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Non-Metric Variants in the Postcranial Bones of the Ainu, Iroquois, and Japanese

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Studies on non-metric skeletal variations for the purpose of population distance analysis have increased rapidly since the pioneer works by LAUGHLIN and JØRGENSEN (1956) and BROTHWELL (1959). Most of the works on this line have limited the scope of study to the variants in the skull (e.g. BERRY & BERRY, 1967; OSSENBERG, 1969; KELLOCK & PARSONS, 1970; DODO, 1974, 1975; CYBULSKI, 1975; PIETRUSEWSKY, 1977; YAMAGUCHI, 1977), and only a few authors so far have made use of the non-metric variants of postcranial bones in the analysis of population affinities (ANDERSON, 1968; CZARNETZKI, 1972; FINNEGAN, 1974, 1978; SAUNDERS, 1978).

The purposes of this paper are, first, to record and compare the frequencies of 14 postcranial variants in the skeletal series of Hokkaido Ainu, Ontario Iroquois, and Japanese, and, secondly, to calculate the distances among them by means of the proportions of those variants and compare the results with the distance patterns derived from the analyses of cranial measurements and proportions of non-metric cranial traits that were published previously by the author (YAMAGUCHI, 1977).

Materials

The Ainu materials examined are the 95 skeletons in the University Museum, the University of Tokyo, and the 62 skeletons in the Department of Anatomy, Sapporo Medical College. The former series was collected by the late Dr. Y. KOGANEI from various cemeteries in the central and northeastern parts of Hokkaido, and the latter was collected by Prof. K. MITSUHASHI and the present author from two cemeteries in Hidaka District in central Hokkaido.

The Ontario Iroquoian materials are mixed bones of about 200 disarticulated skeletons, excavated from Carton Ossuary, a secondary mass burial site, probably of 17th century Neutral tribe, in Halton County, southern Ontario, and stored in the Department of Anthropology, the University of Toronto. The materials were sorted and examined by the author while he stayed at Toronto in 1967–1969.

Incidence data of the recent Japanese, to be compared with those of the Ainu and Iroquois, were collected from various sources in the anatomical literature.

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pology, the University of Toronto for the opportunities to examine the Ainu and Iroquoian skeletal collections.

Methods

The following two criteria were employed to select the non-metric variants in the postcranial bones:

(1) Variant should be definable as objectively as possible so that the presence or absence can be judged with least intra- and inter-observer errors.

(2) Variants showing significant sex dimorphism are not desirable because separation of male and female series makes the sample size too samll.

Thus the hypotrochanteric fossa, the third trochanter and similar other continuously varying traits were excluded from the list of variants according to the first criterion in favor of more discrete traits. But some discrete traits such as the septal aperture of the humerus and the pre-auricular sulcus of the ilium, displaying significant sex dimorphism, were not included in consideration of the second criterion.

The 14 non-metric postcranial variants thus selected are as follows:

1) *Superior articular surface of atlas double*

Only the complete osseous division into anterior and posterior facets was scored as present.

2) *Bony bridge over groove for vertebral artery af atlas*

Lateral bridging (2a) from the superior articular process to the transverse process and posterior bridging (2b) from the superior articular process to the arch were treated as a single trait in distance calculation.

3) *Number of sacral vertebrae*

Number of the vertebral segments of each sacrum was recorded. Proportion of the sacra with anomalous number of segments (4 and 6) was used in distance analysis.

4) *Level of sacral hiatus*

The level of the cranial end of the sacral hiatus was recorded with reference to the dorsal sacral foramina. Sacral hiatus reaching the level of the dorsal foramina between the 3rd and 4th sacral vertebrae were scored as 3/4. Those reaching a level higher than the foramina between the 3rd and 4th vertebrae but lower than the foramina between the 2nd and 3rd vertebrae were scored as 3. The proportion of the sacral hiatus higher than 3/4 was used in distance calculation.

5) *Perforation of sternal body*

Only the complete hole was scored as present.

6) *Central pit of glenoid cavity* (Fig. 1)

A small depression in the center of the glenoid cavity of the scapula was scored. Although the pit may look as if it were one of the degenerative changes due to osteoarthritis in case of elderly skeleton, the author regards it as a non-pathological variant of some genetic character, since it occurs not only to mature scapulae of adults, but also

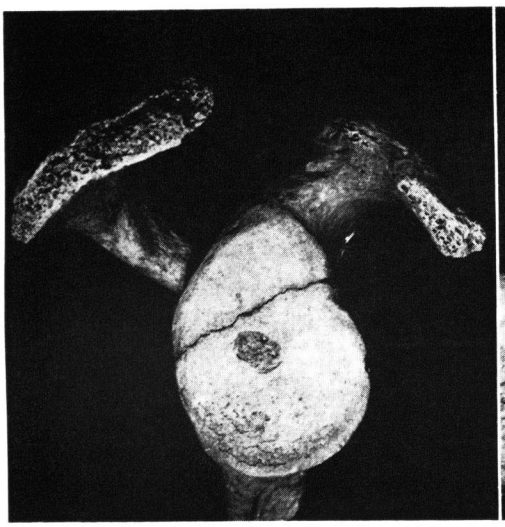

Fig. 1. Central pit of glenoid cavity.

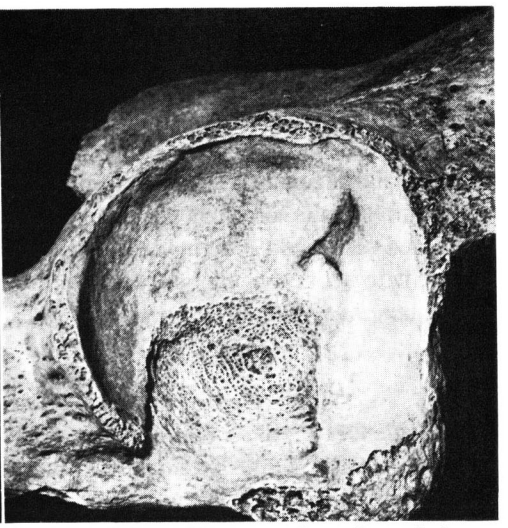

Fig. 2. Defect of lunate surface of acetabulum.

to immature scapulae of juveniles.

7) *Suprascapular foramen*

Bony bridging over the scapular notch as the result of ossification of the suprascapular ligament.

8) *Defect of lunate surface of acetabulum* (Fig. 2)

Pit- or crease-like defect of articular surface of various shape and depth can be seen occasionally in the anterosuperior part of the lunate surface of the acetabulum. It is not the remnant of the cartilaginous junction between the ilium and ischium or pubis, because it occurs also to the lunate surface of the unfused ilia of juveniles.

9) *Empreinte iliaque*

A well-demarcated round depression at the superior part of the anterior surface of the femoral neck, close to the border of the articular surface of the head was scored. Simple extension of the head surface toward the neck and localized erosion of the cortex exposing underlying trabeculae (ALLEN's fossa) in the anterior surface of the neck were disregarded.

10) *Vastus notch*

Shallow notch at the superolateral corner of the patella. Only those of 5 mm or more in breadth were scored.

11) *Bipartite patella*

Defect of ossification at the superolateral corner of the patella.

12) *Lateral squatting facet of tibia*

Superior extension of the lateral part of the anterior margin of the distal articular surface of tibia. Extensions less than 1 mm in maximum vertical diameter were disregarded.

13) *Lateral squatting facet of talus*

Forward extension of the lateral part of the anterior margin of the trochlear surface over the neck of the talus, with sagittally concave curvature. The definition of the type F of BARNETT (1954) was followed.

14) *Anterior and middle talar facets of calcaneus discrete*

Only the complete separation by a bony groove was scored.

Skeletal incidences as well as side incidences could be calculated separately on the male and female series of the Ainu, whereas only the right side incidences in sex-combined series could be investigated for the Iroquois, since the time available was insufficient to work on all bones of both sides and the sexing of separate bones from an ossuary was virtually impossible.

Incidences in the Ainu

Incidences of the 14 non-metric postcranial traits in the Ainu calculated by individual skeletons and by sides for each sex are given in Tables 1～3. Incidences of four pair patterns are also given for 11 bilateral traits.

Sex differences in individual incidences as well as in total side incidences of the 14 variants and side differences of the 11 bilateral variants were tested with the chi square test or the FISHER exact probability test, and all the differences turned out to be insignificant at the level of 0.05.

Incidences in the Iroquois

The right side incidences of 11 bilateral variants and the skeletal incidences of 3 median variants in the Iroquoian ossuary materials of mixed sexes from Carton site are given in Table 4.

Comparison of the Ainu, Iroquois, and Japanese

The incidences of the 14 non-metric variants in the sex-combined skeletal series of the Ainu and the Iroquois are shown by the side of those of the recent Japanese published by various authors in Table 5. Only the right side incidences are given for the bilateral variants. Differences between the incidences in these three series were tested with the level of significance set at 0.05 by the chi square test or the FISHER exact probability test. Results are as follows.

No significant differences are detected between the three skeletal series in the incidences of the atlas with double superior articular surface (1), the sacrum with anomalous number of segments (3), the scapula with the suprascapular foramen (7), the femur with empreinte iliaque (9), the patella bipartite (11), and the talus with lateral squatting facet (13). The incidence of the atlas with groove for vertebral artery bridged (2) is the highest in the Ainu, followed by the Iroquois, and the least in the Japanese. The difference between the Ainu and the Japanese is significant. The sacrum with sacral hiatus reaching over 3/4 (4) occurs most frequently to the Ainu, less

Table 1. Variants of the atlas in the Ainu series.

	Males	Females	?sex	Total		Pair patterns	
1. Superior articular surface double							
Sk	3/53	1/34	1/7	5/94	(*0.053*)	—	89
Lt	2/55	0/34	1/7	3/96	(*0.031*)	L–	2
Rt	2/53	1/35	0/7	3/95	(*0.032*)	–R	2
LR	4/108	1/69	1/14	6/191	(*0.031*)	LR	1
2a. Foramen atlantoideum laterale (Lateral bridging)							
Sk	3/47	1/31	1/6	5/84	(*0.060*)	—	79
Lt	2/51	1/32	1/6	4/89	(*0.045*)	L–	3
Rt	2/48	0/33	0/7	2/88	(*0.023*)	–R	1
LR	4/99	1/65	1/13	6/177	(*0.034*)	LR	1
2b. Foramen atlantoideum posterius (Posterior bridging)							
Sk	5/50	3/33	0/6	8/89	(*0.090*)	—	81
Lt	3/54	2/33	0/6	5/93	(*0.054*)	L–	3
Rt	4/50	2/35	0/7	6/92	(*0.065*)	–R	3
LR	7/104	4/68	0/13	11/185	(*0.059*)	LR	2
2ab. Foramen atlantoideum laterale s. posterius (Lateral or posterior bridging)							
Sk	8/46	3/31	1/6	12/83	(*0.145*)	—	71
Lt	5/50	2/32	1/6	8/88	(*0.091*)	L–	5
Rt	6/47	2/32	0/7	8/86	(*0.093*)	–R	4
LR	11/97	4/64	1/13	16/174	(*0.092*)	LR	3

Sk, Lt, Rt, and LR are frequencies calculated by individual skeletons, left sides, right sides, and total sides. —, L–, –R, and LR stand for bilaterally absent, present on left side only, present on right side only, and bilaterally present.

Table 2. Variants of the sacrum and sternum in the Ainu series.

	Males	Females	?sex	Total	
3. Number of sacral vetebrae					
4 vertebrae	0/41	1/21	0/5	1/67	(*0.015*)
5 vertebrae	28/41	16/21	4/5	48/67	(*0.716*)
6 vertebrae	13/41	4/21	1/5	18/67	(*0.269*)
4. Level of sacral hiatus					
(open)	6/45	1/23	0/5	7/73	(*0.096*)
(1)	0/45	0/23	0/5	0/73	(*0*)
(1/2)	0/45	0/23	0/5	0/73	(*0*)
(2)	0/45	0/23	0/5	0/73	(*0*)
(2/3)	4/45	0/23	0/5	4/73	(*0.055*)
(3)	8/45	7/23	0/5	15/73	(*0.205*)
(3/4)	5/45	4/23	0/5	9/73	(*0.123*)
(4)	10/45	6/23	2/5	18/73	(*0.247*)
(4/5)	11/45	4/23	2/5	17/73	(*0.233*)
(5)	1/45	1/23	1/5	3/73	(*0.041*)
5. Perforation of sternal body					
	3/24	1/15	0/1	4/40	(*0.100*)

Table 3. Variants of the limb bones in the Ainu series.

		Males	Females	?sex	Total		Pair patterns	
6.	Central pit of glenoid cavity							
	Sk	24/40	12/26	1/3	37/69	(*0.536*)	—	32
	Lt	27/50	13/34	1/5	41/89	(*0.461*)	L–	10
	Rt	22/49	10/31	1/6	33/86	(*0.384*)	–R	8
	LR	49/99	23/65	2/11	74/175	(*0.423*)	LR	19
7.	Suprascapular foramen							
	Sk	1/38	0/20	0/3	1/61	(*0.016*)	—	60
	Lt	0/47	1/34	0/4	1/85	(*0.012*)	L–	0
	Rt	1/44	0/21	0/6	1/71	(*0.014*)	–R	1
	LR	1/91	1/55	0/10	2/156	(*0.013*)	LR	0
8.	Defect of lunate surface of acetabulum							
	Sk	16/59	10/33	3/5	29/97	(*0.299*)	—	68
	Lt	11/69	7/36	2/6	20/111	(*0.180*)	L–	7
	Rt	11/61	9/38	2/6	22/105	(*0.210*)	–R	11
	LR	22/130	16/74	4/12	42/216	(*0.194*)	LR	11
9.	Empreinte iliaque							
	Sk	30/39	17/24	3/3	50/66	(*0.758*)	—	16
	Lt	33/45	16/30	3/4	52/79	(*0.658*)	L–	8
	Rt	31/48	17/28	5/5	53/81	(*0.654*)	–R	7
	LR	64/93	33/58	8/9	105/160	(*0.656*)	LR	35
10.	Vastus notch							
	Sk	5/11	5/6	0/0	10/17	(*0.588*)	—	7
	Lt	8/16	5/9	1/1	14/26	(*0.538*)	L–	3
	Rt	7/16	6/10	0/0	13/26	(*0.500*)	–R	2
	LR	15/32	11/19	1/1	27/52	(*0.519*)	LR	5
11.	Bipartite patella							
	Sk	1/11	0/6	0/0	1/17	(*0.059*)	—	16
	Lt	0/16	0/9	0/1	0/26	(*0*)	L–	0
	Rt	1/16	0/10	0/0	1/26	(*0.038*)	–R	1
	LR	1/32	0/19	0/1	1/52	(*0.019*)	LR	0
12.	Lateral squatting facet of tibia							
	Sk	24/29	21/22	1/1	46/52	(*0.885*)	—	6
	Lt	29/38	22/27	2/2	53/67	(*0.791*)	L–	4
	Rt	28/36	23/27	3/3	54/66	(*0.818*)	–R	4
	LR	57/74	45/54	5/5	107/133	(*0.805*)	LR	38
13.	Lateral squatting facet of talus							
	Sk	5/20	2/7	1/2	8/29	(*0.276*)	—	21
	Lt	4/26	2/13	0/3	6/42	(*0.143*)	L–	3
	Rt	4/25	1/9	1/2	6/36	(*0.167*)	–R	4
	LR	8/51	3/22	1/5	12/78	(*0.154*)	LR	1
14.	Anterior and middle talar facets of calcaneus discrete							
	Sk	6/22	1/14	0/0	7/36	(*0.194*)	—	29
	Lt	8/28	1/16	1/3	10/47	(*0.213*)	L–	2
	Rt	4/26	2/18	0/1	6/45	(*0.133*)	–R	0
	LR	12/54	3/34	1/4	16/92	(*0.174*)	LR	5

Table 4. Variants of the postcranial bones in the Iroquoian series. (Male and female materials are combined, and only the right side frequencies are given for the bilateral traits.)

	Variants	Incidence	
1.	Atlas with double superior surface	2/168	(*0.012*)
2.	(a) Atlas with foramen atlantoideum laterale	6/131	(*0.046*)
	(b) Atlas with foramen atlantoideum posterius	2/151	(*0.013*)
	(a, b) Atlas with foramen atlantoideum laterale s. posterius	8/127	(*0.063*)
3.	Sacrum with 4 vertebrae	2/54	(*0.037*)
	〃 〃 5 vertebrae	38/54	(*0.704*)
	〃 〃 6 vertebrae	14/54	(*0.259*)
4.	Sacrum with hiatus reaching the level 3	3/53	(*0.057*)
	〃 〃 3/4	2/53	(*0.038*)
	〃 〃 4	17/53	(*0.321*)
	〃 〃 4/5	18/53	(*0.340*)
	〃 〃 5	13/53	(*0.245*)
5.	Sternum with perforated body	7/45	(*0.156*)
6.	Scapula with central pit of the glenoid cavity	75/151	(*0.497*)
7.	Scapula with suprascapular foramen	2/76	(*0.026*)
8.	Innominate bone with defect of lunate surface	60/141	(*0.426*)
9.	Femur with empreinte iliaque	83/133	(*0.624*)
10.	Patella with vastus notch	86/126	(*0.683*)
11.	Patella bipartite	2/126	(*0.016*)
12.	Tibia with lateral squatting facet	77/101	(*0.762*)
13.	Talus with lateral squatting facet	31/150	(*0.207*)
14.	Calcaneus with discrete anterior and middle talar facets	47/154	(*0.305*)

to the Japanese, and rarely to the Iroquois. Differences between the three series are all significant. The sternum with perforated body (5) is the most frequent in the Iroquois, less in the Ainu, and the least in the Japanese. Although the difference between the Iroquois and the Ainu is not significant, the differences between the Japanese and the two formers are significant. Incidence of the scapula with central pit of the glenoid cavity (6) is the highest in the Iroquois, lower in the Ainu, and the lowest in the Japanese. Only the difference between the Iroquois and the Japanese is significant. The innominate with defect of the lunate surface is frequent in the Iroquois, and much less frequent in other series. Differences between the Iroquois and the two others are significant. Incidence of the patella with vastus notch (10) is considerably higher in the Iroquois and the Ainu than in the Japanese. Differences of the Japanese from the two former series are both significant. The tibia with lateral squatting facet (12) is also common in the Iroquois and the Ainu, and less frequent in the Japanese. The incidence in the latter is again significantly lower than those in the two other series. The calcaneus with completely separated anterior and middle talar facets (14) is significantly less frequent in the Ainu than in the Iroquois and the Japanese.

Of these 14 variants, the 9th, 10th, 12th, and 13th are generally regarded to be causally related with the habit of squatting. The incidences of these four squatting

Table 5. Comparison of the incidences of the 14 postcranial variants in the Iroquoian, Ainu, and Japanese skeletal series. (The two sexes are combined, and only the right side incidences are given for the bilateral traits.)

Variants	Iroquois		Ainu		Japanese		Significant differences
	(*n*)	*P*	(*n*)	*P*	(*n*)	*P*	
1. Atlas with double superior articular surface	(168)	*0.012*	(95)	*0.032*	(229)	*0.009*[1,2,3]	
2. Atlas with groove for vertebral artery bridged	(127)	*0.063*	(86)	*0.093*	(214)	*0.023*[4]	A>J
3. Sacrum with anomalous number of segments	(54)	*0.296*	(67)	*0.284*	(231)	*0.299*[1,2]	
4. Sacrum with sacral hiatus higher than 3/4	(53)	*0.057*	(73)	*0.356*	(167)	*0.192*[1,2,5]	A>I, A>J, J>I
5. Sternum with perforated body	(45)	*0.156*	(40)	*0.100*	(559)	*0.025*[6,7,8]	I>J, A>J
6. Scapula with central pit of glenoid cavity	(151)	*0.497*	(86)	*0.384*	(127)	*0.323*[9]	I>J
7. Scapula with suprascapular foramen	(76)	*0.026*	(71)	*0.014*	(332)	*0.018*[10,11]	
8. Innominate bone with defect of lunate surface	(141)	*0.426*	(105)	*0.210*	(128)	*0.117*[9]	I>A, I>J
9. Femur with empreinte iliaque	(133)	*0.624*	(81)	*0.654*	(52)	*0.500*[12]	
10. Patella with vastus notch	(126)	*0.683*	(26)	*0.500*	(224)	*0.295*[13,14]	I>J, A>J
11. Patella bipartite	(126)	*0.016*	(26)	*0.038*	(100)	*0.000*[13]	
12. Tibia with lateral squatting facet	(101)	*0.762*	(66)	*0.818*	(52)	*0.500*[12]	I>J, A>J
13. Talus with lateral squatting facet	(150)	*0.207*	(36)	*0.167*	(52)	*0.096*[12]	
14. Calcaneus with discrete anterior and middle talar facets	(154)	*0.305*	(45)	*0.133*	(138)	*0.326*[15,16]	I>A, J>A

1) OKAMOTO, 1930. 2) HASEBE, 1913. 3) HIBI, 1931–1932. 4) MURAKI, 1964. 5) TSUNEMATSU, 1957. 6) KIKITSU, 1930. 7) TAKENAKA, 1953. 8) HORI, 1928. 9) Present author's unpublished data on the Japanese skeleton from Kanto and Hokkaido. 10) TAKANO, 1958. 11) SAITO, 1933. 12) MITSUHASHI, 1963. 13) KATO, 1953. 14) SAITO, 1966. 15) SUNADA, 1932. 16) TOYOFUKU, 1959.

variants tend to be higher in the Iroquois and the Ainu than in the Japanese.

Apart from these squatting variants, the Iroquoian series is characterized by relatively high frequencies of the sternal perforation, central pit of the glenoid cavity, and defect of the lunate surface, and low frequency of the high sacral hiatus, whereas the Ainu series are by relatively high frequencies of the bridging of the atlas and the high sacral hiatus, and low frequency of the separated anterior and middle talar facets of the calcaneus.

Distance Analysis

Of many different methods devised for the distance analysis of qualitative variables, C. A. B. SMITH's mean measure of divergence (MMD)

$$X=\frac{1}{r}\sum\left[(\theta_1-\theta_2)^2-\left(\frac{1}{n_1}+\frac{1}{n_2}\right)\right]$$

where r is the number of variables, n is sample size, and θ is angular transformation (in radian) of proportion (P) by the formula

$$\theta=\arcsin(1-2P)$$

which had been used most widely in skeletal population comparisons (e.g. BERRY & BERRY, 1967; SJØVOLD, 1973, 1977) was employed here. Null proportion was substituted by $1/4n$ (BARTLETT's adustment).

The MMDs between the Iroquois, the Ainu, and the Japanese series based on the incidences of the 14 variants are given in the 1st column of Table 6. The distance between the Iroquois and the Ainu is the closest, and the Japanese is distant from them, being slightly closer to the Ainu than to the Iroquois.

In a similar distance analysis of the Iroquois, Ainu, and Japanese based on the incidences of 17 non-metric cranial variants (YAMAGUCHI, 1977), lumped together were the Iroquois and the Japanese, and isolated was the Ainu as shown in the 2nd column of Table 6. These two distance patterns do not conform with each other. This situation is entirely different from that of the Eskimo and Aleut skeletons reported by FINNEGAN (1978) where postcranial trait distances correlated very highly with cranial trait distances.

The best possible way, in the present case, to estimate the population distance pattern from the incidences of non-metric characters is to increase the number of variants by combining those of the skull and those of the postcranial skeleton. The 3rd column in Table 6 gives the MMDs calculated from the proportions of the 31 (17 cranial and 14 postcranial) variants altogether. As a result of joining cranial and postcranial variants together, clusters have disappeared and the three series are separated from each other by nearly equal distances. This final pattern resembles that obtained by the shape components of D^2 based on eight representative cranial measurements (YAMAGUCHI, 1977), shown in the 4th column in Table 6.

Although it is hard to assess relative importance of the cranial and postcranial variants in analyzing population affinities, postcranial variants are certainly useful to make the results of distance calculation stable by increasing the number of variants to be analyzed.

Table 6. Distances (MMD) based on the proportions of 14 postcranial and 17 cranial variants and shape components of D^2 based on 8 cranial measuremnts.

	14 postcranial variants	17 cranial variants	31 variants together	shape components of D^2
Iroquois ——Ainu	0.0669	0.1273	0.1000	3.72
Iroquois ——Japanese	0.1414	0.0536	0.0933	3.56
Ainu ———Japanese	0.0833	0.0978	0.0913	2.86

Summary and Conclusion

The incidences of 14 non-metric postcranial variants in the Ainu and Iroquoian skeletal series were recorded (Tables 1～4). They were compared with each other and with those in various Japanese skeletal series (Table 5). The distance based on these postcranial variants was the closet between the Iroquois and the Ainu. However, distance calculated from the incidences of the 17 non-metric variants of the skull (YAMAGUCHI, 1977) had been the closest between the Iroquois and the Japanese. When the 17 cranial and 14 postcranial variants are put together in calculating the distances, the resultant distance triangle is almost equilateral and no cluster is formed. Such patterns of nearly equal interpopulation distances closely resembles the distance pattern obtained by D^2 analyses of the cranial measurements (Table 6). These results seem to suggest the importance of additional information contributed by postcranial variants to the non-metric distance analysis.

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