

## Incidence of Degenerative Bone Changes in the Distal Joint Surfaces of the Humerus and Femur

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**Abstract** The distal articular surfaces of the humerus and femur of the Japanese, the Ainu, and the prehistoric skeletal series of the Jomon period were examined for degenerative bone changes, and the incidences of osteoarthritis were compared with those reported by some authors on several skeletal series from North America. The Jomon skeletal series was found to be one of the healthiest and the Ainu series to be the worst in respect of osteoarthrotic involvement of these major appendicular joint surfaces. The recent Japanese series was intermediate in the liability between those two series, and more similar to the Canadian Eskimo than to the North American White and Black series in the inter-joint incidence pattern.

Osteoarthritis or degenerative disease of articular surface, characterized by porotic destruction (pitting), increase in bone density (eburnation), and/or formation of new bone (osteophyte and lipping), is among the commonest pathological changes observable in macerated or excavated skeletal material (BOURKE, 1967; etc.). Being closely associated with the aging of joint tissues, it generally occurs in later life and the incidence increases with the advance of age.

Besides the age factor, mechanical stresses involved in various physical activities can accelerate the degenerative processes in the joints, causing considerable variations in individuals and in populations as to the extent of affection (BOURKE, 1967; ORTNER, 1968; etc.). JURMAIN (1977, 1980) found, in his analysis of the pattern of involvement of major appendicular degenerative joint disease in the skeletal materials of the Terry Collection, that degenerative diseases in the shoulder and hip joints are highly associated with age while those in the elbow and knee are less dependent on the age factor. This seems to suggest relatively high liability of the elbow and knee joints to localized functional stresses. Particularly high incidence and early onset of degenerative involvement of the elbow joints were reported for Eskimo series by JURMAIN (1977, 1980) and MERBS (1983). Both authors interpreted their findings as indicating severe functional stresses exerted upon the elbow joint in the daily life of the Eskimo.

Although some palaeopathological cases of severe osteoarthrotic involvements of major appendicular joints have been reported (IMAMICHI, 1934; OGATA, 1972; etc.), hardly any attempt has been made at statistical treatment of the osteoarthritis from anthropological view point in this country, except those on the spinal columns (SUZUKI, 1978; WADA, 1975).

The purpose of the present work is to record the frequencies of osteoarthrotic involvement of the stress-sensitive joint surfaces of the distal humerus and distal femur in skeletal samples of modern Japanese, modern Ainu, and prehistoric Jomon population from Japan, and to compare the incidence patterns with those reported so far for various North American populations.

### Materials and Methods

The skeletal materials investigated are listed in Table 1. The Japanese sample was derived from anatomical dissection rooms and well documented as to sex and age at death. Only the skeletons over 20 years of age were examined.

The Ainu and Jomon samples are excavated materials. Subadult skeletons were excluded from these series, and sex was estimated by morphological observation of the innominate bone and the skull. Most of the Ainu materials belong to the Koganei

Table 1. Skeletal materials investigated.

	Male	Female	Total	Provenance	Collection
Jomon material	35	39	74	Iwate and Aichi	Anthrop., Natn. Sci. Museum, Tokyo
Recent Japanese	97	29	126	Kantō and Hokkaidō	Anatomy, Sapporo Medical College
Recent Ainu	56	34	90	Hokkaidō	Museum, University of Tokyo; Anatomy, Sapporo Medical College

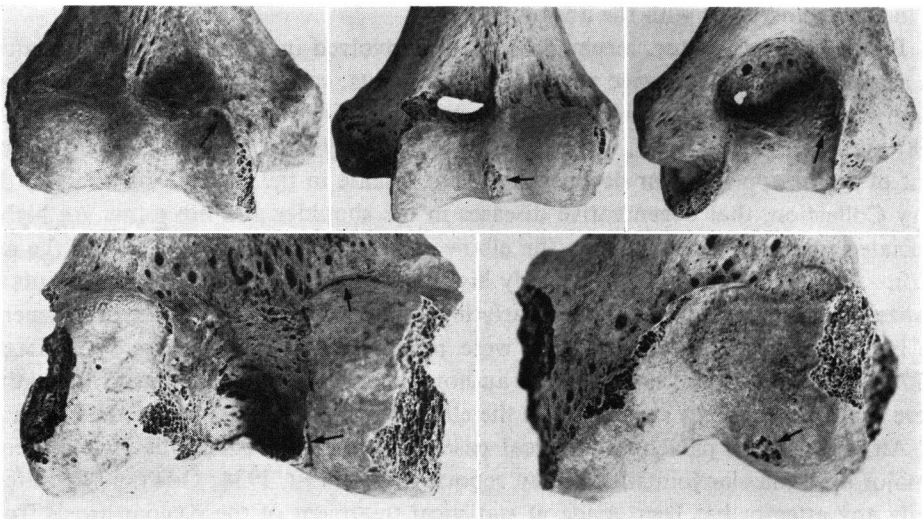


Fig. 1. Examples of degenerative changes, scored as "present", in the distal articular surfaces of the humerus and femur.

Collection collected from Hokkaidō in the 19th century. The Jomon sample, dating to the 1st and 2nd millennia B.C., consists mainly of the skeletal remains from Ebishima shell mound, Iwate Prefecture (YAMAGUCHI, 1983), but it also contains some remains from shell mounds of Miyano in Iwate Prefecture and of Ikawazu in Aichi Prefecture.

As the condition of preservation of the proximal ends of the ulna, radius and tibia is generally less favorable than that of the distal ends of the humerus and femur in excavated skeletal materials, only the distal articular surfaces of the humerus and femur were examined for degenerative changes in this study.

Degenerative change on each articular surface was scored as follows: absent (0), trace (0.5), present (1), or severe (2). For incidence values, "trace" was pooled with "absent", and "severe" was combined with "present". Fig. 1 shows examples of slightest changes scored as "present".

### Incidence and Comparison

The incidences of the degenerative changes of the distal articular surfaces of the humerus and femur in the recent Japanese series, classified by sex, side, and age group, are given in Table 2. The female series could be divided into only two age groups because of small sample size. The table shows that the incidence is higher in females than in males in each age group and increases with the advance of age. It also shows that the elbow joint is more liable to degenerative changes than the knee joint.

The incidence data in six age groups of males are compared graphically with those of the modern American White and Black series, published by JURMAIN (1977), in Fig. 2. Percentage of incidence, as such, can not be compared with due accuracy because JURMAIN scored degenerative involvements of the elbow and knee on the basis of observations not only of the humerus and femur but also of the ulna, radius, and tibia. As regards inter-joint incidence pattern, however, it is almost undoubted that the more frequently affected and in closer age association in the American White and Black series is the knee joint whereas it is the elbow joint instead of the knee joint in

Table 2. Incidences of degenerative changes in the recent Japanese series by age category.

Sex	Age	Distal humerus		Distal femur	
		Right	Left	Right	Left
Male	20~29	0 in 14 ( 0.0)	0 in 14 ( 0.0)	0 in 14 ( 0.0)	0 in 14 ( 0.0)
	30~39	3 in 21 (14.3)	1 in 20 ( 5.0)	0 in 21 ( 0.0)	0 in 21 ( 0.0)
	40~49	4 in 26 (15.4)	5 in 27 (18.5)	2 in 27 ( 7.4)	6 in 27 (22.2)
	50~59	3 in 18 (16.7)	4 in 18 (22.2)	3 in 17 (17.6)	7 in 18 (38.9)
	60~84	12 in 17 (70.6)	10 in 17 (58.8)	3 in 17 (17.6)	3 in 17 (17.6)
	Total	22 in 96 (22.9)	20 in 96 (20.8)	8 in 96 ( 8.3)	16 in 97 (16.5)
Female	20~49	2 in 14 (14.3)	5 in 14 (35.7)	1 in 14 ( 7.1)	2 in 14 (14.3)
	50~81	10 in 15 (66.7)	6 in 15 (40.0)	6 in 15 (40.0)	5 in 15 (33.3)
	Total	12 in 29 (41.4)	11 in 29 (37.9)	7 in 29 (24.1)	7 in 29 (24.1)

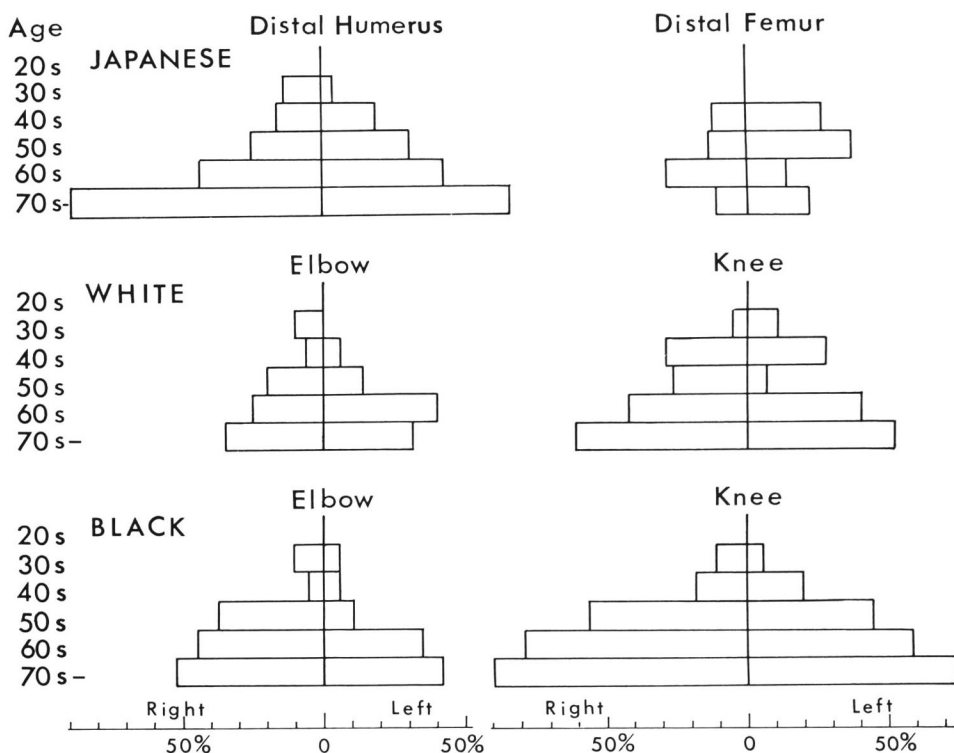


Fig. 2. Incidences of degenerative changes by age group in the male series of the Japanese (present study) and of the American White and Black (JURMAIN, 1977). Age ranges are 21-30, 31-40, 41-50, 51-60, 61-70, and 71+.

the Japanese series. The figure also shows that the right elbow joint is involved slightly more frequently than the left in all series, but there is no such consistent side difference in the frequency of the knee joint involvements.

Since age at death is not known as to the Ainu and Jomon materials, total adult incidence alone has been calculated for each side of each sex of these series. Table 3 gives not only such incidence data obtained in the present study, but also some similar data on other human skeletal series obtained by various authors. Graphically represented in Fig. 3 are incidence patterns of degenerative changes in the right elbow and knee joints of various skeletal series. They are arranged in the order of proportion between the incidences of the elbow and knee involvements.

The overall incidence of osteoarthritis is highest in the Ainu series, next in the Alaskan Eskimo, and lowest in the Jomon and the Pecos Pueblo series. Incidences are nearly equally divided between males and females in all series, with the only exception of the Japanese where the incidences are definitely in favor of males.

As for the relative incidence pattern between the elbow and the knee joints, the

Table 3. Comparison of adult incidences of degenerative changes in various Japanese and North American skeletal series.

	Elbow joint						Knee joint						Sources	
	Right			Left			Right			Left				
	N	%	m.s.*	N	%	m.s.*	N	%	m.s.*	N	%	m.s.*		
Ainu**	{M	29	79.3	(0.828)	39	71.8	(0.795)	41	36.6	(0.415)	40	30.0	(0.300)	present study
	{F	20	65.0	(0.750)	22	45.5	(0.500)	23	52.2	(0.652)	25	36.0	(0.440)	
Jomon**	{M	23	26.1	(0.261)	24	25.0	(0.292)	14	21.4	(0.214)	13	23.1	(0.231)	present study
	{F	25	16.0	(0.200)	27	22.2	(0.278)	10	20.0	(0.200)	17	5.9	(0.059)	
Japanese**	{M	96	22.9	(0.240)	96	20.8	(0.208)	96	8.3	(0.083)	97	16.5	(0.165)	present study
	{F	29	41.4	(0.414)	29	37.9	(0.379)	29	24.1	(0.241)	29	24.1	(0.241)	
Iroquoian**	M & F	127	26.0					121	28.9					YAMAGUCHI***
American White	{M	107	18.3					107	30.0					JURMAIN, 1980
	{F	103	13.7					103	46.5					
American Black	{M	116	25.0					116	42.7					JURMAIN, 1980
	{F	118	22.6					118	50.5					
Pecos Pueblo	{M	111	15.2					111	31.0					JURMAIN, 1980
	{F	97	13.4					97	16.1					
Alaskan Eskimo	{M	80	49.1					80	45.9					JURMAIN, 1980
	{F	66	29.3					66	36.0					
Canadian Eskimo	{M	41	39		41	38		41	15		41	13		MERBS, 1983
	{F	50	33		50	23		50	7		50	5		

\* Mean of scores of involvement (absent=0, trace=0.5, present=1, severe=2).

\*\* Scored on the basis of examinations of the distal joint surfaces of the humerus and femur.

\*\*\* Unpublished data on the historic Iroquoian ossuary material from Carton site, Ontario.

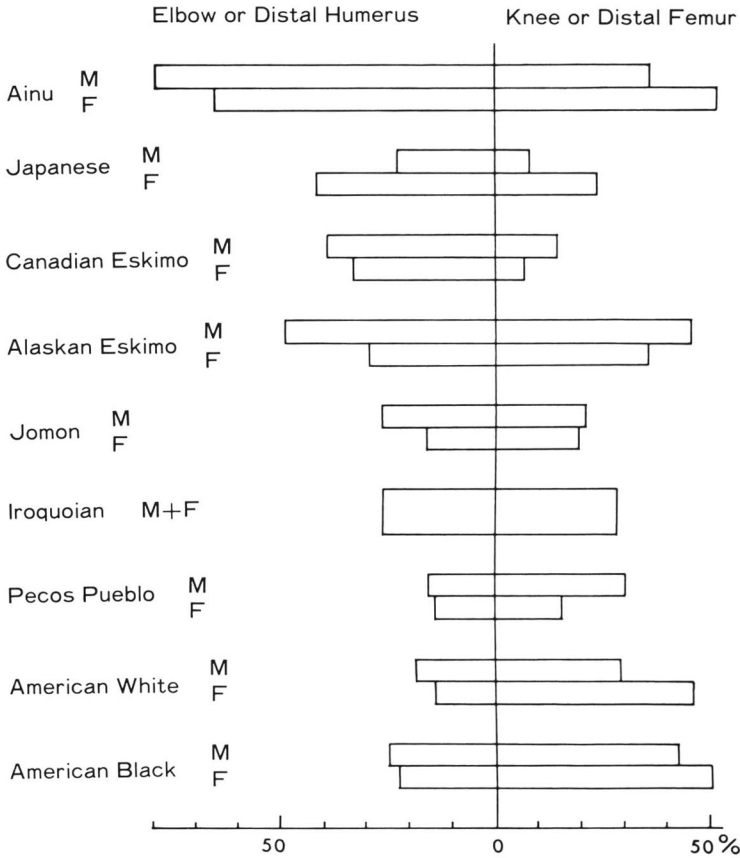


Fig. 3. Incidences of degenerative changes in the right elbow and knee joints.

elbow involvement predominates the knee involvement in the Ainu, Japanese, and Canadian Eskimo series, whereas the latter is greater than the former in the Pecos Pueblo, American White and American Black series. The Alaskan Eskimo, Jomon, and Iroquoian series show nearly equivalent incidences in the elbow and knee joints.

### Discussion

The marked difference in the osteoarthrotic morbidity between the Ainu and the Japanese series is hardly ascribable to the difference in age structure of those skeletal materials, since it is unlikely that the average age of death of the former series is much higher than that in the latter (45.6 years in males and 51.8 years in females). It may be worthy of noting in this respect that chronic rheumatism was recorded as the commonest disease among the Ainu by SEKIBA (1896) who gave nearly four hundred Ainu patients free surgical treatment at Sapporo between 1892 and 1895. He blamed the

condition on intense labors in unfavorable climate. It is thus probable that the high frequency of osteoarthrotic degenerations in the Ainu skeletal material actually reflect the prevalence of joint diseases among the Ainu. Incidentally, the trochlea is involved more than three times as often as the capitulum in the distal humerus of the Ainu.

On the other hand, the prehistoric Jomon series was found much healthier, with rather low incidences of osteoarthrotic involvement, especially in females. One possible explanation may be that many of the people in the Jomon period died too early to have their appendicular joints involved in senile degenerative changes. It is highly probable that the average age of death of the Jomon people was considerably lower than that of the modern Japanese (KOBAYASHI, 1967).

The considerable sex difference in the Japanese series can not be attributed to the difference in the age structure of the male and female series, because the female incidence in each age group is higher than the male incidence in the same age group. It may reflect some differences in behaviors between males and females. MORIMOTO (1982) examined attrition lesions of articular cartilage in the knee joint of a large number of Japanese cadavers of both sexes and found higher incidence of lesions in female cadavers. He explained the difference in the incidence of lesions as due to different postural habits of males and females in Japan.

The preponderance of the elbow in osteoarthrotic involvement over the knee among the Ainu, Japanese, and Canadian Eskimo series is well contrasted with the pattern shown by the American White and Black series where the knee is more frequently involved than the elbow. TAINTER (1980) found a similar difference in the incidence pattern between the series of different social ranking in a Middle Woodland mortuary population from the lower Illinois River Valley. He attributed the incidence pattern in the series of lower social ranks, viz. more frequent in the elbow and less in the knee, to more intense physical activities and smaller body size, and, on the other hand, the pattern in the series of higher social level, viz. more frequent in the knee and less in the elbow, to their status-linked lower physical activity and higher nutritional level resulting in larger body size.

MERBS (1983) found, in his systematic study of Canadian Eskimo skeletal pathology, much higher incidences of osteoarthritis in the upper limb joints than in the lower limb joints, and interpreted the pattern as due to physical stresses involved in such activities as Kayak-paddling, skin scraping, and so on.

The Japanese series also shares the tendency toward greater osteoarthrotic involvement of the elbow than the knee with the Canadian Eskimo series and the Middle Woodland lower class series. This is not contrary to the explanations given by TAINTER (1980) and MERBS (1983), since the Japanese series was derived from dissection room cadavers which would generally represent underprivileged class characterized by low level of nourishment and intense physical labors.

However, BROTHWELL (1961) reported on early British skeletal materials of pre-Conquest date that while 21.2% of 270 femora were osteo-arthritic, only 12.6% of

223 humeri were involved. This may suggest a possible genetic predisposition of the Europeans for liability to osteoarthritis in the lower limbs. Thus, before putting an interpretation on different inter-joint incidence patterns of osteoarthritis, it is necessary to analyze more materials of larger sample size, from different provenance, and of different average body size.

### Conclusions

The Jomon population is one of the healthiest of all compared series in terms of osteoarthrotic involvement, whereas the modern Ainu is the worst, especially in the incidence of the elbow involvement. The modern Japanese are intermediate between those two series in the frequency of the osteoarthrotic involvement, and are very similar to the Canadian Eskimo in the generalized frequencies as well as in the tendency toward greater involvement in the elbow than in the knee and quite different from the modern American White and Black populations who are characterized by higher morbidity in the knee than in the elbow.

### Acknowledgments

Professor K. MITSUHASHI in Sapporo, Professor T. OOË, and Professor H. SUZUKI in Tokyo are cordially acknowledged for their kindness in allowing the author access to the collections under their custody.

### References

- BOURKE, J. B., 1967. A review of the palaeopathology of the arthritic diseases. In: D. BROTHWELL and A. T. SANDISON (eds.), *Diseases in Antiquity* (Springfield, C. C. Thomas), 352–370.
- BROTHWELL, D., 1961. The palaeopathology of early British man: an essay on the problems of diagnosis and analysis. *J. Roy. Anthrop. Inst. Gr. Brit. Irel.*, **91**: 318–344, Pl. III-X.
- IMAMICHI, Y., 1934. On the arthritis deformans of the cubital joint among the stone age people of Japan. *J. Anthrop. Soc. Tokyo*, **49** (Suppl. V): 1–4. (In Japanese.)
- JURMAIN, R. D., 1977. Stress and the etiology of osteoarthritis. *Am. J. Phys. Anthrop.*, **46**: 353–365.
- 1980. The pattern of involvement of appendicular degenerative joint disease. *Am. J. Phys. Anthrop.*, **53**: 143–150.
- KOBAYASHI, K., 1967. Trend in the length of life based on human skeletons from prehistoric to modern times in Japan. *J. Fac. Sci., Univ. of Tokyo, Sec. V*, **3**: 107–162, Pl. I-II.
- MERBS, C. F., 1983. Patterns of activity-induced pathology in a Canadian Inuit population. *Natn. Mus. Man Mercury Series, Archaeol. Survey of Canada Paper No. 119*. xvi+199 pp. Ottawa, National Museums of Canada.
- MORIMOTO, I., 1982. Attrition lesions of articular cartilage in Japanese knee joint due to formal sitting and squatting postures. *J. Anthrop. Soc. Nippon*, **90** (Suppl.): 163–176.
- OGATA, T., 1972. Palaeopathological studies on the ancient Japanese skeletons. *Niigata Igakkai Zasshi* (Niigata Med. J.), **86**: 466–477, Pl. I-VIII. (In Japanese.)
- ORTNER, D. J., 1968. Description and classification of degenerative bone changes in the distal joint surfaces of the humerus. *Am. J. Phys. Anthrop.*, **28**: 139–155.



- SEKIBA, F., 1896. *Ainu Ijidan* (Medical Essays on the Ainu). Sapporo. 227 pp. (In Japanese.) Reprinted in: *Sekiba Rido Senshu* (Selected Papers of Dr. Sekiba) (1966, Tokyo, Kanehara Shuppan), 1–108.
- SUZUKI, T., 1978. A palaeopathological study of the vertebral columns of the Japanese from Jomon to Edo Periods. *J. Anthropol. Soc. Nippon*, **86**: 321–336. (In Japanese, with English summary.)
- TAINTER, J. A., 1980. Behavior and status in a Middle Woodland mortuary population from the Illinois Valley. *Am. Antiquity*, **45**: 308–313.
- WADA, H., 1975. Study of changes in the vertebral bodies of Japanese with the advance of age. *Sapporo Igaku Zasshi* (*Sapporo Med. J.*), **44**: 139–152. (In Japanese, with English summary.)
- YAMAGUCHI, B., 1983. Postcranial bones of the human skeletal remains of the Jomon period from the Ebishima (Kaitori) shell mound in Hanaizumi, Iwate Prefecture. *Memoirs Natn. Sci. Mus., Tokyo*, No. 16: 201–222, Pl. 10. (In Japanese, with English summary.)

