3.6		92.1	2.8
	Nasion subtence (calculated)	14.1	2.4		14.5	3.1	12.5	2.3		13.1	2.3
44	Biorbital breadth	97.9	3.8		97.3	3.7	93.6	3.5		92.8	3.1
45	Bizygomatic breadth	134.9	4.5	>	133.1	5.1	125.0	3.8		123.8	4.6
46	Bimaxillary breadth (zm)	99.9	4.7	⩾	97.3	5.0	93.3	3.8		92.2	4.8
46b	Bimaxillary breadth (zm:a)	99.9	4.7	⩾	97.6	4.9	94.1	4.2		92.7	4.9
	Subspinale subtence (calculated)	22.7	3.3	<	23.9	2.9	20.5	3.0	⩽	22.0	2.3
48	Upper facial height	72.2	4.2	<	73.7	3.3	66.7	4.2	⩽	68.5	3.4
48H	Upper facial height (Howells)	68.3	4.0	⩽	69.9	3.2	63.4	4.4	<	65.1	3.6
48d	Malar height	24.3	2.5		23.7	2.5	22.0	2.0		21.9	1.9
49a	Interorbital breadth	21.0	2.0		20.7	2.1	20.3	2.1		19.7	2.0
50	Anterior interorbital breadth	16.9	2.1		16.9	2.1	16.4	1.9		16.3	1.7
51	Orbital breadth	43.3	2.0		43.4	1.8	40.8	1.9		41.2	1.5
52	Orbital height	34.1	1.9	⩽	35.6	1.9	33.3	1.8	⩽	34.6	1.7
54	nasal breadth	25.6	1.9	⩾	24.5	1.7	24.4	1.6		24.5	1.9
55	nasal height	52.3	3.1	⩽	53.6	2.6	48.5	2.7		49.4	2.6
55(1)	Height of piriform aperture	29.6	2.6	<	30.7	2.5	26.5	2.2	<	27.5	2.7
56	Length of nasal bone	24.4	2.8		24.9	3.0	22.6	2.5		22.9	2.8
57(1)	Maximum breadth of nasal bone	18.2	1.9		17.7	1.6	16.9	1.6		17.1	1.9
57	Least nasal breadth	7.3	1.6		7.2	2.0	7.0	1.9	⩽	7.8	1.6
	Nasal subtense (calculated)	2.5	1.0		2.6	1.1	1.8	0.9	⩽	2.3	0.9
60	External palate length	52.3	3.0	⩾	50.4	3.5	50.3	3.6	⩾	48.9	2.3
61	External palate breadth	65.7	3.8		65.5	3.8	61.4	3.4		61.5	3.6
62	Internal palate length	45.5	2.7		44.7	2.7	44.0	2.7		43.4	2.1
63	Internal palate breadth	40.7	3.3	>	39.5	3.3	38.1	2.6		38.6	3.0
66	Bigonial breadth	100.2	5.8		98.9	5.9	93.8	5.6	⩾	90.9	4.5
68	Projective length of mandible	70.7	5.0		69.8	4.9	66.2	4.3		65.6	4.3
65	Bicondylar breadth	121.6	5.7		120.8	5.8	113.8	5.2	⩾	110.8	5.8
65(1)	Bicoronoid breadth	97.4	4.8		98.1	5.2	90.5	4.5		90.5	5.0
67	Bimental breadth	47.5	2.5		47.4	2.5	45.8	2.2		45.2	2.0
69	Height of mandibular symphysis	35.6	3.2		36.0	3.1	31.6	3.2		32.2	2.8
69(1)	Mandibular body height	31.6	2.7		32.1	2.4	28.7	2.5		28.9	2.1
69(2)	Mandibular body height at M2	26.8	2.5		26.5	2.7	24.8	2.2		24.3	2.0
69(3)	Mandibular body breadth	13.2	1.4	⩾	12.5	1.4	12.7	1.2	>	12.2	1.1
69b	Mandibular body breadth at M2	17.1	1.6	>	16.6	1.3	17.0	1.4	>	16.3	1.5
70	Height of mandibular ramus	64.9	4.4		64.8	4.3	57.6	3.9		57.6	3.9
71a	Minimum width of ramus	34.7	3.3	⩾	32.4	2.6	33.1	2.7	⩾	31.2	2.4
71(1)	Condylo-cornoid breadth	36.2	3.2	⩾	33.4	3.9	34.1	3.0	⩾	32.7	2.9
	Mandibular condyle breadth	20.7	2.0		20.6	1.9	18.5	1.7	>	17.9	1.4

Table 2 Continued.

Martin No.	Variables	Male Hayaoke (N=131) Mean	S.D.		Male Kamekan (N=50) Mean	S.D.	Female Hayaoke (N=70) Mean	S.D.		Female Kamekan (N=48) Mean	S.D.
69(3)	Mandibular body breadth	13.2	1.4	≫	12.5	1.4	12.7	1.2	>	12.2	1.1
69b	Mandibular body breadth at M2	17.1	1.6	>	16.6	1.3	17.0	1.4	>	16.3	1.5
70	Height of mandibular ramus	64.9	4.4		64.8	4.3	57.6	3.9		57.6	3.9
71a	Minimum width of ramus	34.7	3.3	≫	32.4	2.6	33.1	2.7	≫	31.2	2.4
71(1)	Condylo-cornoid breadth	36.2	3.2	≫	33.4	3.9	34.1	3.0	≫	32.7	2.9
	Mandibular condyle breadth	20.7	2.0		20.6	1.9	18.5	1.7	>	17.9	1.4
8/1	Cranial index	0.76	0.03	≪	0.80	0.04	0.77	0.05	≪	0.80	0.03
17/1	Index	0.75	0.03	≪	0.78	0.03	0.76	0.03	≪	0.78	0.03
17/8	Index	0.98	0.04		0.98	0.04	0.98	0.05		0.98	0.03
9/10	Index	0.82	0.03	>	0.81	0.03	0.82	0.04		0.81	0.03
9/8	Index	0.68	0.03		0.67	0.04	0.67	0.04		0.66	0.03
8/12	Index	1.28	0.05	≪	1.31	0.06	1.28	0.06	<	1.30	0.05
40/5	Index	0.98	0.04	>	0.96	0.05	0.99	0.04	>	0.98	0.03
16/7	Index	0.83	0.06	<	0.85	0.06	0.84	0.05		0.84	0.05
27/26	Index	1.00	0.07		0.99	0.07	1.00	0.07		1.00	0.09
28/26	Index	0.94	0.08		0.93	0.06	0.95	0.08		0.95	0.08
29/26	Index	0.88	0.02		0.87	0.02	0.88	0.02		0.88	0.02
30/27	Index	0.89	0.02		0.89	0.03	0.90	0.02		0.89	0.04
31/28	Index	0.83	0.03	<	0.84	0.02	0.84	0.03	≪	0.86	0.02
(1+8+17)/3	Modulus	152.03	3.54		152.24	4.09	145.35	3.59		145.49	3.37
	Frontal index of flatness	0.14	0.02		0.15	0.03	0.13	0.02		0.14	0.02
	Zygomatic index of flatness	0.23	0.03	≪	0.25	0.03	0.22	0.03	≪	0.24	0.03
43/8	Index	0.76	0.03	≫	0.74	0.03	0.75	0.04	≫	0.73	0.03
46/45	Index	0.74	0.03		0.73	0.03	0.75	0.03		0.74	0.03
48/45	Index	0.54	0.03	≪	0.55	0.03	0.53	0.03	≪	0.55	0.03
48/46	Index	0.72	0.04	≪	0.76	0.04	0.72	0.05	≪	0.75	0.05
9/45	Index	0.69	0.03	≪	0.71	0.03	0.71	0.03		0.72	0.03
45/8	Index	0.97	0.04	≫	0.94	0.04	0.94	0.04	≫	0.92	0.03
50/44	Index	0.17	0.02		0.17	0.02	0.17	0.02		0.18	0.02
52/51	Index	0.79	0.04	≪	0.82	0.05	0.82	0.04	<	0.84	0.05
54/55	Index	0.49	0.04	≫	0.46	0.03	0.51	0.04		0.50	0.04
54/55(1)	Index	0.87	0.10	≫	0.80	0.08	0.93	0.09		0.90	0.13
	Simotic index	0.34	0.12		0.37	0.13	0.25	0.12		0.29	0.11
57/57(1)	Index	0.40	0.09		0.41	0.11	0.41	0.10	≪	0.46	0.09
61/60	Index	1.26	0.08	≪	1.30	0.10	1.22	0.09	<	1.26	0.09
63/62	Index	0.90	0.08		0.87	0.16	0.87	0.07		0.89	0.08
68/65	Index	0.58	0.04		0.58	0.05	0.58	0.05		0.59	0.04
69(3)/69(1)	Index	0.42	0.05	≫	0.39	0.05	0.44	0.04	>	0.42	0.04
69b/69(2)	Index	0.64	0.07		0.63	0.08	0.69	0.07		0.68	0.09
71/70	Index	0.54	0.05	≫	0.50	0.05	0.58	0.06	≫	0.54	0.05
72	Total profile angle	83.3	3.09	<	84.4	3.62	81.3	3.36	<	82.7	2.55
73	Nasal profile angle	92.4	3.10		92.8	4.03	87.9	11.19	≪	90.1	12.27
74	Alveolar profile angle	64.8	6.33	≪	67.5	6.67	62.8	6.20		64.3	5.21
75	Profile angle of nasal bone	63.4	6.02		62.2	5.54	65.1	5.08		64.7	5.02
79	Mandibular angle	124.5	6.90	<	126.5	6.89	126.5	6.84	<	129.6	7.17

"<" and "≪" mean the results of the two sample t-test or Mann-Whiteny U test between "Hayaoke" group and "Kamekan" group.

"<" means $P<0.05$ and "≪" means $P<0.01$ respectively.

The means with under bar indicates that the normal distribution of its variable is denied with the Sapiro-Wilk test.

any, the restricted contamination of easily identifiable pieces; 5) an almost complete skull without deformation or missing values for all measurements; and 6) some descriptions or pictures of the burial system of skeletal remains in the published reports of excavations.

The sexual assessment of individuals was basically carried through cranial features (Sakaue and Adachi, 2009). When these traits were inadequate, pelvic features, such as a greater sciatic notch, ventral arc and ischiopubic proportion, were used (Bruzek, 2002). A total of 67 measurements were examined (Table 2), and its definitions followed those of Martin's measurements (Baba, 1991). When both sides were available, the left side was basically measured.

Statistical analyses were undertaken as follows. First, the Shapiro-Wilk test was conducted for all variables in each group, in order to test for any deviations from a normal distribution. Second, so as to compare the relative significance of difference between the "*Kamekan*" group and "*Hayaoke*" groups, two-sample t-tests were conducted for variables with normal distributions, or the Mann-Whiteny U test was carried out for variables of doubtful normal distribution, angles, and indexes in each sex. Forty-seven variables were arbitrarily chosen in considering normal distribution and independency in multivariate analysis. In order to test the differences of these groups for a combination of dependent variables, Wilks' lambda was also calculated, and its statistical significance was tested.

Principal component analysis was performed to elucidate group differences in cranial variation of people buried in *kamekan* and those in *hayaoke*. After the analysis of 299 individuals, the principal component scores of the higher class were calculated. The measurements of the higher class were carried out with elaborative casts of Kaneiji12 (the lawful wife of the 10th shogun Ieharu), Kaneiji13 (the lawful wife of the 9th shogun Ieshige), Kaneiji15 (the lawful wife of the 13th shogun Isesada), Kaneiji23 (the mistress wife of the 11th shogun Ienari), Kaneiji 24 (the mistress wife of the 10th shogun Ieharu) (Baba and Sakaue, 2012), Tadakazu Makino (the 4th lord of the Nagaoka domain), Tadachika Makino (the 5th lord of the Nagaoka domain), Tadachika Makino (the 5th lord of the Nagaoka domain), Tadataka Makino (the 6th lord of the Nagaoka domain), Tadatoshi Makino (the 7th lord of the Nagaoka Domain), Tadatune Makino (son of the 9th lord of the Nagaoka Domain) (Baba and Sakaue, 2012; Kato *et al.*, 1986). In this paper, the wives of shoguns are classified as the "Ooku" group and the lords as the "Daimyo" group. All statistical analyses were carried out with SYSTAT 13

Results

Table 2 shows the descriptive statistics. In both sexes, the cranial form of the "*Kamekan*" group was more brachycephalic than that of the "*Hayaoke*" group. The variables indicating the sagittal length of the alveolar (basion-prosthion length, subspinale subtense, and external palate length) indicate significant group differences. The face and orbit variables of "*Kamekan*" group are significantly higher than those of the "*Hayaoke*" group. In comparison, some variables of the mandible (mandibular body breadths, minimum ramus widths, and condylo-cornoid breadths) of the "*Kamekan*" group were smaller than those of the "*Hayaoke*" group, indicating that the mandible of the former tended to be gracile. The indexes of facial flatness of the "*Kamekan*" group tend to be larger, suggesting more prominent facial anteriorly. On the contrast, angles indicating prognathism (total angle and alveolar profile angle) tend to be higher (weaker prognathism) in the "*Kamekan*" group, which also has a significantly higher mandibular angle.

The Wilks' lambdas and its probabilities are in Table 3. Significant differences of the 47 variables exist between the two groups for both sexes.

Table 4 shows the results of the principal component analysis of males. The first principal component, accounting for 24.3% of the total variance, has relatively high loading values for almost all measurements, especially the maximum length, biauricular breadth, horizontal circumference, and facial breadth variables. Therefore, this component may be interpreted as indicating total skull size. For the second princi-

Table 3. Result of Wilk's lambda

	Male	Female
Wilks' λ	0.481	0.444
p-Value	0.000	0.009

Table 4. Result of princiapal component analysis with male Edo comon people.

Martin No.	Variables	1	2	3	4	5	6
1	Maximum length	**0.656**	−0.240	0.273	0.062	**0.308**	**−0.361**
8	Maximum breadth	**0.351**	**0.566**	0.082	**0.344**	0.120	**0.340**
17	Basion-Bregma height	**0.552**	0.039	−0.203	**0.476**	0.106	0.036
9	Least frontal breadth	**0.566**	**0.442**	0.046	−0.195	0.133	−0.163
10	Maximum frontal breadth	**0.428**	**0.609**	0.094	0.128	0.109	0.002
5	Basion-Nasion length	**0.519**	**−0.336**	−0.023	0.025	−0.144	−0.226
11	Biauricular breadth	**0.619**	0.261	0.219	0.031	−0.140	**0.358**
12	Biasterionic breadth	**0.455**	0.094	0.094	**0.357**	0.212	0.017
40	Basion-Prosthion length	**0.481**	**−0.632**	0.056	0.048	0.135	−0.023
14	Minimum cranial breadth	**0.542**	**0.384**	−0.107	−0.042	−0.129	0.097
7	Foramen magnum length	0.260	0.130	0.186	0.149	−0.139	**−0.540**
16	Foramen magnum breadth	0.125	0.144	0.025	**0.304**	**−0.333**	**−0.403**
23	Horizontal circumference	**0.787**	0.046	0.261	0.183	0.300	−0.216
24	Transverse arc	**0.470**	**0.456**	−0.104	**0.420**	**0.372**	0.204
29	Frontal sagittal chord	**0.430**	−0.013	−0.033	**0.320**	**0.309**	0.024
30	Parietal sagittal chord	**0.375**	−0.024	0.116	0.172	**0.384**	−0.227
31	Occipital sagittal chord	**0.385**	0.048	−0.017	0.269	**0.247**	−0.089
43	Outer biorbital breadth	**0.796**	0.152	0.095	−0.280	0.008	−0.152
	Nasion subtence (calculated)	0.097	0.096	**−0.310**	**−0.461**	0.111	**−0.312**
44	Biorbital breadth	**0.796**	0.136	0.073	−0.259	−0.067	−0.201
45	Bizygomatic breadth	**0.747**	0.101	0.219	−0.121	**−0.345**	0.193
46	Bimaxillary breadth (zm)	**0.701**	−0.207	0.084	−0.166	−0.236	0.182
	Subspinale subtence (calculated)	0.113	0.004	**−0.566**	−0.083	0.013	−0.095
48	Upper facial height	**0.514**	−0.032	**−0.672**	−0.024	−0.091	−0.015
48d	Malar height	**0.471**	−0.289	−0.217	−0.069	0.002	0.273
49a	Interorbital breadth	**0.558**	0.115	0.231	**−0.443**	**0.302**	0.029
50	Anterior interorbital breadth	**0.524**	0.135	0.159	**−0.502**	0.268	0.023
51	Orbital breadth	**0.573**	0.181	−0.127	−0.036	−0.245	**−0.384**
52	Orbital height	0.252	**0.425**	**−0.390**	0.199	−0.272	−0.220
54	nasal breadth	**0.518**	−0.188	0.300	−0.224	0.112	0.027
55	nasal height	**0.463**	0.060	**−0.563**	−0.055	−0.260	−0.073
57	Least nasal breadth	0.230	0.151	−0.190	**−0.485**	**0.345**	0.055
	Nasal subtense (calculated)	0.096	0.068	**−0.477**	−0.202	0.208	0.077
60	External palate length	**0.369**	**−0.610**	−0.204	0.080	0.136	−0.040
61	External palate breadth	**0.568**	−0.101	−0.207	0.052	0.033	0.215
66	Bigonial breadth	**0.481**	0.051	0.177	0.033	**−0.355**	0.130
68	Projective length of mandible	**0.464**	**−0.407**	−0.109	0.114	−0.043	0.118
65	Bicondylar breadth	**0.588**	0.088	0.280	−0.045	**−0.388**	0.092
65(1)	Bicoronoid breadth	**0.593**	0.316	0.078	−0.144	−0.281	0.130
67	Bimental breadth	**0.517**	−0.092	0.002	−0.027	−0.033	**0.330**
69	Height of mandibular symphysis	**0.363**	−0.206	**−0.509**	0.028	0.190	0.133
69(1)	Mandibular body height	**0.455**	−0.182	**−0.489**	0.058	0.024	−0.035
69(3)	Mandibular body breadth	**0.315**	**−0.407**	0.180	0.057	0.078	0.185
70	Height of mandibular ramus	**0.389**	−0.185	−0.212	0.096	−0.235	0.041
71a	Minimum width of ramus	**0.440**	**−0.617**	0.163	−0.011	−0.106	0.095
71(1)	Condylo-cornoid breadth	**0.347**	**−0.522**	0.216	0.079	−0.047	−0.227
	Mandibular condyle breadth	**0.421**	−0.196	0.101	0.199	−0.261	−0.026
	Eigenvalues	11.44	4.07	3.11	2.41	2.23	1.92
	Percent of explained (%)	24.3	8.7	6.6	5.1	4.7	4.1

A bold number means its loading score beyond 0.3

pal component, some variables of the calvarial breadth and orbital height have positive and relatively high factor loadings and negatively correlate with the variables of the sagittal diameters of facial structure. The third principal component is interpreted as indicating that the three subtenses of the facial flatness correlate with the height of the orbit, nose, and mandibular symphysis.

Table 5 reveals the results of the principal component analysis of females. The first princi-

Table 5. Result of princiapal component analysis with female Edo comon people.

		1	2	3	4	5	6
1	Maximum length	**0.576**	**0.510**	0.128	−0.212	−0.277	0.225
8	Maximum breadth	**0.440**	**−0.643**	0.058	**−0.410**	−0.101	−0.038
17	Basion-Bregma height	**0.471**	−0.039	**0.502**	−0.074	−0.063	0.142
9	Least frontal breadth	**0.702**	−0.205	−0.267	0.136	−0.237	0.064
10	Maximum frontal breadth	**0.574**	**−0.456**	0.037	**−0.354**	−0.213	0.139
5	Basion-Nasion length	**0.643**	**0.346**	0.126	0.286	−0.009	**0.324**
11	Biauricular breadth	**0.660**	−0.272	−0.197	**−0.311**	0.184	−0.037
12	Biasterionic breadth	**0.464**	0.003	−0.013	**−0.301**	−0.120	0.220
40	Basion-Prosthion length	**0.480**	**0.523**	**0.341**	**0.333**	−0.068	−0.003
14	Minimum cranial breadth	**0.587**	**−0.355**	−0.020	−0.107	0.190	0.076
7	Foramen magnum length	0.121	0.199	−0.165	−0.292	**0.350**	**0.449**
16	Foramen magnum breadth	0.170	0.183	−0.237	−0.160	**0.501**	**0.340**
23	Horizontal circumference	**0.751**	0.100	0.100	**−0.394**	−0.294	0.120
24	Transverse arc	**0.434**	**−0.490**	**0.352**	**−0.352**	−0.181	0.068
29	Frontal sagittal chord	**0.440**	−0.096	**0.352**	**−0.389**	−0.031	0.091
30	Parietal sagittal chord	**0.390**	**0.308**	0.121	−0.247	**−0.355**	−0.005
31	Occipital sagittal chord	0.213	0.137	0.263	0.057	−0.106	0.264
43	Outer biorbital breadth	**0.790**	0.001	**−0.334**	0.196	−0.016	−0.074
	Nasion subtence (calculated)	**0.387**	−0.049	0.010	**0.464**	−0.258	0.220
44	Biorbital breadth	**0.787**	0.068	**−0.308**	0.188	0.088	−0.062
45	Bizygomatic breadth	**0.785**	−0.001	−0.284	−0.193	0.199	−0.175
46	Bimaxillary breadth (zm)	**0.613**	0.253	**−0.306**	0.180	0.116	−0.262
	Subspinale subtence (calculated)	0.197	−0.243	0.209	**0.537**	−0.194	0.016
48	Upper facial height	**0.511**	**−0.476**	**0.330**	0.282	**0.311**	0.042
48d	Malar height	**0.425**	0.061	0.145	0.290	0.009	**−0.349**
49a	Interorbital breadth	**0.491**	0.223	**−0.435**	0.069	−0.295	−0.045
50	Anterior interorbital breadth	**0.509**	0.108	**−0.401**	0.187	−0.285	0.018
51	Orbital breadth	**0.557**	−0.086	−0.072	0.285	0.215	0.046
52	Orbital height	0.077	**−0.531**	−0.091	**0.337**	**0.306**	**0.335**
54	nasal breadth	**0.459**	0.021	**−0.466**	0.197	−0.066	0.038
55	nasal height	**0.473**	**−0.408**	0.057	**0.359**	0.264	0.225
57	Least nasal breadth	**0.456**	−0.149	−0.194	0.298	**−0.313**	0.197
	Nasal subtense (calculated)	0.131	−0.270	0.083	0.214	−0.125	0.280
60	External palate length	**0.422**	**0.315**	**0.450**	0.175	0.083	−0.058
61	External palate breadth	**0.492**	−0.148	0.283	0.159	0.091	−0.272
66	Bigonial breadth	**0.411**	0.100	−0.275	−0.080	0.069	**−0.394**
68	Projective length of mandible	**0.458**	**0.385**	0.238	0.095	0.158	0.058
65	Bicondylar breadth	**0.576**	0.140	−0.181	**−0.380**	**0.307**	−0.052
65(1)	Bicoronoid breadth	**0.630**	−0.277	−0.253	−0.231	0.014	−0.207
67	Bimental breadth	**0.362**	0.159	0.048	−0.052	−0.116	−0.285
69	Height of mandibular symphysis	**0.304**	**−0.315**	**0.491**	0.084	0.101	**−0.303**
69(1)	Mandibular body height	**0.438**	−0.247	**0.467**	−0.054	0.177	−0.199
69(3)	Mandibular body breadth	**0.320**	**0.304**	**0.376**	−0.113	−0.140	−0.052
70	Height of mandibular ramus	0.269	0.041	0.204	0.173	0.114	−0.262
71a	Minimum width of ramus	**0.302**	**0.643**	0.201	−0.091	0.177	−0.054
71(1)	Condylo-cornoid breadth	0.253	**0.588**	0.189	−0.029	**0.307**	0.214
	Mandibular condyle breadth	**0.368**	0.272	−0.106	−0.093	0.226	−0.056
	Eigenvalues	11.15	4.43	3.37	3.05	2.07	1.86
	Percent of explained (%)	23.7	9.4	7.2	6.5	4.4	3.9

A bold number means its loading score beyond 0.3

pal component may be interpreted as indicating the total size of skulls. For the second principal component, the sagittal size of the calvaria and facial structure negatively correlate with the variables of the calvarial breadth and the height of facial components (face, orbit, and nose). The third principal component is interpreted as indicating that skull height negatively correlate with facial breadth. The relationship between facial flatness and the height of the orbit and nose can

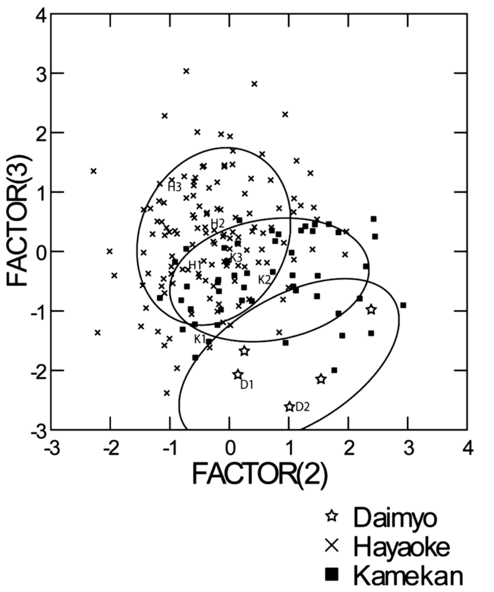

Figure 1. Plot of the second and third principal component scores of male. The ellipses represent the 68.27% confidence interval for each group. The letters in plot correspond to those of Figure 3.

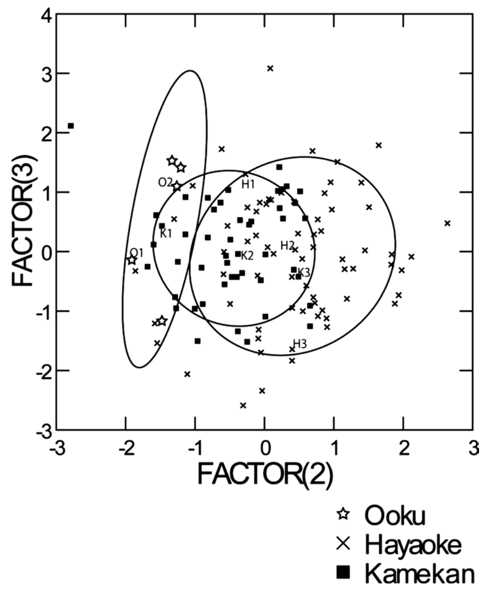

Figure 2 Plot of the second and third principal component scores of females. The ellipses represent the 68.27% confidence interval for each group. The letters in plot correspond to those of Figure 4.

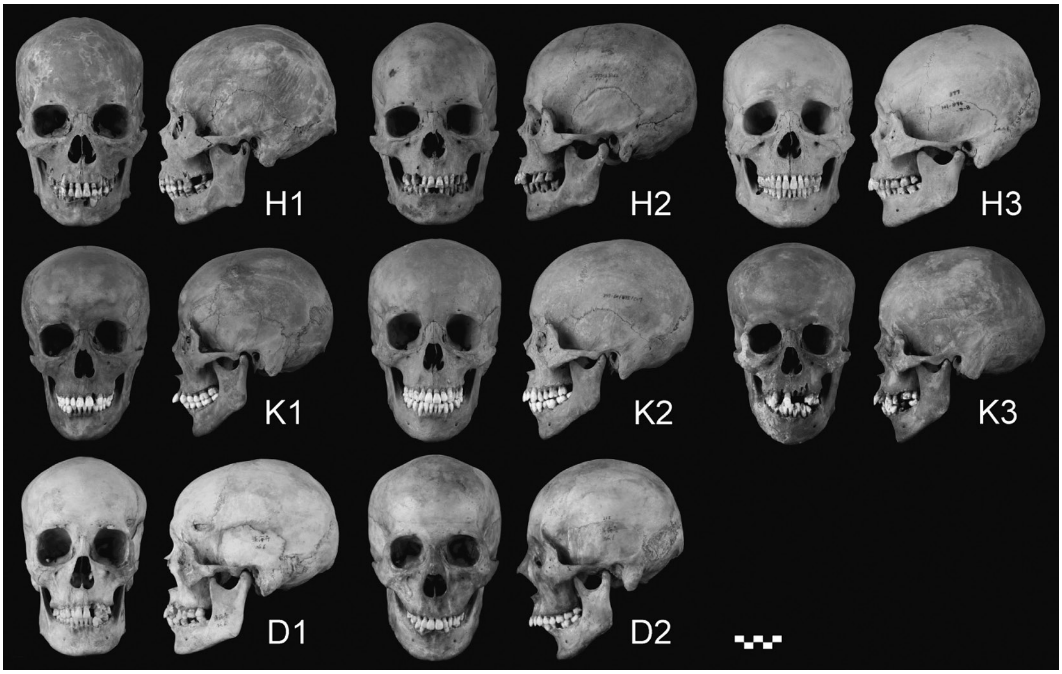

Figure 3 Male examples of each group. The letters correspond to those of Figure 1. "H" means "*Hayaok*e" group, "K" does "*Kamekan*" group, and "D" does "*Daimyo*" group.

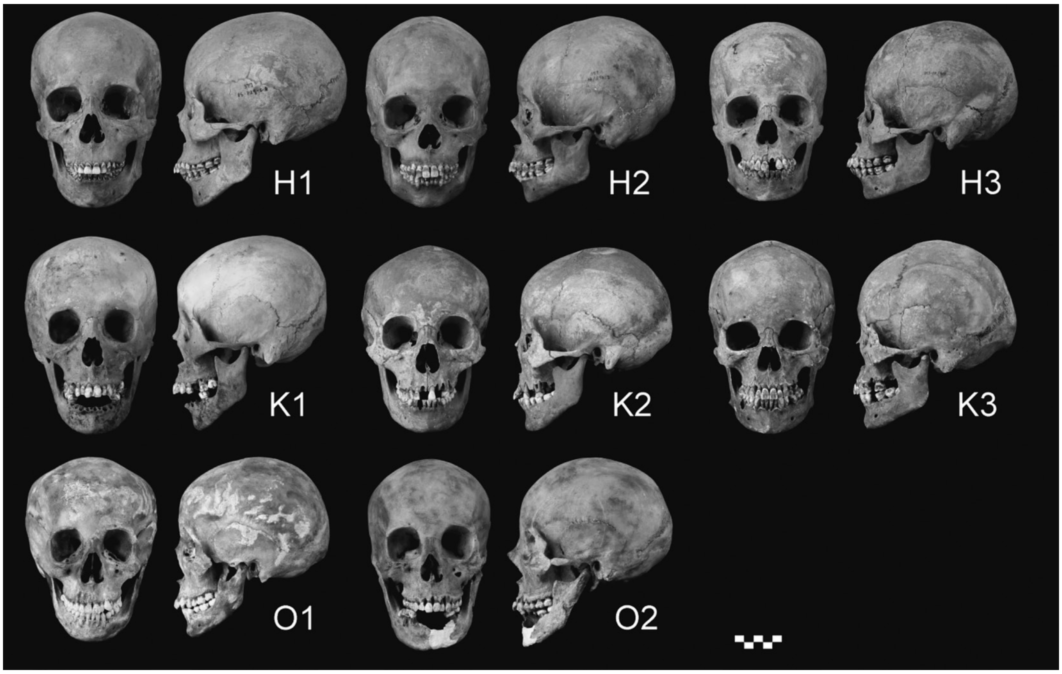

Figure 4 Female examples of each group. The letters are corresponding to those in Figure 2. "H" means "*Hayaoke*" group, "K" does "*Kamekan*" group, and "O" does "*Ooku*" group.

be seen in the fourth principal component; they are negatively correlated with calvarial breadth.

The scatter plots of the second and third principal component scores are presented in Figure 1 for males and Figure 2 for females. The letters in the plots correspond to the photographs in Figure 3 for males and Figure 4 for females. "K" and "H" of these letters mean "*kamekan*" and "*hayaoke*" respectively, and number "K2" and "H2" indicate the nearest individuals to the centroid of each group. In these plots, the group difference between "*kamekan*" and "*hayaoke*" and the transitional cline of these two and "higher class" are evident.

Discussion

This study demonstrates that the skull morphology of the common people of the Edo city was of two types. Because the burial style of the Edo era depended on the sociological status of buried persons (Tanigawa, 1989), the morphological differences in the skulls of the lower-middle classes of samurai and the townsman are apparent. The characteristics of the "*Kamekan*" group in this study are similar to those of the Type II of Suzuki (1985). However, the "aristocratic characteristics" were not restricted to the higher class, and a morphological cline, a sort of "aristocratic tendency," existed among the common Edo people.

Suzuki (1985) argues that the reduction of the masticatory force among the higher class essentially caused their "aristocratic characteristics." In this research, some variables of the maxilla and mandibular of the "*Kamekan*" group tend to be more gracile than those of the "*Hayaoke*" group. Although it is not clear whether the diet and foodstuffs of the lower-middle class of samurai and townsman differed, it is possible that a reduction of stress on the masticatory structure when eating and performing physical labor caused the facial change in the lower-middle class in the Edo era. This issue requires more detail research into postcranial skeletons and into historical records.

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