Comparison of the Prevalence of Radiographic Osteoarthritis of the Knee and Hand Between Japan and the United States

SHOJI YOSHIDA, KIYOSHI AOYAGI, DAVID T. FELSON, PIRAN ALIABADI, HIROYUKI SHINDO, and TAI-ICHIRO TAKEMOTO

ABSTRACT. ***Objective.*** There is no direct international comparison of the prevalence of osteoarthritis (OA) between Japanese and Caucasians. We compared the prevalence of radiographic knee and hand OA between women in Hizen-Oshima, Japan, and in Framingham, Massachusetts, USA.

Methods. A population based cross sectional study among 358 women in Japan and 815 women in the USA aged 63 years or older for knee joints, and 157 women in Japan and 655 women in the USA aged 71 years or older for hands. Radiographs were obtained of knees and hands, and were graded according to the Kellgren-Lawrence (K-L) criteria. Definite OA was defined as K-L grade 2 or higher, present in at least one joint of a given group. A person was defined as having OA or not in a given joint group, and we used logistic regression with the US group as referent to determine the prevalence odds ratio of OA among Japanese.

Results. The age adjusted prevalence of knee OA in Japanese women was higher than in Caucasians (OR 1.96, 95% CI 1.50–2.56), while the prevalence of hand OA other than distal interphalangeal joint in Japanese was lower than in Caucasians (OR for proximal interphalangeal joint 0.66, 95% CI 0.46–0.93; OR for metacarpophalangeal joint 0.62, 95% CI 0.42–0.90), especially base of thumb OA (OR 0.15, 95% CI 0.11–0.22).

Conclusion. These findings suggest site-specific differences in the prevalence of OA that may be attributed to genetic and/or environmental factors. (J Rheumatol 2002;29:1454–8)

Key Indexing Terms:
OSTEOARTHRITIS
USA
JAPAN
ETHNICITY

Studies examining the prevalence of osteoarthritis (OA) in people from different racial (genetic) and environmental backgrounds have the potential to provide insights into disease etiologies. Although several studies have compared the prevalence of OA in different populations, most of these comparisons were of Caucasians and Blacks[1-7]. There are a few reports comparing Caucasians with Asians[8-10]. These comparisons have not necessarily incorporated similar methodologies. Japanese are different from Caucasians in genetic background, and have a characteristic traditional lifestyle, such as using tatami mats indoors (requiring knee bending and squatting) and chopsticks in eating meals. However, there is no direct international comparison of the prevalence of OA between Japanese and Caucasians. We compared the prevalence of radiographic knee and hand OA between women in Japan and the USA using the same methodology.

From the Department of Orthopedic Surgery and Department of Public Health, Nagasaki University School of Medicine, Nagasaki, Japan; the Multipurpose Arthritis and Musculoskeletal Diseases Center, Boston University School of Medicine; and Brigham and Women's Hospital, Boston, Massachusetts, USA.

Supported in part by the Japan Society for the Promotion of Science (Grant-in-Aid for Scientific Research C 11670374); Merck & Co. Inc.; and by US National Institutes of Health grant AR20613.

S. Yoshida, MD, Research Assistant, Department of Orthopedic Surgery; K. Aoyagi, MD, PhD, Associate Professor, Department of Public Health, Nagasaki University School of Medicine; D.T. Felson, MD, MPH, Professor, Multipurpose Arthritis Center and Department of Medicine, Boston University School of Medicine; P. Aliabadi, MD, Associate Professor of Radiology, Brigham and Women's Hospital; H. Shindo, MD, PhD, Professor, Department of Orthopedic Surgery; T. Takemoto, MD, PhD, Professor, Department of Public Health, Nagasaki University School of Medicine.

Address reprint requests to Dr. K. Aoyagi, Department of Public Health, Nagasaki University School of Medicine, 1-12-4 Sakamoto, Nagasaki 852-8523, Japan. E-mail: kiyoshi@net.nagasaki-u.ac.jp

Submitted July 30, 2001; revision accepted January 24, 2002.

MATERIALS AND METHODS

Hizen-Oshima Study, Japan. The Hizen-Oshima Study is a prospective population based cohort study on musculoskeletal conditions (osteoporosis and OA). We recruited community dwelling women aged 40 years or over in Oshima town, Nagasaki prefecture, Japan. The women were identified by the municipal electoral list and contacted through mailings. The town of Oshima has a population of about 5800 (2850 men, 2950 women), in which the population of women aged 40 or over is roughly 2000. The percentage of women aged 40 or over in Oshima (2000/5800 = 34%) was higher compared to the 1995 Census in Japan (27%); Oshima has a greater population of aged persons compared to all Japan. All women aged 40 or over were invited to participate through mailings. The baseline examination was performed at the Oshima Health Center in 1998 and 1999. A total of 586 women (roughly 30% of eligible women) participated in the study. The response rates in the age groups 40–49, 50–59, 60–69, 70–79, and 80 years or over were 10, 28, 45, 39, and 15%, respectively. Younger women may

have been busy with work, or may have not been interested in their musculoskeletal health. The oldest women may have had severe symptoms or disability preventing attendance at the study site. We compared the age distribution of participants vs nonparticipants. In total, the mean age of participants (63.9 yrs) was significantly higher than nonparticipants (61.1 yrs). Despite having a shipyard in the town, Oshima is a mainly rural (farming/fishery) district. About half the women who participated in the study continue to grow rice and vegetables by manual labor, sometimes using machinery. All participants were noninstitutionalized and living independently at baseline. All subjects gave written informed consent before examination.

Height (m) and weight (kg) were measured, and body mass index (BMI) was calculated as weight (kg)/height (m^2). The mean (standard deviation) BMI was 23.4 (3.5).

Framingham OA Study, USA. The Framingham Heart Study, begun in 1948, was designed to investigate factors associated with the development of cardiovascular disease in a representative sample of the adult population of Framingham, MA, USA. The study population has been reexamined every 2 years since inception. During the period of the 18th biennial examination, the cohort participants (age range 63–93 yrs) were evaluated for the presence of knee OA. Eight years later at the followup examination for knee OA, the remaining subjects were examined for hand OA (minimum age 71 yrs).

Radiographs. Radiographs were obtained of knees (anteroposterior weight bearing) and hands (posteroanterior), and were graded according to the Kellgren-Lawrence criteria (K-L)[11]. In both studies, knee radiographs were obtained with knees in full extension and hand radiographs were obtained with central ray focused on the 3rd metacarpophalangeal (MCP) joint. To standardize readings between the studies, the Japanese reader (SY) trained with the primary reader of the Framingham Study (PA) and used the same atlas and grading scheme. To evaluate interrater reliability for OA grade, we randomly selected 40 subjects from each population. In testing whether OA was present or absent on readings between the studies, the kappa statistic was 0.77 ($p < 0.001$) for knees and 0.68 ($p < 0.001$) for hands (combining all joints). Intrarater reliability for OA grade was 0.77 for the knee ($p < 0.001$). It was not evaluated for hands. Definite OA was defined as K-L grade 2 or higher, present in at least one joint of a given group. We examined the following groups: the knees, the second and third distal interphalangeal (DIP), the proximal interphalangeal (PIP), the MCP, and the base of thumb. Each subject was defined as having OA in a given joint group when at least one joint from this group (e.g., knee) was affected. If a joint from a given group was unreadable, we characterized OA in the group (e.g., DIP) based on the remaining readable joints. Unreadable joints accounted for < 5% of all joints for all groups.

Analysis. Data were analyzed using the Statistical Analysis System, version 6.12 (SAS Institute Inc., Cary, NC, USA). We calculated the age-specific prevalence of knee and hand OA for both populations. Since Japanese subjects had a broader age range than those from Framingham, to compare OA prevalence we restricted the ages of both groups to those of the Framingham women. Age adjusted OR was calculated using logistic regression analysis. Analyses were limited to 358 women in Japan and 815 women in the USA aged 63 years or older for knee joints, and to 157 women in Japan and 655 women in the USA aged 71 years or older for hands, to provide a comparable age range for both populations.

RESULTS

Age-specific prevalence of radiological changes of OA grade 2–4 in the knee joint is given in Table 1. The prevalence of knee OA in each age group was more common in Japanese women than in Caucasians in the USA.

The age-specific prevalence of radiological changes of grade 2–4 OA in hand joints is shown in Table 2. Japanese women had a higher prevalence of OA at the DIP joint in each age group than US women. All Japanese women aged 80–89 years had OA at the DIP joint. On the other hand, the prevalence of OA at PIP, MCP, or base of thumb was less in Japanese women than in US women. The difference in the prevalence of OA at base of thumb was especially pronounced.

The odds ratios adjusting for age indicated that Japanese women had more frequent knee OA and less OA in hand joints (PIP, MCP, and base of thumb) than US women (Table 3). Compared with women from Framingham, the odds of knee OA were twice as high in Japanese women. The OR for OA at the thumb base for Japanese women was 0.15, indicating much lower prevalence in Japanese compared with Framingham women. We could not make definitive comparisons of the prevalence of DIP OA because it was nearly universal in both groups, although the prevalence in Japanese women was modestly higher.

Table 1. Age-specific prevalence of knee OA among women in Hizen-Oshima, Japan, and Framingham, USA.

	Japan		USA	
Age Group, yrs	No.	Prevalence, %	No.	Prevalence, %
63–69	157	35.8	291	26.5
70–79	171	54.0	415	36.4
80–89	30	63.3	109	52.3

Table 2. Age-specific prevalence of OA at the distal interphalangeal (DIP), proximal interphalangeal (PIP), metacarpophalangeal (MCP), and base of thumb joint.

	Japan		USA	
Age Group, yrs	No. *	Prevalence, %	No.	Prevalence, %
DIP				
71–79	110	97.3	389	83.0
80–89	28	100.0	266	86.5
PIP				
71–79	120	40.0	389	56.6
80–89	30	43.3	266	68.1
MCP				
71–79	127	20.5	389	34.2
80–89	30	33.3	266	44.0
Base of thumb				
71–79	127	18.1	389	62.2
80–89	29	27.6	266	70.3

* Some subjects had missing data for a specific joint, thus numbers for each joint differ.

DISCUSSION

It is still controversial whether racial differences in the prevalence of OA exist or not. To our knowledge, this is the first study to compare the prevalence of knee and hand OA between Japanese and Caucasians in the United States. The Japanese genetic background and lifestyle are different from

Table 3. Age-adjusted odds ratios and 95% confidence intervals for OA at each joint of Japanese women in reference to US women.

Joint	OR	95% CI
Knee	1.96	1.50–2.56
DIP	NC	
PIP	0.66	0.46–0.93
MCP	0.62	0.42–0.90
Base of thumb	0.15	0.11–0.22

NC: no convergence, because there were no Japanese women in their 80s without OA in this joint.

those of Americans, and this may contribute to the development of OA. Our results suggest site-specific differences in the prevalence of OA, with disease in the knee more prevalent and disease in most hand joints less prevalent in Japanese than in Caucasian women.

Direct international comparison of the prevalence of OA in different countries is difficult, since the same methodology and disease definition are needed. The reader in the Japan study was trained in reading radiographs by the primary reader in the Framingham study, and all Japanese radiographs were read by this one observer (SY). Further, we evaluated DIP, PIP, and MCP joints at only the 2nd and 3rd finger, not all fingers. However, a recent report showed that the results of only 2nd and 3rd fingers were similar to those of all fingers[12]. Thus, our results could be surrogate (or representative) for evaluating all fingers.

The prevalence of hand OA, especially at the base of thumb, was much lower in Japanese women than in Caucasians in this study. Several studies have reported that in the hands over 50% of OA may be associated with inheritance[13,14]. Base of thumb OA is regarded as a part of generalized OA[15-17]. Thus there may be, in part, a tendency for Caucasians to have multiple joints affected by OA more than Japanese, through genetic factors.

Environmental or cultural (lifestyle) differences between the populations may account for the differences in OA prevalence we found. Half the Japanese women we studied were engaged in farming, and these women may have a high risk of joint injury and of repetitive hand use; these may be risk factors for OA[18,19]. The prevalence of OA at the DIP joint in Japanese was modestly higher than in Caucasians, suggesting that farming might, in part, contribute to site-specific OA such as in the DIP joint. Although there is insufficient data on OA at the DIP joint, the prevalence of OA at the hip or knee in farming areas is higher than in urban areas[20]. Thus the prevalence of OA in urban areas may be different from that in the farming area we studied. Similarly, it is possible that the Framingham women are not representative of the broader Caucasian US population in terms of OA prevalence.

On the other hand, the prevalence of hand OA in joints other than the DIP joint was lower in Japanese than in Caucasians. In eating meals, Japanese use chopsticks, while Caucasians use knife and fork. Chopsticks require use of palmar pinch, while knife and fork use demands lateral pinch. Cooney, *et al*[21] reported constraint forces in the thumb, estimating that joint compression forces averaged 3.0 kg at the interphalangeal joint, 5.4 kg at the MCP joint, and 12.0 kg at the base of thumb during simple pinch. On the other hand, they estimated compression forces were as great as 120 kg at the thumb base during a strong grasp. Thus using chopsticks could confer less impact to the thumb base joint compared with the use of knife and fork.

Obesity is an important risk factor for knee OA[22,23], and generally Caucasians in the USA tend to be obese more than Japanese. However, the prevalence of knee OA in Japanese was higher than that in Caucasian women. Thus Japanese women must have other risk factors for OA. Knee bending and squatting are strongly associated with OA of the knee[24,25]. Lifelong knee bending and squatting behavior, a component of the traditional Japanese lifestyle, may have had a longterm effect on occurrence of knee OA. Since elderly Japanese have spent most of their lives using tatami mats and Eastern-style toilets (all of which are within inches of ground level and require squatting), these traditional daily activities may contribute to the development of knee OA. However, the Western lifestyle has been creeping into Japan recently, and it might change the prevalence of knee OA in Japanese women in the future.

Our goal was to evaluate the overall prevalence differences between Japanese and Caucasian women. The differences in weight would suggest that, when adjusted for weight, knee OA differences may be even greater than suggested by our data. Whether the racial differences can be explained by known risk factors for these disorders, including obesity, will be the subject of another inquiry. Since there are so few data on the prevalence of OA in Asian populations, we felt that presenting these prevalence estimates and comparing them to a well studied population based Caucasian group would be of value. While symptoms were assessed in this study, the survey did not use questions on symptoms that were comparable to those used in the Framingham Study, and different symptom questions have been found to yield substantial differences in symptom prevalence.

Skyline and lateral views of the knee for the assessment of patellofemoral joint OA were not available in the current study. A recent community study in women aged > 55 years in the UK estimated the occurrence of isolated symptomatic patellofemoral joint OA as 8%[26]. Although the prevalence of isolated patellofemoral joint OA in Japanese is not known, our findings might be an underestimate of the true prevalence.

An advantage of logistic regression is the ability to control for a potential confounder. However, the resulting odds ratios will overestimate the true association when the

outcome of interest is greater than 5–10%. Thus, relative prevalence of OA is not as high or low as suggested by odds ratios in this study, because of high prevalence of OA. For these comparisons, the reader can also compare the age-specific prevalence values provided in Tables 1 and 2, which are not affected by assumptions of the logistic regression model.

This study has several limitations. The sample size in the Hizen-Oshima study was one-quarter of that in the Framingham study. The number of women aged 80 years or over in the Hizen-Oshima study was small. Although we attempted to obtain a representative sample of the Japanese population, the subjects had to be mobile enough to attend the study site. The response rate in the Hizen-Oshima study was about 30% of eligible women, which might be a potential source of selection bias. If we had been able to obtain the nonresponders' symptom reporting, the bias might be reduced. Our mail survey did not yield a high response rate, but there was only one mailing to the general community and no attempted followup. Further, information on other possible risk factors for OA such as history of joint injury, occupation, etc., was not available[27,28]. Future studies to compare populations should make every effort to obtain higher response rates and other data such as symptoms and other risk factors for OA.

There are other limitations to our study that would probably make results of the comparisons imprecise; among these are that we read only selected hand joints for hand OA and not all potentially affected joints. Even so, we found large differences in prevalence of hand OA between Japanese and Caucasian subjects, suggesting that the substance of our findings would not have changed. The 2nd and 3rd DIP, PIP, and MCP joints are among the most commonly affected by OA. Indeed, studies have suggested the high correlation between involvement of one joint in a row and involvement of others in the same row[17], and this suggests further that evaluating only 2nd and 3rd fingers would provide results similar to an evaluation of all the DIP, PIP, and MCP joints. Certainly, trauma to an individual joint might be more represented in this sample than in a sample in which more joints were incorporated. Data on joint trauma of the hand were not available, however.

The prevalence of OA at knee and DIP joints in Japanese was higher than that in Caucasians, while the prevalence of hand OA other than DIP joint in Japanese was lower than that in Caucasians, especially thumb base OA, which suggests the difference of prevalence of site-specific OA may be attributed to genetic or environmental factors, or both. It remains unclear what factors have contributed to the gap in prevalence between Japanese and Caucasian women and to what extent these results were influenced by biological makeup and culture related factors. The findings suggest that etiologic epidemiological studies might be rewarding.

REFERENCES

1. van Saase JL, van Romunde LK, Cats A, Vandenbroucke JP, Valkenburg HA. Epidemiology of osteoarthritis: Zoetermeer survey. Comparison of radiological osteoarthritis in a Dutch population with that in 10 other populations. Ann Rheum Dis 1989;48:271-80.
2. Bagge E, Bjelle A, Valkenburg HA, Svanborg A. Prevalence of radiographic osteoarthritis in two elderly European populations. Rheumatol Int 1992;12:33-8.
3. Anderson JJ, Felson DT. Factors associated with osteoarthritis of the knee in the first national Health and Nutrition Examination Survey (HANES I). Evidence for an association with overweight, race, and physical demands of work. Am J Epidemiol 1988;128:179-89.
4. Jordan JM, Linder GF, Renner JB, Fryer JG. The impact of arthritis in rural populations. Arthritis Care Res 1995;8:242-50.
5. Lawrence JS, Sebo M. The geography of osteoarthritis. In: Nuki G, editor. The aetiopathogenesis of osteoarthritis. Baltimore: University Park Press; 1980:155-83.
6. Petersson IF. Occurrence of osteoarthritis of the peripheral joints in European populations. Ann Rheum Dis 1996;55:659-61.
7. Croft P. The occurrence of osteoarthritis outside Europe. Ann Rheum Dis 1996;55:661-4.
8. Hoaglund FT, Yau AC, Wong WL. Osteoarthritis of the hip and other joints in southern Chinese in Hong Kong. J Bone Joint Surg Am 1973;55:545-57.
9. Lau E, Lin F, Croft P. Low prevalence of osteoarthritis of the hip in Chinese men [abstract]. Arthritis Rheum 1994;37 Suppl 9:S239.
10. Yoshimura N, Dennison E, Wilman C, Hashimoto T, Cooper C. Epidemiology of chronic disc degeneration and osteoarthritis of the lumbar spine in Britain and Japan: a comparative study. J Rheumatol 2000;27:429-33.
11. Kellgren JH, Lawrence JS. Atlas of standard radiographs. The epidemiology of chronic rheumatism. Oxford: Blackwell Scientific Publications; 1963.
12. Jacobson LT. Definitions of osteoarthritis in the knee and hand. Ann Rheum Dis 1996;55:656-8.
13. Spector TD, Cicuttini F, Baker J, Loughlin J, Hart D. Genetic influences on osteoarthritis in women: a twin study. BMJ 1996;312:940-3.
14. Felson DT, Couropmitree NN, Chaisson CE, et al. Evidence for a Mendelian gene in a segregation analysis of generalized radiographic osteoarthritis: the Framingham Study. Arthritis Rheum 1998;41:1064-71.
15. Kellgren JH, Moore G. Generalized osteoarthritis and Heberden's nodes. BMJ 1952;1:181-7.
16. Hirsch R, Lethbridge-Cejku M, Scott WW, et al. Association of hand and knee osteoarthritis: evidence for a polyarticular disease subset. Ann Rheum Dis 1996;55:25-9.
17. Cooper C, Egger P, Coggon D, et al. Generalized osteoarthritis in women: pattern of joint involvement and approaches to definition for epidemiological studies. J Rheumatol 1996;23:1938-42.
18. Hadler NM, Gillings DB, Imbus HR, et al. Hand structure and function in an industrial setting. Arthritis Rheum 1978;21:210-20.
19. Partridge RE, Duthie JJ. Rheumatism in dockers and civil servants. A comparison of heavy manual and sedentary workers. Ann Rheum Dis 1968;27:559-68.
20. Felson DT. Do occupation-related physical factors contribute to arthritis? Baillieres Clin Rheumatol 1994;8:63-77.
21. Cooney WP, Chao EY. Biomechanical analysis of static forces in the thumb during hand function. J Bone Joint Surg Am 1977;59:27-36.
22. Felson DT, Zhang Y, Hannan MT, et al. Risk factors for incident radiographic knee osteoarthritis in the elderly: the Framingham Study. Arthritis Rheum 1997;40:728-33.
23. Cooper C, Snow S, McAlindon TE, et al. Risk factors for the

incidence and progression of radiographic knee osteoarthritis. Arthritis Rheum 2000;43:995-1000.
24. Kivimaki J, Riihimaki H, Hanninen K. Knee disorders in carpet and floor layers and painters. Scand J Work Environ Health 1992; 18:310-6.
25. Cooper C, McAlindon T, Coggon D, Egger P, Dieppe P. Occupational activity and osteoarthritis of the knee. Ann Rheum Dis 1994;53:90-3.
26. McAlindon TE, Snow S, Cooper C, Dieppe PA. Radiographic patterns of osteoarthritis of the knee joint in the community: the importance of the patellofemoral joint. Ann Rheum Dis 1992;51: 844-9.
27. Felson DT, Anderson JJ, Naimark A, Walker AM, Meenan RF. Obesity and knee osteoarthritis. The Framingham Study. Ann Intern Med 1988;109:18-24.
28. Davis MA, Ettinger WH, Neuhaus JM, Cho SA, Hauck WW. The association of knee injury and obesity with unilateral and bilateral osteoarthritis of the knee. Am J Epidemiol 1989;130:278-88.