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Sexual Differences of Dental Crown Measurements in the Neolithic Jomon People

By

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Abstract Sexual differences of dental crown measurements were investigated for the Neolithic Jomon people in Japan. In the first step of analysis, the sexual differences were compared among five regional groups of the Jomon people, and the modern Japanese. PENROSE's distances between the sexes suggested that the sexual differences in all the Jomon groups were larger than that in the modern Japanese. In the next step of analysis, the sexual differences were examined for the pooled Jomon samples. Most of the male crown diameters were significantly larger than the female ones. The discriminant function analyses for sexing the Jomon samples provided several effective discriminant functions based on various combinations of the dental crown measurements with the accuracy of 75–77 percent. These results should be useful for investigators for sexing damaged skeletal remains excavated from Jomon sites.

Introduction

Sexual differences of dental crown measurements have been examined for worldwide human populations by numerous researchers (DICH & ROSE, 1972; GARN *et al.*, 1964, 1966, 1967, 1977, 1979; TANAKA, 1961; HANIHARA, 1978, HANIHARA & KOIZUMI, 1979). These studies demonstrated significant sexual differences in respective population samples examined. As stated by HANIHARA (1978), pattern of the sexual difference is peculiar to each population sample. In some of the previous studies, discriminant function analyses were attempted and some effective discriminant functions for sexing have been provided.

A large amount of prehistoric skeletal remains have been excavated from the Neolithic Jomon sites in various districts of Japan. The determination of sex for these Jomon skeletal remains has been done by investigators relying on the traditional visual method. But, such sexing technique can be utilized only on a sufficiently good state of skeletal preservation. In case of damaged or fragmentary skeletons, dental crown size must give a clue to identify the sex when the dentition are well preserved. Since BRACE & NAGAI (1982) demonstrated that the dental crown size of the Jomon people was significantly smaller than that of the modern Japanese, the discriminant functions on the bases of the modern Japanese samples, as have been provided by TANAKA (1961) and HANIHARA & KOIZUMI (1979), can not be employed in sexing the Jomon samples.

In the present paper, sexual differences of dental crown measurements in the Jomon people were examined using several statistical analyses. Regarding the dental crown size, previous paper (MATSUMURA, 1989) revealed significant geographical variation whithin the Jomon people. In the first step of analysis, therefore, the sexual differences of dental crown size were compared among five regional groups of the Jomon people. At the same time, the sexual difference in the modern Japanese was compared with those in the regional groups of the Jomon people. In the next step of analysis, the discriminant function analysis for sexing was performed on the pooled Jomon samples. In order to provide utilizable discriminant functions in several states of dental preservation, the analysis was attempted on the bases of various combinations of the dental measurements.

Materials and Methods

The materials examined in the present study were the permanent dentition of the skeletal remains, dating from the middle to latest Jomon stages, excavated from the Hokkaido, Tohoku, Kanto, Tokai and San'yo districts in Japan. These samples are from the collection in the Department of Anatomy of Sapporo Medical College, the Department of Anthropology and Prehistory of the University Museum of the University of Tokyo, the Department of Anthropology of the National Science Museum, Tokyo, and the Primate Research Institute and the Laboratory of Physical Anthropology of Kyoto University.

The dental samples of the modern Japanese were represented by those from the Kanto district. They are the skeletal collection housed at the University Museum of the University of Tokyo.

The sex of each individual modern Japanese sample was positively known from written record. The Jomon samples were sexed by the previous investigators and the present author from the view of the skeletal morphology.

Mesiodistal and buccolingual crown diameters were measured on the right side dentition from the central incisors to the second molars in both jaws, according to the system of dental measurements of FUJITA (1949). When the right side tooth was inappropriate for measurement, then the left side dentition was measured as a substitute.

The distance analysis (CONSTANDSE-WESTERMANN, 1972), the multidimensional scaling method (MDS) (TORGERSON, 1958), and the discriminant function analysis (FISHER, 1936) were attempted on the basis of thus obtained data.

Geographical Variation of Sexual Differences within the Jomon People

In the first step of analysis, geographical variation of sexual difference in the dental crown measurements was examined by the distance analysis. The data of the crown measurements given in the other paper (MATSUMURA, 1989) were used. The

Table 1. PENROSE's distances between the sexes based on 16 crown measurements.

Population	Size	Shape
Hokkaido Jomon	0.492	0.129
Tohoku Jomon	0.563	0.110
Kanto Jomon	0.446	0.048
Tokai Jomon	0.574	0.047
San'yo Jomon	0.586	0.100
Modern Japanese	0.182	0.067

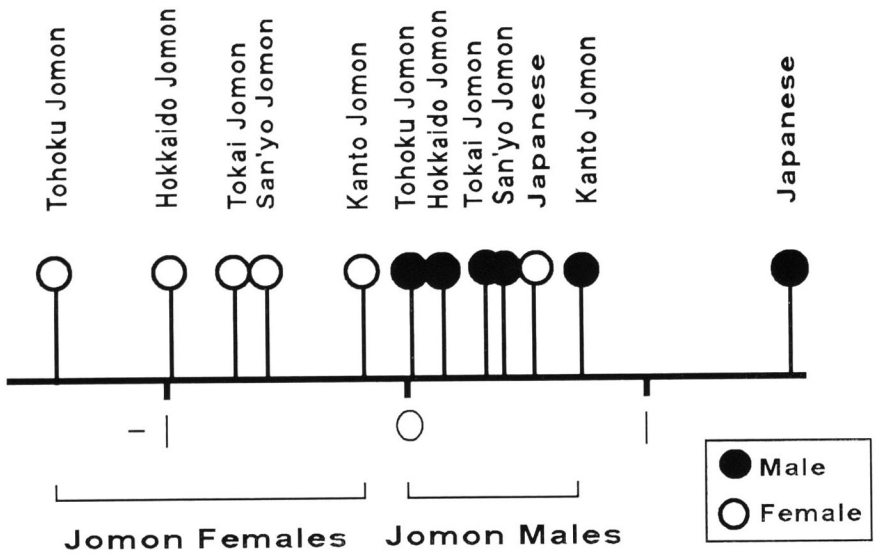

Fig. 1. One dimensional expression of the MDS applied to the PENROSE's size distances.

measurements of the incisors and canines were excluded in this examination, because the numbers of these teeth were not sufficient for statistical analysis. The small sample size of the anterior teeth was chiefly due to customary tooth evulsion among the Jomon people. Thus, 16 measurements concerning the premolars and molars were used in the computations of distances.

Table 1 presents the Penrose's size and shape distances computed between the sexes for the five regional Jomon groups and modern Japanese. The size distances between the sexes are considerably greater in all the Jomon groups than in the modern Japanese. Figure 1 represents the population relationships by the MDS applied to the size distances. It is obvious that the overall tooth sizes of males are larger than those of females in all the regional Jomon groups. In this diagram, the male and female ranges in the Jomon groups do not overlap each other. On the other hand, the female modern Japanese are contained within the range of the Jomon males.

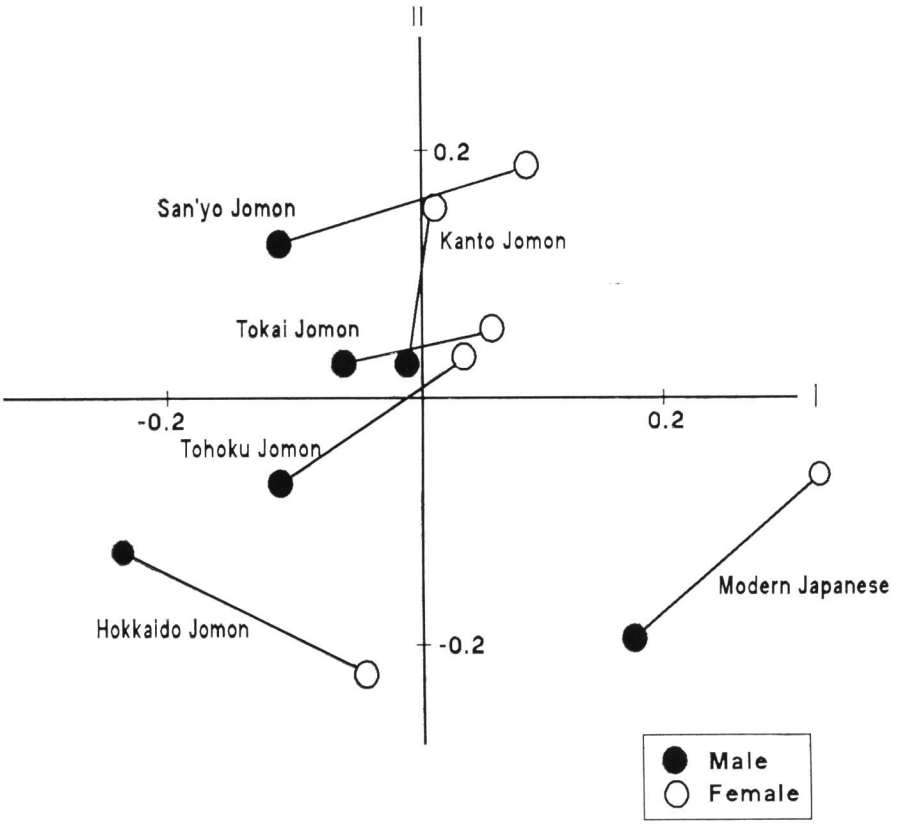

Fig. 2. Two dimensional expression of the MDS applied to the PENROSE's shape distances.

In the shape distances between the sexes given in Table 1, the Kanto and Tokai Jomon groups have smaller sexual differences than the other Jomon groups, as well as the modern Japanese. Figure 2 is a two dimensional expression of the MDS applied to the shape distances. On the first axis the modern Japanese are separated from the five regional Jomon groups. The geographical differences of the Jomon people are represented on the second axis. The Hokkaido Jomon people are slightly distant from the other regional Jomon groups. This finding accords with the previous result of geographical comparison within the Jomon people (MATSUMURA, 1989). The sexual differences tend to be displayed on the first axis, as a whole. The males are plotted on the left side of the females both in the Jomon groups and modern Japanese.

Figure 3 represents the mean square distances between the sexes for the five Jomon groups and modern Japanese on purpose to compare the sexual differences in total aspects. The sexual differences of metrical dental characteristics in the five Jomon groups are larger than that of the modern Japanese.

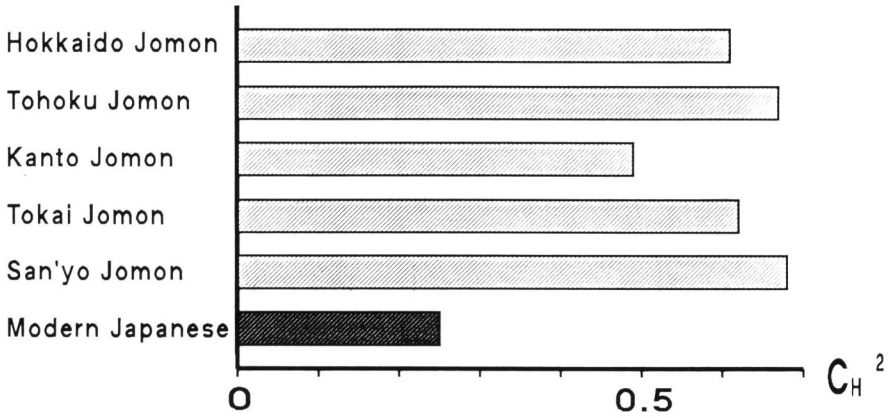

Fig. 3. Penrose's mean square distance between the sexes.

Discriminant Function Analysis for Sexing the Jomon Samples

The above distance analyses for examination of the geographical variation of sexual difference on the bases of the mean dental crown measurements demonstrated that the dispersion of the five Jomon males and that of the Jomon females did not overlap each other both in size and shape components, as a whole. Thereby, the examination of sexual difference and the discriminat function analysis for sexing were performed on the pooled Jomon samples.

Table 2 gives the means and standard deviations of mesiodistal and buccolingual crown measurements for the total samples of 711 Jomon individuals. In addition, Table 1 presents the *t*-values computed for the sexual differences between the mean values. The means of males exceed those of females, and the differences are highly significant in most of the crown measurements. Figure 4 diagrams the male/female ratios of the mean crown measurements. The crown size of males are approximately 103 to 104 percent of the females except for the mesiodistal diameters of the lower incisors.

For the discriminant function analysis, abundant sets of individual data without any missing measurements are needed. If all the measurements are employed in the computation, available data are insufficient even from the pooled Jomon samples. However, by using 16 crown measurements excluding those of the incisors and canines, sufficient sample size was obtained for the discriminant function analysis. The analysis was performed by means of the direct method and stepwise method of computation. Table 3 gives the discriminant function coefficients computed using the 16 measurements. In application of these discriminant functions to individual specimens, a score greater than 0 is more probably male, and one less than 0 is more likely female. As a result of the direct method of computation, the sexes could be correctly identified 76 percent of 162 specimens.

By using the stepwise method of computation, four measurements, concerning the

Table 2. Basic statistics for mesiodistal and buccolingual crown diameters in the males and females of the pooled Jomon people.

Dentition	Jomon Males			Jomon Females			Sexual Difference	
	n	$\bar{X}$ (mm)	SD	*n*	$\bar{X}$ (mm)	SD	*t*-value	M/F %
Mesiodistal Diameter								
UI1	108	8.51	0.40	74	8.28	0.42	3.73***	102.7
UI2	106	7.10	0.47	78	6.84	0.51	3.57***	103.8
UC	68	7.55	0.42	54	7.33	0.52	2.58**	103.0
UP1	153	6.90	0.38	127	6.65	0.48	4.86***	103.7
UP2	183	6.46	0.40	164	6.30	0.44	3.54***	102.5
UM1	190	10.28	0.47	170	9.90	0.49	7.55***	103.8
UM2	172	9.12	0.60	150	8.81	0.54	4.84***	103.5
LI1	61	5.27	0.36	49	5.23	0.41	0.54	100.7
LI2	91	5.72	0.37	62	5.70	0.36	0.33	100.3
LC	112	6.73	0.45	85	6.50	0.37	3.83***	103.5
LP1	172	6.91	0.37	165	6.61	0.47	6.52***	104.5
LP2	190	6.94	0.45	187	6.68	0.52	5.19***	103.8
LM1	210	11.61	0.45	209	11.15	0.49	10.00***	104.1
LM2	201	10.80	0.63	200	10.44	0.58	5.95***	103.4
Buccolingual Diameter								
UI1	125	7.29	0.34	93	7.00	0.34	6.22***	104.1
UI2	118	6.69	0.42	95	6.38	0.38	5.58***	104.8
UC	71	7.96	0.49	58	7.71	0.51	2.83**	103.2
UP1	153	9.27	0.49	124	8.96	0.55	4.95***	103.4
UP2	184	9.00	0.58	165	8.75	0.52	4.22***	102.8
UM1	189	11.78	0.51	176	11.37	0.48	7.89***	103.6
UM2	175	11.45	0.62	151	10.97	0.58	7.18***	104.3
LI1	79	5.93	0.36	59	5.68	0.34	4.13***	104.4
LI2	108	6.20	0.37	78	6.10	0.43	1.69	101.6
LC	115	7.44	0.51	88	7.11	0.40	5.00***	104.6
LP1	173	7.79	0.48	167	7.50	0.51	5.40***	103.8
PL2	192	8.33	0.48	190	8.02	0.52	6.06***	103.8
LM1	218	11.23	0.43	210	10.83	0.48	9.08***	103.6
LM2	207	10.47	0.51	197	10.06	0.51	8.07***	104.0

U: Upper, L: Lower, M: Males, F: Females. Significance level: ** 1%, *** 0.5%.

upper first premolar, upper second premolar, upper second molar and lower first molar, were selected from the 16 measurements for the effective function coefficients, and 75 percent of 162 specimens could be accurately sexed. HANIHARA & KOIZUMI (1979) attempted the discriminant function analysis for sexing on the bases of the dental crown measurements of several worldwide population samples, and pointed out that the measurements of canines, upper first premolar, upper second molar and lower first molar were commonly chosen by use of the stepwise method of computation. It is noteworthy that the similar tendency is observed in the present result from the Jomon samples.

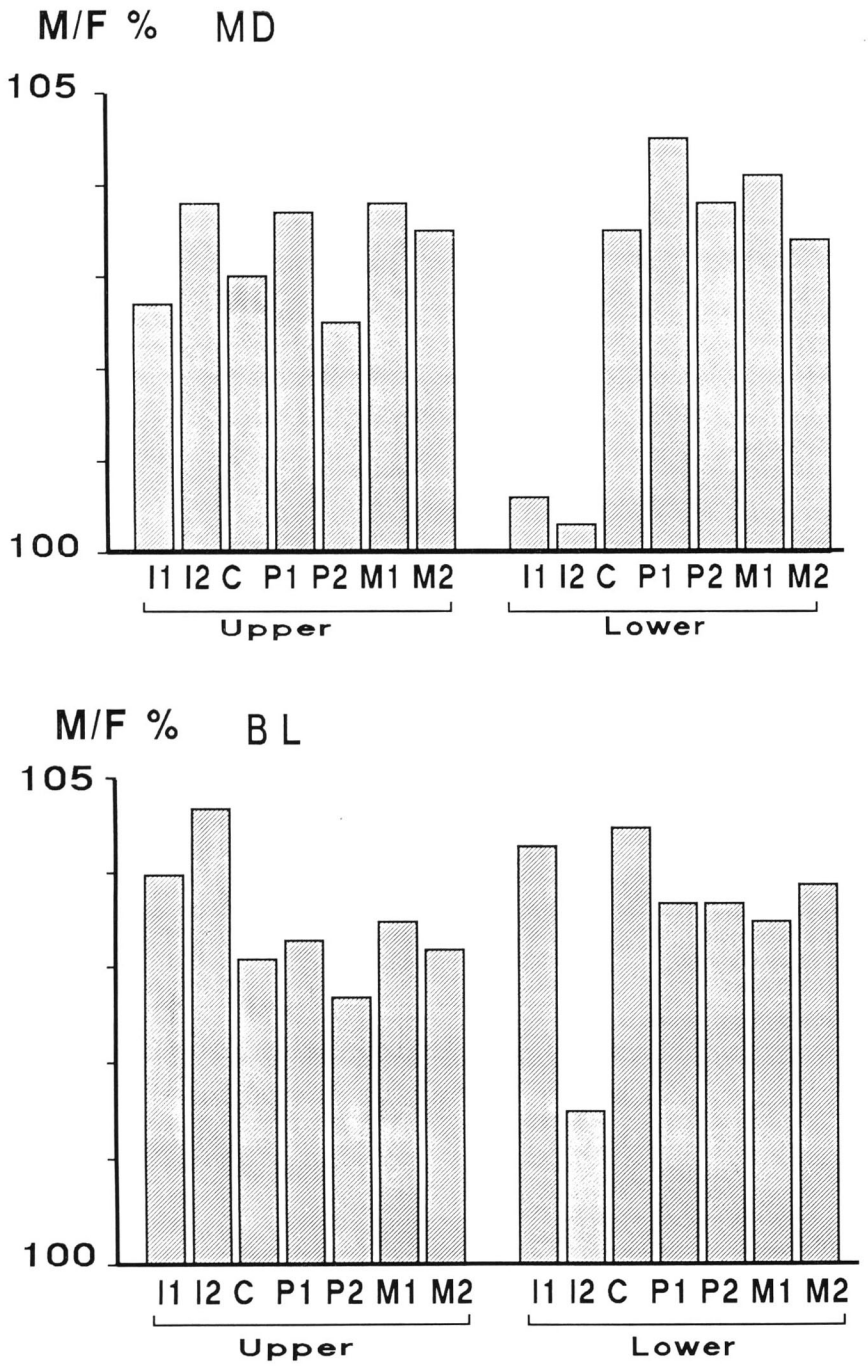

Fig. 4. Diagram of male/female ratio of the mean crown diameters.
MD: Mesiodistal diameter, BL: Buccolingual diameter.

Table 3. Discriminat function coefficients

Dentition	P M (MD BL)	P M (MD)	P M (BL)	UP UM (MD BL)
Sample Size	♂ 89 ♀ 63	♂ 90 ♀ 65	♂ 90 ♀ 65	♂ 113 ♀ 92
Coefficient (Direct Method)				
MD UI1				
MD UI2				
MD UC				
MD UP1	1.231	0.684		0.677
MD UP2	0.293	−0.197		−0.135
MD UM1	−0.119	0.313		0.515
MD UM2	−0.097	0.205		0.262
MD LI1				
MD LI2				
MD LC				
MD LP1	−0.975	0.971		
MD LP2	−1.032	−0.793		
MD LM1	0.694	1.144		
MD LM2	−0.048	0.134		
BL UI1				
BL UI2				
BL UC				
BL UP1	−0.552		0.154	−0.121
BL UP2	−1.303		−1.287	−0.984
BL UM1	0.349		0.850	1.103
BL UM2	1.361		0.948	1.311
BL LI1				
BL LI2				
BL LC				
BL LP1	−0.223		−0.038	
BL LP2	0.770		0.452	
BL LM1	0.278		0.230	
BL LM2	0.108		0.437	
Constant	−26.573	−24.282	−20.986	−28.996
Rate of Correct	76.316 %	71.613 %	75.484 %	75.610 %
Mean Score (Male)	0.6193	0.4290	0.4175	0.6540
Mean Score (Female)	−0.8749	−0.5941	−0.5781	−0.8032
σ (Pooled Score)	1.420	1.125	1.106	1.403
Coefficient (Stepwise Method)				
	MD LM1 0.957	MD LM1 1.374	BL UM1 1.224	BL UM1 1.016
	BL UM2 1.411	MD UP1 0.937	BL UM2 1.170	BL UM2 1.406
	BL UP2 −1.118		BL UP2 −0.850	BL UP2 −0.850
	MD UP1 1.141			MD UM1 0.789
Constant	−24.667	−22.053	−19.834	−27.994
Rate of Correct	75.658 %	70.323 %	73.548 %	73.659 %
Mean Score (Male)	0.529	0.371	0.376	0.626
Mean Score (Female)	−0.747	−0.514	−0.521	−0.769
σ (Pooled Score)	1.287	1.033	1.041	1.365

U: Upper, L: Lower, MD: Mesiodistal diameter, BL: Buccolingual diameter.

for sexing the pooled Jomon samples.

LP LM (MD BL)	UP UM (MD)	LP LM (MD)	UP UM (BL)	LP LM (BL)
♂ 143 ♀ 128	♂ 115 ♀ 94	♂ 145 ♀ 129	♂ 114 ♀ 93	♂ 147 ♀ 129
	0.779			
	−0.450			
	1.227			
	0.600			
0.958		1.002		
−0.514		−0.359		
1.251		1.505		
−0.381		0.053		
			0.287	
			−1.019	
			1.522	
			1.237	
−0.056				0.180
0.270				0.141
0.311				1.067
0.742				0.668
−26.036	−20.2343	−22.117	−25.117	−21.219
70.111 %	68.421 %	66.058 %	77.295 %	67.029 %
0.4943	0.3883	0.4165	0.5605	0.3395
−0.8032	−0.4750	−0.4681	−0.6871	−0.3868
1.145	1.020	1.036	1.273	0.923
MD LM1	MD UM1	MD LM1	BL UM1	BL LM1
1.141	1.154	1.456	1.604	1.132
BL LM2	MD UM2	MD LP1	BL UM2	BL LM2
0.700	0.545	0.836	1.256	0.795
MD LP1	MD UP1		BL UP2	
0.707	0.589		−0.874	
−24.992	−20.577	−22.262	−24.943	−20.705
69.742 %	68.421 %	65.693 %	74.879%	68.478 %
0.458	0.376	0.408	0.556	0.333
−0.512	−0.460	−0.458	−0.681	−0.380
1.094	1.001	1.024	1.267	0.914

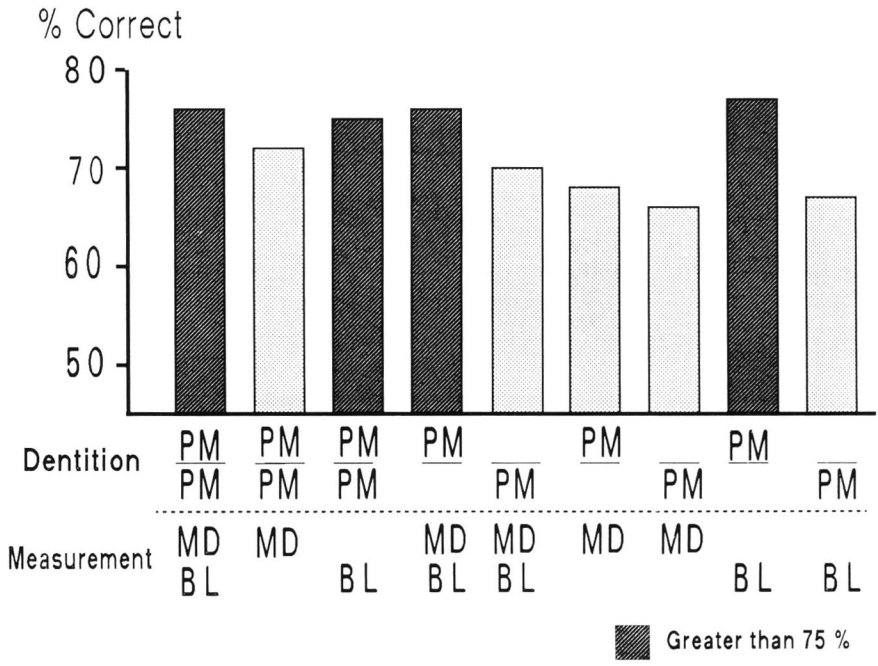

Fig. 5. Accuracy of sexing by application of the discriminant function (by direct method) given in Table 3.

The mean discriminant scores of males ($\bar{Y}_M$) and females ($\bar{Y}_F$), and standard deviations (σ) of the pooled score were calculated, according to the direct and stepwise methods of computations. The results are given in Table 3. The probability that the individual belongs to male or female, $P(G|Y)$, can be computed by the following formula (HANIHARA, 1981).

$$P(G|Y)=\frac{\exp\left[-(Y-\bar{Y}_K)^2/2\sigma^2\right]}{\exp\left[-(Y-\bar{Y}_M)^2/2\sigma^2\right]+\exp\left[-(Y-\bar{Y}_F)^2/2\sigma^2\right]}$$

The four measurements selected by the stepwise method of computation using the 16 crown measurements contain both the mesiodistal and buccolingual diameters, and both the maxillary and mandibular dental crown diameters. As for damaged or fragmentary skeletal remains excavated from Jomon sites, however, this discriminant function is not available for sexing in case any of these four measurements lacked. Thus, in order to determine other effective discriminant functions for various states of dental preservation, additional discriminant function analyses were processed using various combinations of dental crown measurement data. The results are also given in Table 3. Figure 5 is a diagram showing accuracy of sexing by each function resulted from the direct method of computation. The functions that can correctly sex greater than 75% of samples are based on the maxillary dentition or on the buccolingual

crown diameters, as a whole. This tendency suggests that a sample can be sexed with greater accuracy in case the full four maxillary teeth are preserved, or in case the full eight buccolingual measurements were taken. When the functions resulted from the stepwise method of computation on the basis of the same combination of measurements, the specimens can be sexed with approximately the same level of accuracy by smaller number of measurements.

The present findings should aid investigators of human remains from Jomon sites in finding sex discriminant function that will fit the measurements possible on the damaged or fragmentary materials.

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