KOA was higher in the mountainous area than in the seacoast area, whereas the prevalence of LS was higher in the seacoast area than in the mountainous area. The difference in the presence of KOA and LS based on gender difference may in part relate to the etiological differences of these two diseases, including genetic factors; the differences based on regional differences could be affected by environmental factors. Further investigation of the ROAD study will elucidate the genetic and environmental background underlying these diseases, although these could not be determined by the present study. Regarding OP, a high prevalence of OP among the ROAD study participants was confirmed; female sex and advanced age were associated with the presence of OP; and it was confirmed that BMI was associated with BMD at any site. The ROAD study participants will be followed up for at least 10 years to clarify the relationships between musculoskeletal diseases and risk factors for the early prevention of the disabilities caused by them.

There are several limitations in the present study. First, although the ROAD study includes a large number of participants (>3,000), these participants do not truly represent the general population as they have been recruited from only three areas. To confirm whether the participants of the ROAD study are representative of the Japanese population, we compared anthropometric measurements and frequency of smoking and alcohol drinking between the participants and the general Japanese population. The values for the general population were obtained from the report on the 2005 National Health and Nutrition Survey conducted by the Ministry of Health, Labour and Welfare, Japan [25]. The mean BMI (standard deviation in parentheses) of men in the age groups of 40, 50, 60, 70–74, 75–79, and 80 years or older as reported in the National Health and Nutrition Survey was 23.99 (3.27), 23.74 (3.07), 23.75 (2.94), 23.68 (3.18), 23.31 (3.04), and 22.27 (2.64), respectively, and that of women was 22.44 (3.49), 23.06 (3.37), 23.54 (3.66), 23.16 (3.42), 23.42 (3.53), and 22.50 (3.97), respectively. In the ROAD study, the mean BMI for men in identical age strata was 24.50 (4.36), 23.58 (2.90), 23.78 (3.16), 23.08 (2.82), 22.81 (2.86), and 22.62 (2.90), and for women it was 21.92 (4.08), 23.04 (3.29), 23.31 (3.21), 23.44 (3.46), 22.96 (3.66), and 22.21 (3.16), respectively. No significant differences were identified between our participants and the total Japanese population, except that the male participants aged 70–74 years in the ROAD study were significantly smaller in terms of body structure than the overall Japanese population ($P < 0.05$). This difference should be taken into consideration when evaluating the potential risk factors in men aged 70–74 years; factors such as body build, particularly heavy weight, are known to be associated with the occurrence of KOA [26]. Thus, our results might represent an underestimation. Conversely, a small body build is frequently associated with occurrence of OP [27]; therefore, in this case, our results might represent an overestimation.

Although care should always be taken when generalizing results obtained from the ROAD study for all similarly aged men and women, the overall BMI of the participants was basically comparable to that of the broader Japanese population. In addition, the proportion of current smokers and current drinkers (those who regularly smoked or drank more than one drink/month) in the general Japanese population was compared with that in the study population. Both proportions were significantly higher in the general Japanese population than in the study population (smokers: men, 34.8% in Japanese population, 25.3% in ROAD subjects, $P < 0.001$; women, 8.8% in Japanese population, 3.4% in ROAD subjects, $P < 0.001$; drinkers: men, 69.8% in Japanese population, 64.4% in ROAD subjects, $P < 0.01$; women, 30.8% in Japanese population, 25.5% in ROAD subjects, $P < 0.001$), suggesting that participants of the ROAD study had healthier lifestyles than the general Japanese population. This "healthy" selection bias should be taken into consideration when generalizing the results obtained from the ROAD study. Second, the age distributions of the participants among the three cohorts were different. In the urban, mountainous, and coastal areas, 99.8, 84.3, and 54.7% of the participants, respectively, were more than 60 years old. This selection bias should be considered in the analysis of regional differences of frequencies and risk factors. Third, BMD values were not collected from the participants in Itabashi Ward because of lack of available apparatus. So, our estimation of the number of patients with osteoporosis was based on the data collected in the countryside. This selection bias should always be taken into consideration when generalizing the study data to the Japanese population.

In conclusion, the prevalence of KOA, LS, and OP was clarified, and the number of people affected with these diseases in Japan was estimated, using the baseline data of the ROAD study. This study will provide the information required to develop clinical algorithms for the early identification of potential high-risk populations, as well as essential information for the development of policies for the detection and prevention of OA, OP, or osteoporotic fractures. Furthermore, establishment of the cohort will also facilitate the expansion of other studies in related areas of investigation. The knowledge gained from the ROAD study will have major implications for the understanding and management of several additional common problems of aging.

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ORIGINAL ARTICLE

Association of Occupational Activity With Radiographic Knee Osteoarthritis and Lumbar Spondylosis in Elderly Patients of Population-Based Cohorts: A Large-Scale Population-Based Study

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Objective. To investigate the risk of radiographic knee osteoarthritis (OA) and lumbar spondylosis associated with occupational activity in elderly Japanese subjects using the large-scale population-based cohort of the Research on Osteoarthritis Against Disability (ROAD) study.

Methods. From the baseline survey of the ROAD study, 1,471 participants age ≥50 years (531 men and 940 women) living in mountainous and seacoast communities were analyzed. Information collected included a lifetime occupational history and details of specific work place physical activities. Radiographic severity at the knee and lumbar spine was determined by the Kellgren/Lawrence (K/L) grading system.

Results. The prevalence of K/L grade ≥2 knee OA and lumbar spondylosis among agricultural, forestry, and fishery workers was significantly higher than among clerical workers and technical experts in the overall population. For occupational activities, sitting on a chair had a significant inverse association with K/L grade ≥2 knee OA and lumbar spondylosis. Standing, walking, climbing, and heavy lifting were associated with K/L grade ≥2 knee OA, but were not associated with K/L grade ≥2 lumbar spondylosis. Kneeling and squatting were associated with K/L grade ≥3 knee OA.

Conclusion. This cross-sectional study using a population-based cohort suggests that sitting on a chair is a significant protective factor against both radiographic knee OA and lumbar spondylosis in Japanese subjects. An occupational activity that includes heavy lifting appears to have a greater effect on knee OA than on lumbar spondylosis.

INTRODUCTION

Osteoarthritis (OA) and spondylosis, which cause cartilage and disc degeneration and osteophyte formation at joints in the extremities and spine, are major public health issues causing chronic disability in the elderly in developed countries (1–6). Despite the urgent need for strategies to prevent and treat these conditions, epidemiologic data on OA and spondylosis are sparse. Established risk factors for knee OA in whites include older age, female sex, evidence of OA in other joints, obesity, and previous injury or surgery of the knee (7–12). Evidence is accumulating in whites that the disease is more common in people who have performed heavy physical work (13–18), particularly in those whose jobs have involved kneeling or squatting (19–24). However, published work has tended to concentrate on the knee, and few studies have focused on risk

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factors for lumbar spondylosis associated with occupational activity (25–28). In addition, there have been no large-scale population-based epidemiologic studies that have simultaneously evaluated the risk of both knee OA and lumbar spondylosis associated with occupational activity in the same population. Furthermore, most epidemiologic studies of OA and spondylosis associated with occupation are limited in terms of the quality of the information collected about occupational exposure. Occupational histories are not always complete, and exposure has often only been inferred from the subject's job title (13–18). To provide accurate data on the relationship of occupational activities with knee OA and lumbar spondylosis, collected information has to include a lifetime occupational history and details of specific work place physical activities.

With the goal of establishing epidemiologic indexes to evaluate clinical evidence for the development of disease-modifying treatment, we set up a large-scale nationwide OA cohort study called the Research on Osteoarthritis Against Disability (ROAD) study in 2005. In the present study, we used the data of participants living in mountainous and seacoast communities to investigate the association of job title and occupational activity with radiographic knee OA and lumbar spondylosis.

PARTICIPANTS AND METHODS

Participants. The ROAD study is a nationwide prospective study for bone and joint diseases consisting of population-based cohorts established in several communities in Japan. Because the Miyama cohort has been profiled in detail elsewhere (29), the characteristics of the participants are briefly summarized here. To date, we have created a baseline database including clinical and genetic information on 3,040 inhabitants (1,061 men and 1,979 women) ages 23–95 years (mean 70.6 years) who were recruited from listings of resident registrations in 3 communities. All participants provided written informed consent, and the study was conducted with the approval of ethical committees of the University of Tokyo and the Tokyo Metropolitan Institute of Gerontology. Information collected about job title and occupational activity included a lifetime occupational history with details of 7 types of specific work place physical activities, including sitting on a chair, kneeling, squatting, standing, walking, climbing, and heavy lifting. Participants were asked whether they engaged in the following activities: sitting on a chair for ≥2 hours/day, kneeling for ≥1 hour/day, squatting for ≥1 hour/day, standing for ≥2 hours/day, walking ≥3 km/day, climbing up slopes or steps for ≥1 hour/day, and lifting loads weighing ≥10 kg at least once a week. Information on these activities was obtained for the principal job, defined as the job at which the participant had worked the longest. Anthropometric measurements included height, weight, bilateral grip strength, and body mass index (BMI; weight [kg]/height [m^2]). All participants were interviewed regarding knee pain and low back pain by asking them, "In the past 1 month, have you had knee pain on most days lasting?" and "In the past 1 month, have you had low back pain on most days lasting?" Participants who answered yes were defined as having knee pain or low back pain, respectively. From the baseline data of all participants, the present study analyzed 1,471 participants (531 men and 940 women) age ≥50 years living in mountainous and seacoast cohorts.

Radiographic assessment. All participants had a radiographic examination of both knees using anteroposterior and lateral views with weight-bearing and foot map positioning, and an examination of the lumbar spine, including intervertebral levels from L1–L2 to L5–S1 with anteroposterior and lateral views. Knee and lumbar spine radiographs were read without knowledge of participant clinical status by a single well-experienced orthopedist (SM) using the Kellgren/Lawrence (K/L) radiographic atlas, and the severity was determined by K/L grading (30). We defined knee OA and lumbar spondylosis as a K/L grade ≥2 in at least one knee and in one intervertebral level, respectively.

To evaluate the intraobserver variability of K/L grading, 100 randomly selected radiographs of the knee and the lumbar spine were scored by the same observer more than 1 month after the first reading. One hundred other radiographs were also scored by 2 experienced orthopedic surgeons (SM, HO) using the same atlas for interobserver variability. The evaluated intra- and intervariability were confirmed by the kappa analysis to be sufficient for assessment (0.86 and 0.80 for knee OA, 0.84 and 0.76 for lumbar spondylosis, respectively).

Statistical analysis. The differences of age and BMI between men and women were examined by the unpaired *t*-test. To compare the prevalence of radiographic knee OA and lumbar spondylosis between men and women, we performed a logistic regression analysis after adjustment for age and BMI. The percentage of each occupational activity was compared between men and women by a chi-square test. To determine risk factors for knee OA and lumbar spondylosis with K/L grades ≥2 as well as K/L grades ≥3, logistic regression analyses were used to estimate the odds ratio (OR) and the associated 95% confidence interval (95% CI) for variables such as job title and occupational activities after adjustment for age and BMI compared with K/L = 0 or 1 (for K/L grades ≥2) and K/L = 0, 1, or 2 (for K/L grades ≥3). Furthermore, the overall population was classified into 4 subpopulation groups based on the presence or absence of knee OA and lumbar spondylosis, and a multinomial logistic regression analysis was performed to determine factors associated with knee OA, lumbar spondylosis, and their combination after adjustment for age, sex, and BMI. The subpopulation with neither knee OA nor lumbar spondylosis was used as a reference group. Data analyses were performed using SAS, version 9.0 (SAS Institute, Cary, NC).

RESULTS

Characteristics of the 1,471 participants age ≥50 years in the 2 cohorts of the ROAD study are shown in Table 1. The

Table 1. Characteristics of participants*

	Overall	Men	Women
No. of subjects	1,471	531	940
Age, years	68.4 ± 9.2	69.1 ± 9.1	68.0 ± 9.2†
Height, cm	154.3 ± 9.3	162.3 ± 7.1	149.8 ± 7.2
Weight, kg	55.2 ± 10.5	61.0 ± 10.3	51.8 ± 9.1
BMI, kg/m^2	23.1 ± 3.3	23.1 ± 3.1	23.1 ± 3.5
Grip strength, kg	26.7 ± 9.3	34.7 ± 8.4	22.1 ± 6.1
K/L ≥2 knee OA, %	55.6	45.6	61.2‡
K/L ≥3 knee OA, %	23.0	16.8	26.5‡
K/L ≥2 lumbar spondylosis, %	65.3	79.1	57.6‡
K/L ≥3 lumbar spondylosis, %	38.7	38.8	38.7
Current smoker, no. (%)	169 (11.5)	140 (26.4)	29 (3.1)§
Current alcohol drinking, no. (%)	562 (38.2)	343 (64.6)	219 (23.3)§

* Values are the mean ± SD unless otherwise indicated. BMI = body mass index; K/L = Kellgren/Lawrence grading system; OA = osteoarthritis.
† $P < 0.05$ versus men by unpaired t-test.
‡ $P < 0.05$ versus men by logistic regression analysis after adjustment for age and BMI.
§ $P < 0.05$ versus men by chi-square test.

prevalence of K/L grade ≥2 and K/L grade ≥3 knee OA was significantly higher in women than in men, whereas that of K/L grade ≥2 lumbar spondylosis was significantly lower in women than in men. The prevalence of K/L grade ≥3 lumbar spondylosis was comparable between sexes.

There was great diversity in the job titles of the study participants (Table 2). Although a substantial proportion includes clerical workers and technical experts, there were many agricultural, forestry, and fishery workers. Among various occupational activities, agricultural, forestry, and fishery workers had the highest rates of kneeling, squatting, standing, walking, climbing, and lifting weights and the lowest rates of sitting on a chair, whereas clerical workers and technical experts had the lowest rates of kneeling, squatting, standing, walking, climbing, and lifting weights and the highest rates of sitting on a chair (Figure 1).

To determine factors associated with K/L grade ≥2 knee OA and lumbar spondylosis, we performed a logistic regression analysis to estimate ORs and 95% CIs (Tables 3 and 4). Analysis of job titles revealed that agricultural, forestry, and fishery workers had a significantly higher risk of knee OA and lumbar spondylosis compared with clerical workers and technical experts in the overall population. We then examined the association of occupational activities with knee OA and lumbar spondylosis (Tables 3 and 4). Sitting on a chair for ≥2 hours/day was a significant protective factor for knee OA and lumbar spondylosis

Table 2. Participants with job title and occupational activity reported as the principal job

	Overall	Men	Women
Job titles, no. (%)			
Clerical workers/technical experts	363 (24.7)	170 (32.0)	193 (20.5)
Agricultural/forestry/fishery workers	318 (21.6)	164 (30.9)	154 (16.4)
Factory/construction workers	153 (10.4)	68 (12.8)	85 (9.0)
Shop assistants/managers	132 (9.0)	25 (4.7)	107 (11.4)
Housekeepers	126 (8.6)	0 (0.0)	126 (13.4)
Teachers	82 (5.6)	42 (7.9)	40 (4.3)
Dressmakers	51 (3.5)	1 (0.2)	50 (5.3)
Clinical workers	41 (2.8)	1 (0.2)	40 (4.3)
Hairdressers	17 (1.2)	6 (1.3)	11 (1.2)
Others (cooks, taxi drivers, etc.)	72 (4.9)	22 (4.1)	50 (5.3)
No answer	116 (7.9)	32 (6.0)	84 (8.9)
Occupational activities, no. (%)			
Sitting on a chair ≥2 hours/day	657 (44.7)	254 (47.8)	403 (42.8)
Kneeling ≥1 hour/day	292 (19.9)	96 (18.1)	196 (20.9)
Squatting ≥1 hour/day	386 (26.2)	131 (24.7)	255 (27.1)
Standing ≥2 hours/day	1,235 (84.0)	456 (85.9)	779 (82.9)
Walking ≥3 km/day	673 (45.8)	268 (50.5)	405 (43.1)
Climbing ≥1 hour/day	346 (23.5)	185 (34.8)	161 (17.1)*
Lifting weights ≥10 kg at least once a week	788 (53.6)	347 (65.3)	441 (46.9)*

* $P < 0.05$ versus men by chi-square test.

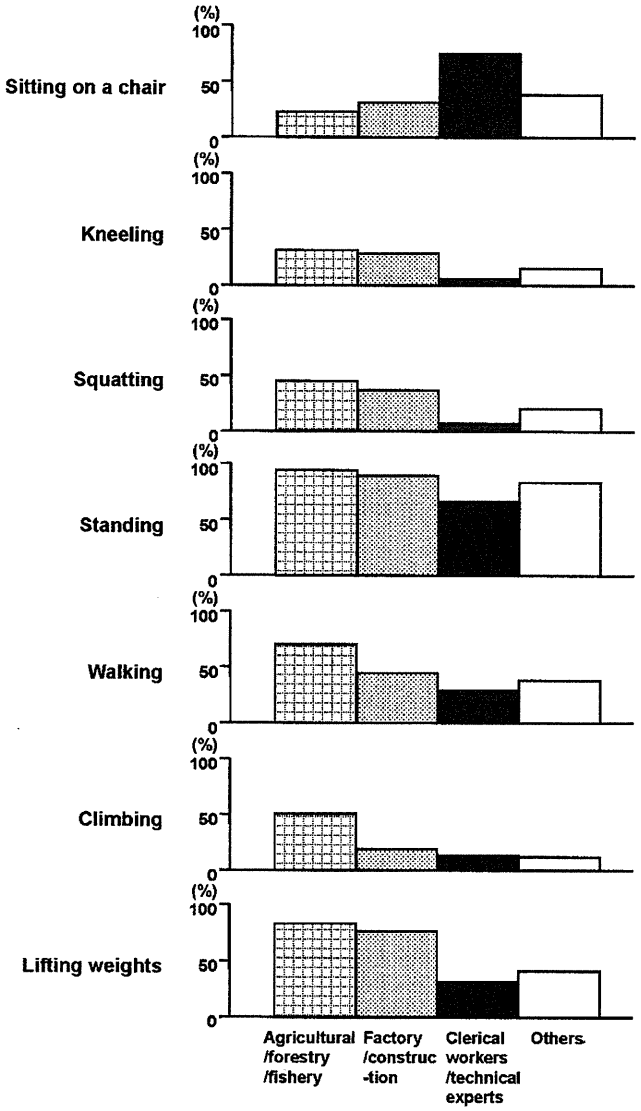

Figure 1. Percentages of participants engaged in each occupational activity: sitting on a chair ≥2 hours/day, kneeling ≥1 hour/day, squatting ≥1 hour/day, standing ≥2 hours/day, walking ≥3 km/day, climbing ≥1 hour/day, or lifting weights ≥10 kg at least once a week among agricultural, forestry, and fishery workers; factory and construction workers; clerical workers and technical experts; and others.

in the overall population and in men. Neither kneeling for ≥1 hour/day nor squatting for ≥1 hour/day was associated with knee OA in the overall population. Standing for ≥2 hours/day, walking ≥3 km/day, climbing for ≥1 hour/day, and lifting weights ≥10 kg at least once a week were significantly associated with knee OA in the overall population and in both sexes (Table 3). A multiple logistic regression analysis after adjustment for age, BMI, sex, and the above 4 occupational activities showed that climbing and lifting weights were significantly associated with knee OA overall (OR 1.65, 95% CI 1.18–2.32 and OR 1.51, 95% CI 1.16–1.95, respectively) and in men (OR 1.75, 95% CI 1.10–2.80 and OR 1.76, 95% CI 1.14–2.73, respectively), suggesting that among the 4 activities that required a standing position, climbing and lifting weights had an independent association with knee OA. In contrast, these occupational activities had no significant association with lumbar spondylosis except for lifting weights in women (Table 4).

We next performed a multinomial logistic regression analysis to determine factors associated with K/L grade ≥2 knee OA, lumbar spondylosis, and their combination after adjustment for age, sex, and BMI. Sitting on a chair was confirmed to be a significant protective factor for the presence of both knee OA and lumbar spondylosis (OR 0.62, 95% CI 0.45–0.86). Although neither kneeling nor squatting was associated with the presence of knee OA or lumbar spondylosis, standing (OR 2.03, 95% CI 1.32–3.12), walking (OR 1.56, 95% CI 1.12–2.17), climbing (OR 2.14, 95% CI 1.38–3.40), and lifting weights (OR 2.05, 95% CI 1.48–2.86) were associated with the presence of both knee OA and lumbar spondylosis. For the subpopulation group with knee OA and without lumbar spondylosis, standing (OR 1.69, 95% CI 1.04–2.79), climbing (OR 2.34, 95% CI 1.39–3.97), and lifting weights (OR 1.92, 95% CI 1.31–2.81) were also significantly associated, although there were no significant associations of the subpopulation group with lumbar spondylosis and without knee OA compared with the subpopulation group without knee OA or lumbar spondylosis.

We further analyzed the association of K/L grade ≥2 knee OA and lumbar spondylosis with job titles and occupational activities according to the presence of knee pain and low back pain at the baseline examination (Supplementary Tables A and B, available in the online version of this article at http://www3.interscience.wiley.com/journal/77005015/home). Although some of the job titles and occupational activities showed higher ORs in the subpopulation with knee pain, the direction of association was similar regardless of the presence of pain, and the results did not differ between the overall population and the subpopulation without knee pain or low back pain.

We next determined factors associated with K/L grade ≥3 knee OA and lumbar spondylosis using logistic regression analysis after adjustment for age and BMI. Analysis of occupational activities revealed that sitting on a chair was a significant protective factor for lumbar spondylosis in men (OR 0.58, 95% CI 0.40–0.84). In the overall population and in women, kneeling (OR 1.40, 95% CI 1.01–1.93 and OR 1.69, 95% CI 1.16–2.47, respectively), squatting (OR 1.34, 95% CI 1.00–1.80 and OR 1.51, 95% CI 1.06–2.15, respectively), and lifting weights (OR 1.60, 95% CI 1.21–3.12 and OR 1.73, 95% CI 1.25–2.43, respectively) were associated with knee OA. A multinomial logistic regression analysis also showed that sitting on a chair was a protective factor for the presence of both K/L grade ≥3 knee OA and lumbar spondylosis, as well as for the presence of lumbar spondylosis and the absence of knee OA in men (OR 0.46, 95% CI 0.23–0.87 and OR 0.63, 95% CI 0.42–0.94, respectively). Lifting weights (OR 1.57, 95% CI 1.10–2.23) was associated with the presence of both knee OA and lumbar spondylosis. For the subpopulation group with knee OA and without lumbar spondylosis, kneeling (OR 1.76, 95% CI 1.13–2.72), squatting (OR 1.85, 95% CI 1.23–2.77), and lifting weights (OR 1.77, 95% CI 1.19–2.65) were significantly associated, although there were no

Table 3. Association of K/L grade ≥2 knee OA with job title and occupational activity*

	Overall, OR (95% CI)	Men, OR (95% CI)	Women, OR (95% CI)
Job titles (vs. clerical workers/technical experts)			
Agricultural/forestry/fishery workers	1.69 (1.19–2.41)	1.58 (0.98–2.56)	1.90 (1.14–3.20)
Factory/construction workers	1.52 (0.99–2.36)	1.33 (0.72–2.47)	1.64 (0.90–3.06)
Other†	1.18 (0.88–1.60)	1.21 (0.73–2.00)	1.20 (0.82–1.76)
Occupational activities			
Sitting on a chair ≥2 hours/day	0.73 (0.57–0.92)	0.63 (0.44–0.92)	0.80 (0.60–1.09)
Kneeling ≥1 hour/day	1.11 (0.83–1.48)	0.79 (0.49–1.26)	1.36 (0.93–1.97)
Squatting ≥1 hour/day	1.23 (0.94–1.61)	0.89 (0.58–1.35)	1.50 (1.06–2.13)
Standing ≥2 hours/day	1.97 (1.43–2.72)	2.31 (1.32–4.17)	1.78 (1.21–2.63)
Walking ≥3 km/day	1.80 (1.42–2.29)	2.17 (1.49–3.16)	1.59 (1.17–2.16)
Climbing ≥1 hour/day	2.24 (1.65–3.04)	2.43 (1.64–3.60)	1.85 (1.19–2.96)
Lifting weights ≥10 kg at least once a week	1.90 (1.50–2.42)	2.26 (1.52–3.40)	1.68 (1.24–2.26)

* ORs were calculated by a logistic regression analysis after adjustment for age, sex, and BMI in the overall population, and for age and BMI in both sexes. K/L = Kellgren/Lawrence grading system; OA = osteoarthritis; OR = odds ratio; 95% CI = 95% confidence interval; BMI = body mass index.
† Includes all participants except for agricultural/forestry/fishery workers, factory/construction workers, and clerical workers/technical experts.

significant associations of the subpopulation group with lumbar spondylosis and without knee OA compared with the subpopulation group without knee OA or lumbar spondylosis.

DISCUSSION

Using baseline data from the ROAD study, the present investigation evaluated the risk of occupational activity for radiographic knee OA and lumbar spondylosis, and revealed that sitting on a chair was a significant protective factor for both radiographic knee OA and lumbar spondylosis in Japanese subjects. For other occupational activities, kneeling, squatting, standing, walking, climbing, and heavy lifting were significantly associated with radiographic knee OA, whereas there was no significant occupational activity for radiographic lumbar spondylosis in the overall population. To our knowledge, this is the first epidemiologic study using a large-scale population-based cohort to determine the risk of occupational activity for both knee OA and lumbar spondylosis simultaneously in the same population. Information on occupational activities was collected by direct inquiry rather than being inferred from the job title.

In the present study, agricultural, forestry, and fishery workers had a significantly higher prevalence of both radiographic knee OA and lumbar spondylosis compared with clerical workers and technical experts in the overall population. These jobs have historically been among the first to be identified in relation to knee OA in whites (31,32), which is also compatible with our data in this Japanese population. As other authors have hypothesized, the combination of intense exposure to heavy labor of varied nature and repeated local stresses, especially at a young age, could contribute to some systemic mechanism in the development of OA (33). This argument would support the implementation of preventive measures as a priority to reduce the intensity of physical labor in this sector, particularly for young male and female farm workers.

For occupational activities, standing, walking, climbing, and heavy lifting were associated with K/L grade ≥2 knee OA in the overall population, whereas kneeling and squat-

Table 4. Association of K/L grade ≥2 lumber spondylosis with job title and occupational activity*

	Overall, OR (95% CI)	Men, OR (95% CI)	Women, OR (95% CI)
Job titles (vs. clerical workers/technical experts)			
Agricultural/forestry/fishery workers	1.46 (1.02–2.11)	1.49 (0.83–2.68)	1.42 (0.89–2.28)
Factory/construction workers	1.05 (0.68–1.55)	1.52 (0.76–3.22)	0.84 (0.49–1.44)
Other†	1.22 (0.91–1.64)	1.53 (0.87–2.76)	1.11 (0.78–1.58)
Occupational activities			
Sitting on a chair ≥2 hours/day	0.78 (0.62–0.99)	0.48 (0.30–0.76)	0.93 (0.71–1.23)
Kneeling ≥1 hour/day	0.96 (0.72–1.28)	0.95 (0.55–1.70)	0.97 (0.70–1.35)
Squatting ≥1 hour/day	1.05 (0.81–1.38)	0.95 (0.58–1.61)	1.09 (0.80–1.48)
Standing ≥2 hours/day	1.11 (0.81–1.50)	1.14 (0.61–2.04)	1.10 (0.77–1.57)
Walking ≥3 km/day	1.00 (0.79–1.26)	0.89 (0.57–1.40)	1.04 (0.79–1.37)
Climbing ≥1 hour/day	1.02 (0.76–1.38)	1.09 (0.68–1.78)	0.98 (0.67–1.44)
Lifting weights ≥10 kg at least once a week	1.15 (0.91–1.45)	1.09 (0.69–1.72)	1.23 (1.01–1.55)

* ORs were calculated by a logistic regression analysis after adjustment for age, sex, and BMI in the overall population, and for age and BMI in both sexes. See Table 3 for definitions.
† Includes all participants except for agricultural/forestry/fishery workers, factory/construction workers, and clerical workers/technical experts.

Table 5. Comparison of characteristics of epidemiologic studies

Author, ref.	Ethnicity/country	Age, years	Total no.	Men:women
Muraki et al, current study	Japan	≥50	1,471	531:940
Yoshimura et al, 34	Japan	≥45	202	0:202
Lau et al, 35	Chinese		1,316	332:984
Anderson and Felson, 19	Blacks and whites/US	55–64	1,250	606:644
Felson et al, 20	Whites/US	≥63	1,376	569:807
Cooper et al, 21	UK	≥55	327	90:237
Coggon et al, 22	UK	≥47	1,036	410:626
Sandmark et al, 23	Sweden	≥55	1,173	589:584
Manninen et al, 24	Finland	≥55	805	195:610

ting were not, which was similar to previous studies in Japan and China (34,35). Comparison of characteristics and ORs for knee OA associated with occupational activity among epidemiologic studies is shown in Tables 5 and 6. The present study showed different results from other previously published studies (Table 6). Because each study defined knee OA and cases somewhat differently (in some studies, a case was defined as a subject with K/L grade ≥3 OA with knee pain, while it was defined as a subject with K/L grade ≥2 or K/L grade ≥3 OA in the present study), our results are not directly comparable with those of other studies. Even so, studies of whites have suggested that occupational activities of kneeling and squatting and job titles that required kneeling and squatting were associated with knee OA (19–24), whereas these activities were not associated with K/L grade ≥2 OA in this study. The discrepancies between white and Japanese subjects may be partly explained by the Japanese traditional lifestyle, which includes sitting on the heels on a mat and using the Japanese-style lavatory, where subjects have to take a deep squatting position. These positions may cause mechanical stress to the knee joint and possibly lead to the acceleration of knee OA. Among elderly Japanese subjects, kneeling and squatting are common postures in daily life, which could obscure the association between knee OA and occupational activities of kneeling and squatting.

The direction of the association of kneeling and squatting with knee OA was also different between sexes in the present study, although these differences were not signif-

Table 6. Comparison of odds ratios for knee osteoarthritis associated with occupational activity among epidemiologic studies*

	Muraki et al (current study)		Yoshimura et al (34), K/L ≥3 with knee pain	Lau et al (35), K/L ≥3	Anderson and Felson (19), K/L ≥2	Felson et al (20)		Cooper et al (21), K/L ≥3 with knee pain	Coggon et al (22), listed for knee surgery	Sandmark et al (23), TKA	Manninen et al (24), TKA
	K/L ≥2	K/L ≥3				K/L ≥2	K/L ≥3				
Sitting on a chair	0.7†	0.8	–					1.2		–	
Men	0.6†	0.8	–					–		0.7	
Women	0.8	0.8	0.4†					–		0.9	
Kneeling	1.1	1.4†	–	–				3.4†	1.8†	–	1.7‡
Men	0.8	0.9	–	1.4				–	1.7†	2.1†	1.7
Women	1.4	1.7†	1.0	0.9				–	2.0†	1.5	1.8†
Squatting	1.2	1.3†	–	–	–	–	–	6.9†	2.3†	–	1.7‡
Men	0.9	1.0	–	1.2	2.5†	2.2†	2.0	–	2.2†	2.9†	1.7
Women	1.5†	1.5†	1.1	1.1	3.5†	0.4	0.7	–	2.8†	1.1	1.8†
Standing	2.0†	1.4	–					0.8		–	0.6†
Men	2.3†	1.1	–					–		1.7†	0.4†
Women	1.8†	1.5	1.2					–		1.6†	0.7
Walking	1.8†	1.1	–	–				0.9	1.9†		1.1
Men	2.2†	0.9	–	2.2†				–	1.7		1.5
Women	1.6†	1.1	0.9	1.4†				–	2.1†		1.1
Climbing	2.2†	1.3	–	–				2.7†	1.5†	–	1.6
Men	2.4†	1.0	–	4.1†				–	2.3†	1.2	2.8
Women	1.9†	1.5	0.9	6.1†				–	0.7	1.4	1.5
Lifting weights	1.9†	1.6†	–	–				1.4	1.7†	–	1.0
Men	2.3†	1.3	–	1.7				–	1.9†	3.0†	0.9
Women	1.7†	1.7†	1.0	1.5†				–	1.5†	1.7†	1.1

* K/L = Kellgren/Lawrence grading system; TKA = total knee arthroplasty.
† $P < 0.05$.
‡ $P < 0.05$. Kneeling or squatting.

icant, except for squatting in women. Because men are known to have greater muscle strength than women of all ages and muscle strength has a protective effect on knee OA (36–38), it might be that the greater muscle strength obscures the harmful effects of kneeling and squatting on knee OA in men, resulting in lower ORs for knee OA than in women.

For K/L grade ≥2 lumbar spondylosis, there were no occupational activities associated with the increased prevalence except for heavy lifting in women. Few studies have focused on risk factors for lumbar spondylosis associated with occupational activity (25–28), and no increased risk of lumbar osteophytes due to physical activities has been reported (25,39,40).

In the present study, the occupational activity of sitting on a chair was inversely associated with both K/L grade ≥2 knee OA and lumbar spondylosis. For knee OA, our previous small-scale study showed that prolonged sitting on a chair at work was associated with a reduced prevalence of knee OA (34) (Table 5). Regarding the relationship between sedentary work and OA, the results of studies investigating the influence of sedentary work on knee OA are controversial (21,22). Although sitting on a chair clearly involves reduced load on many joints compared with other working activities, no other studies have reported a relationship between sedentary activity and knee OA. Sitting on a chair as a physical activity in the work place appears to represent a characteristic protective factor for OA in Japan.

Contrary to K/L grade ≥2 knee OA, occupational activities of kneeling and squatting were significantly associated with K/L grade ≥3 knee OA, whereas those of standing, walking, and climbing were not. Considering the definition of the K/L grade, this may suggest distinct risk factors between osteophytosis and joint space narrowing. In this population-based cohort study, the prevalence of K/L grade ≥2 knee OA was 45.6% in men and 61.2% in women, which was higher than that in whites, whereas that of K/L grade ≥3 was 16.8% and 26.5%, which is comparable with that in whites (41), suggesting that the Japanese lifestyle may be associated with osteophytosis rather than joint space narrowing. Therefore, regarding K/L grade ≥2 knee OA, the Japanese lifestyle could obscure the association between knee OA and occupational activities of kneeling and squatting as mentioned above. Furthermore, the discrepancy between risk factors for K/L grade ≥2 and K/L grade ≥3 knee OA may also be due to differences between the mechanism of osteophytosis and joint space narrowing. There is accumulating evidence that osteophytosis and joint space narrowing have distinct etiologic mechanisms (25,42–47). A previous prospective study using a large-scale OA cohort reported that there was no association between the 2 representative features of knee OA (44). A recent cross-sectional study also showed that osteophytosis was unrelated not only to joint space narrowing on plain radiographs, but also to cartilage loss measured by quantitative magnetic resonance imaging (45). Furthermore, our study on an experimental mouse model for OA has identified a cartilage-specific molecule, carminerin, which regulates osteophytosis without affecting joint cartilage destruction during OA progression (46,47). Further clinical and basic research will disclose the distinct backgrounds of these 2 features of OA.

There are several limitations in the present study. First, this is a cross-sectional study on factors associated with knee OA and lumbar spondylosis, so a causal association with occupational activity could not be determined. However, information collected included a lifetime occupational history and details of specific work place physical activities; therefore, ample evidence on the background of knee OA and lumbar spondylosis could be obtained. Second, information regarding past occupational exposures was obtained by self-report and there is a possibility that both self-selection bias and recall bias may have occurred. People with painful conditions may choose work that allows them to avoid aggravation of their conditions, so the impact of job titles and occupational activities on knee OA and lumbar spondylosis may be underestimated in the present study. Conversely, people with painful knee and lumbar conditions are likely to look for and assign a cause when asked about past work exposures. To determine the impact of working conditions on knee OA and lumbar spondylosis independently of the presence of pain at the examination, we analyzed the association of knee OA and lumbar spondylosis with job titles and occupational activities according to the presence of knee pain and low back pain at the baseline examination. The direction of association was similar regardless of the presence of pain, and the results between the overall population and the subpopulation without knee pain or low back pain were not different, suggesting that pain at the examination may not affect the results of the overall population very much in this study.

In conclusion, the present cross-sectional study using a large-scale population from the ROAD study revealed distinct risk factors of occupational activities for radiographic knee OA and lumbar spondylosis in Japanese subjects. Sitting on a chair was a significant protective factor for both radiographic knee OA and lumbar spondylosis. Other occupational activities of kneeling, squatting, standing, walking, climbing, and heavy lifting were risk factors for radiographic knee OA, but not for radiographic lumbar spondylosis. Further studies, along with longitudinal data in the ROAD study, will elucidate the environmental backgrounds of OA and spondylosis and clarify clinical evidence for the development of disease-modifying treatments.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. Muraki had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Muraki, Akune, Oka, Mabuchi, En-yo, Yoshida, Saika, Nakamura, Kawaguchi, Yoshimura.

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Analysis and interpretation of data. Muraki, Akune, Oka, Mabuchi, En-yo, Yoshida, Saika, Nakamura, Kawaguchi, Yoshimura.

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Prevalence of radiographic knee osteoarthritis and its association with knee pain in the elderly of Japanese population-based cohorts: The ROAD study

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Summary

Objective: We investigated the prevalence of radiographic knee osteoarthritis (OA) and knee pain in the Japanese elderly using a large-scale population of a nationwide cohort study, Research on Osteoarthritis Against Disability (ROAD), and examined their association.

Methods: From the baseline survey of the ROAD study, 2,282 participants ≥60 years (817 men and 1,465 women) living in urban, mountainous and seacoast communities were analyzed. The radiographic severity at both knees was determined by the Kellgren/Lawrence (KL) grading system. KL ≥ 2 and KL ≥ 3 knee OA were examined separately to assess osteophytosis and joint space narrowing (JSN).

Results: The prevalence of KL ≥ 2 OA (47.0% and 70.2% in men and women, respectively) was much higher than that of previous studies in Caucasians, while that of KL ≥ 3 OA was not much different in men. Age, BMI, female sex and rural residency were risk factors for radiographic knee OA, knee pain and their combination. The prevalence of knee pain was age-dependent in women, but not in men. Knee pain was more strongly associated with KL ≥ 3 OA than with KL = 2, and the association was higher in men than in women. Female sex was a strong risk factor even in the subgroup without radiographic knee OA (KL = 0/1).

Conclusion: The present cross-sectional study revealed a high prevalence of radiographic knee OA in the Japanese elderly. Knee pain was strongly associated with JSN especially in men, while women tended to have knee pain even without radiographic OA.

Key words: Osteoarthritis, Knee, Prevalence, Pain, Cross-sectional.

Introduction

Knee osteoarthritis (OA), characterized by pathological features including joint space narrowing (JSN) and osteophytosis, is a major public health issue causing chronic pain and disability of the elderly in most developed countries[1–3]. Despite the urgent need of strategies for the prevention and treatment of this condition, the prevalence overall and among demographic subgroups is not well characterized. The reported prevalence of radiographic knee OA differs considerably among previous population-based epidemiologic studies[4–14]. This may be due to a limitation of the sample size or a variability of age, ethnicity and radiological acquisition.

With the goal of establishing epidemiologic indexes to evaluate clinical evidence for the development of a disease-modifying treatment of OA, we set up a large-scale nationwide OA cohort study called Research on Osteoarthritis Against Disability (ROAD) in 2005. We have to date created a baseline database with detailed clinical and genetic information on three population-based cohorts in urban, mountainous and seacoast communities of Japan. The present study initially investigated the prevalence and distribution of knee OA according to age, gender and community using cohorts of 2,282 participants who were 60 years or older in the baseline survey of the ROAD study.

The most popular grading system for the radiographic severity of knee OA is the Kellgren/Lawrence (KL) system with classification into five-grade (0–4) scales. KL grade 2 is defined as osteophyte formation and grade 3 as JSN in addition to osteophyte formation; and KL ≥ 2 is generally thought to be the standard of the diagnostic criterion of knee OA[15,16]. However, accumulating evidence has shown that osteophytosis and JSN have distinct etiologic mechanisms and their progression is neither constant nor proportional[17–19]. Hence, to assess these two pathological features separately, the present study examined not only the prevalence of KL ≥ 2, but also that of KL ≥ 3 knee OA.

Arthritis is the most common cause of pain in the elderly, and knee pain is the principal clinical symptom of knee OA[20]. Although much effort has been devoted toward a definition of knee pain, the correlation with radiographic severity of the knee OA was not as strong as one would expect[21–23]. This study also examined the association of

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KL $\geq$ 2 and KL $\geq$ 3 knee OA separately with the presence of knee pain according to gender and age stratum.

Subjects and methods

SUBJECTS

The ROAD study is a nationwide OA prospective study constituted of population-based cohorts established in several communities in Japan. To date, we have completed creation of a baseline database including clinical and genetic information of 3,040 inhabitants (1,061 men and 1,979 women) ranging in age from 23–95 years (mean 70.6 years), who were recruited from listings of resident registration in three communities. Itabashi-ku, an urban community located in the east of Tokyo, had a population of 529,400/32 km^2 with 0.1, 25, and 75% of jobs in the primary industry (agriculture, forestry, fishing and mining), the secondary industry (manufacturing and construction), and the tertiary industry (service industry), respectively, and residents $\geq$65 years constituted 19.1% of the population. Hidakagawa-cho, a rural mountainous community located in the center of Wakayama, had a population of 11,300/330 km^2 with 29, 24 and 47% of jobs in the three industries above, and 30.5% were $\geq$65 years. Taiji-cho, a rural seacoast community located south of Wakayama, had a population of 3,500/6 km^2 with 13, 18, and 69% of jobs in the three industries, and those $\geq$65 years accounted for 34.9% of the total. Participants in the urban region were recruited from a cohort study[24] in which the participants were randomly drawn from the Itabashi-ward residents register database and the response rate in the age groups of 60 years or older was 75.6%. Participants in the mountainous and seacoast regions were recruited from listings of resident registration and the response rates in the age groups of 60 years or older were 68.4% and 29.3%, respectively. All participants provided written informed consent, and the study was conducted with the approval of ethics committees of the University of Tokyo and the Tokyo Metropolitan Institute of Gerontology. Participants completed an interviewer-administered questionnaire of 400 items that included lifestyle information such as occupational career, smoking habits, alcohol consumption, family history, medical history, physical activity, reproductive variables, and health-related quality of life. Anthropometric measurements included height, weight, arm length, bilateral grip strength and body mass index (BMI; weight [kg]/height^2 [m^2]). Medical information was taken by well-experienced orthopaedic surgeons (S.M. and H.O.) on systemic, local and mental status including information of knee, hip and low back pain, swelling and range of motion of the joints, and patellar and achilles tendon reflex. Knee pain was defined as that in and around the knee joint on most days during the past month. A self-recorded nutritional survey was also performed. Blood and urine samples were collected for biochemical and genetic examinations. Plain radiographs of knee, hip and lumbar spine were taken for all participants. Participants were confirmed to be comparable to the Japanese general population according to the national nutrition survey by the Ministry of Health, Labour and Welfare (Japan). Mean height was 162.5 and 149.7 cm in men and women, respectively, in the ROAD study vs 162.6 and 149.9 cm in the Japanese general population. Weight was 61.3 and 51.8 kg vs 61.6 and 53.8 kg. Percentage of the population with a smoking habit was 26.4 and 3.2% vs 29.4 and 4.0%. From the baseline data of the overall participants, the present study analyzed 2,282 (817 men and 1,465 women) aged 60 years or older, after excluding six subjects with total knee arthroplasty.

RADIOGRAPHIC ASSESSMENT

All participants had radiographic examination of both knees using an anterior–posterior view with weight-bearing and foot map positioning. Fluoroscopic guidance with a horizontal anterior–posterior X-ray beam was used to visualize the joint space properly. Knee radiographs were read without knowledge of participant clinical status by a single well-experienced orthopaedist (S.M.), and KL grade was defined using the KL radiographic atlas for overall knee radiographic grades[15]. The higher KL grade in both knees was designated as that of a participant. The radiographic knee OA with pain was defined as: (1) a subject reporting knee pain lasting at least 1 month with pain having last occurred within the current or previous year; and (2) radiographic OA in that painful knee. To evaluate the intraobserver variability of the KL grading, 100 randomly selected radiographs of the knee were scored by the same observer more than 1 month after the first reading. One hundred other radiographs were also scored by two experienced orthopeadic surgeons (S.M. & H.O.) using the same atlas for interobserver variability. The intra- and inter variabilities evaluated for KL grade (0–4) were confirmed by the kappa analysis to be sufficient for assessment (0.86 and 0.80, respectively). Further, to determine the prevalence of medial and lateral knee OA, knee radiographs were also read for JSN in the medial and lateral compartment separately according to the Osteoarthritis Research Society International (OARSI) atlas by a single well-experienced orthopaedist (S.M.)[25]. Medial OA was defined as present when a knee had a KL grade $\geq$2 and medial JSN score of $\geq$1 on a 0–3 scale. Lateral OA was defined as being present when a knee had a KL grade $\geq$2 and lateral JSN score of $\geq$1 on a 0–3 scale.

STATISTICAL ANALYSIS

The differences of age and BMI between men and women were examined by non-paired *t*-test. Differences in age, height, weight and BMI among the urban, mountainous and seacoast communities were determined using one-way analysis of covariance and Scheffe's test. To compare the prevalence of radiographic knee OA between men and women, we performed logistic-regression analysis after adjustment for age and BMI. Association of prevalence with age was determined by logistic-regression analysis after adjustment for BMI. Association of the variables such as age, BMI, gender and community with radiographic knee OA was evaluated by multivariate logistic-regression analysis. Logistic-regression analyses were used to estimate odds ratio and the associated 95% confidence interval (CI) of KL = 2 and KL $\geq$ 3 knee OA for pain compared with KL = 0 or 1 after adjustment for age, BMI, and community. Data analyses were performed using SAS version 9.0 (SAS Institute Inc., Cary, NC).

Results

The characteristics of the 2,282 participants aged 60 years and older in the three cohorts of the ROAD study are shown in Table I. Men were significantly older than women in the overall population and in some communities. Although the seacoast residents tended to show higher body height and weight than the other two communities, BMI was comparable among the three communities and between genders.

Table II shows the prevalence of radiographic knee OA, knee pain and radiographic knee OA with pain in the overall population and subgroups classified by gender and community. In the overall population, prevalence of KL $\geq$ 2 and KL $\geq$ 3 OA was 61.9 and 20.6%, respectively, and that of knee pain was 32.8%. That of KL $\geq$ 2 and KL $\geq$ 3 OA with knee pain was 26.1% and 13.2%, respectively. The prevalence of unilateral and bilateral KL $\geq$ 2 knee OA was 12.3% and 49.5%, respectively, while the prevalence of unilateral and bilateral KL $\geq$ 2 knee OA with pain was 2.9% and 20.4%, respectively. We next analyzed the prevalence of

Table I
Characteristics of participants

	Men				Women			
	Overall	Urban	Mountainous	Seacoast	Overall	Urban	Mountainous	Seacoast
Number of subjects	817	396	266	155	1,465	740	433	292
Age, years	74.7 ± 6.1	77.3 ± 4.1	72.1 ± 6.2†	72.7 ± 7.4†	74.0 ± 6.4*	76.4 ± 4.8*	72.0 ± 7.0†	70.9 ± 6.8*†
Height, cm	161.3 ± 6.3	161.3 ± 5.9	160.3 ± 6.6	163.0 ± 6.1†	148.6 ± 6.2	148.6 ± 5.7	146.8 ± 6.4†	151.1 ± 5.9†
Weight, kg	60.1 ± 9.9	59.8 ± 8.3	59.3 ± 11.4	62.2 ± 10.6†	50.9 ± 8.9	50.7 ± 8.4	49.8 ± 9.7	53.0 ± 8.6†
BMI, kg/m^2	23.0 ± 3.3	23.0 ± 2.7	23.0 ± 3.8	23.3 ± 3.3	23.0 ± 3.7	22.9 ± 3.5	23.0 ± 4.1	23.2 ± 3.5

Data are means ± SD.
*$P < 0.05$ vs men in the corresponding group by non-paired *t*-test.
†$P < 0.05$ vs urban residents in the corresponding group by Scheffe's test.

Table II
Number (percentage) of participants with radiographic knee OA, knee pain, and their combination

	Overall	Men				Women			
		Overall	Urban	Mountainous	Seacoast	Overall	Urban	Mountainous	Seacoast
Radiographic knee OA									
KL ≥ 2	1,413 (61.9)	384 (47.0)	171 (43.2)	154 (57.9)	59 (38.1)	1,029 (70.2)*	521 (70.4)*	340 (78.5)*	168 (57.5)*
KL ≥ 3	470 (20.6)	110 (13.5)	27 (6.8)	45 (16.9)	38 (24.5)	360 (24.6)*	133 (18.0)*	139 (32.1)*	88 (30.1)*
Knee pain	748 (32.8)	197 (24.1)	100 (25.3)	76 (28.6)	21 (13.5)	551 (37.6)*	299 (40.4)*	176 (40.6)*	76 (26.0)*
Radiographic knee OA with pain									
KL ≥ 2	595 (26.1)	129 (15.8)	54 (13.6)	60 (22.6)	15 (9.7)	466 (31.8)*	237 (32.0)*	165 (38.1)*	64 (21.9)*
KL ≥ 3	301 (13.2)	63 (7.7)	21 (5.3)	29 (10.9)	13 (8.4)	238 (16.2)*	97 (13.1)*	93 (21.5)*	48 (16.4)*

*$P < 0.01$ vs men in the corresponding group by logistic-regression analysis after adjustment for age and BMI.

medial and lateral knee OA in the participants and found that they were 20.4 and 2.1% in men and 40.0 and 3.1% in women, respectively. Logistic-regression analysis after adjustment for age and BMI revealed that the prevalence of radiographic knee OA, knee pain, and their combination was significantly higher in women than in men. When the association of the prevalence with the age group (<65, 65–69, 70–74, 75–79 and ≥80) was examined, radiographic knee OA (KL ≥ 2 and KL ≥ 3) tended to increase with age in both genders [Fig. 1(A)]. Interestingly, the prevalence of knee pain was age-dependent in women, but not in men. Hence, that of radiographic OA with pain tended to be higher with age in women, but was affected little by age in men [Fig. 1(B)].

To examine the association of age, BMI, gender, and community with radiographic knee OA, knee pain, and their combination, we further performed logistic-regression analyses to estimate odds ratios and 95% CI (Table III). Age, BMI, and female sex were shown to be risk factors for all of them. Among the communities, mountainous area residents had a higher risk of KL ≥ 2 and KL ≥ 3 knee OA than urban residents, and seacoast area residents had a higher risk for KL ≥ 3 knee OA than urban residents.

We then evaluated the association between radiographic knee OA and knee pain in the designated knee. Figure 2 shows the percentage of subjects with knee pain in subgroups classified by radiographic OA severity: KL = 0/1, KL = 2, and KL ≥ 3. Although the percentage with pain was positively correlated with the radiographic severity, the difference between KL = 2 and KL ≥ 3 appeared to be greater than that between KL = 0/1 and KL = 2 in the overall population and all communities. When odds ratios of KL = 2 and KL ≥ 3 OA as compared to KL = 0/1 for the pain were estimated by logistic-regression analysis after adjustment for age, BMI, and community, KL = 2 OA was moderately but significantly associated with knee pain in both genders of the overall population (Table IV). However, KL ≥ 3 OA was much more strongly associated with knee pain not only in both genders of the overall population, but also in those of all age strata. Interestingly, although association of KL = 2 OA with pain was comparable between men and women, that of KL ≥ 3 OA with pain was stronger in

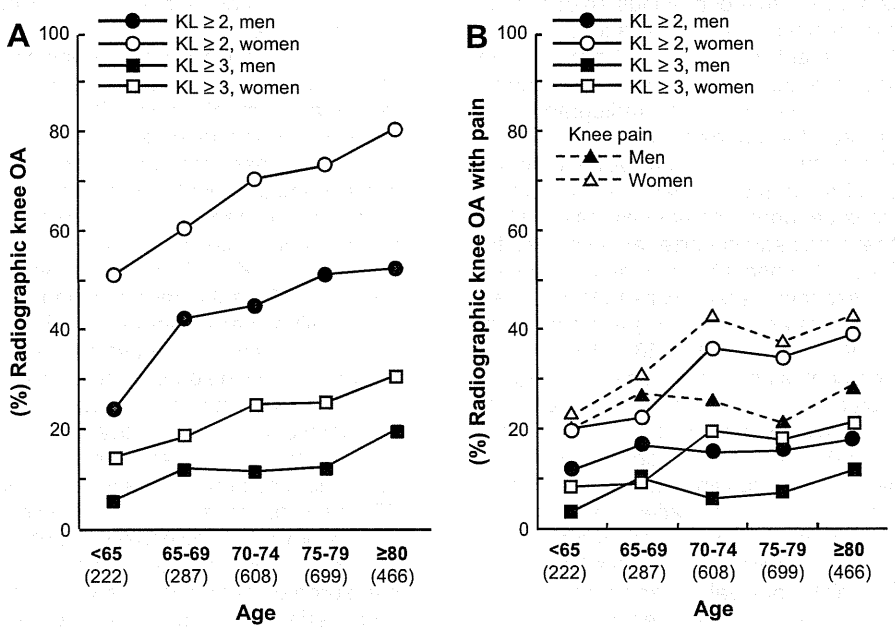

Fig. 1. (A) Percentage of subjects with radiographic knee OA (KL ≥ 2 or KL ≥ 3) in each age stratum (<65, 65–69, 70–74, 75–59 and ≥80). (B) Percentage of subjects with knee pain and radiographic knee OA (KL ≥ 2 or KL ≥ 3) with pain in each age stratum. The number of subjects in each age stratum is shown in parentheses.

Table III
Association of age, BMI, gender, and community with radiographic knee OA, knee pain and their combination

	Radiographic knee OA				Knee pain		Radiographic knee OA with pain			
	KL ≥ 2		KL ≥ 3				KL ≥ 2		KL ≥ 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age, years	1.09	1.07–1.11*	1.11	1.09–1.13*	1.04	1.02–1.06*	1.07	1.05–1.08*	1.09	1.07–1.12*
BMI, kg/m^2	1.14	1.11–1.18*	1.23	1.19–1.28*	1.18	1.14–1.21*	1.21	1.17–1.25*	1.24	1.20–1.29*
Women (vs Men)	3.28	2.71–3.97*	1.58	1.39–1.79*	2.05	1.68–2.51*	2.83	2.26–3.57*	2.59	1.92–3.53*
Community (vs Urban)										
Mountainous	2.64	2.08–3.35*	3.83	2.92–5.03*	1.27	1.02–1.58*	1.95	1.54–2.47*	2.84	2.09–3.85*
Seacoast	0.95	0.74–1.23	4.13	3.05–5.59*	0.56	0.42–0.73*	0.75	0.55–1.01	1.95	1.35–2.78*

The odds ratios were calculated by logistic-regression analysis after adjustment for all other variables.
*$P < 0.01$ OR = odds ratio, CI = confidential interval.

men. Considering that knee pain is more prevalent in women than in men (Tables II and III), we examined the association of gender with knee pain according to the KL grade. The odds ratio for knee pain of women compared with men estimated by a logistic-regression analysis after adjustment for age and BMI in the subgroup without radiographic knee OA (KL = 0/1) was comparable to or greater than that in those with radiographic knee OA (KL = 2 or KL ≥ 3) (Supplementary Table SI), suggesting independent backgrounds of knee pain between genders.

Discussion

The present study initially estimated the prevalence of knee OA in the Japanese elderly (≥60 years) using the baseline data of population-based cohorts in the ROAD study. The prevalence of KL ≥ 2 OA, the conventional diagnostic criterion of radiographic OA determined by the anterior–posterior view with standing position, was 47.0% and 70.2% in men and women, respectively (Table II), which was much higher than that of previous epidemiologic studies in elderly Caucasians in the USA and Europe[4–9], although not greatly different from African Americans and Chinese[10–12] (Supplementary Table SII). Caucasians seem to show a lower prevalence of radiographic OA than other races. In fact, the Johnston County study and the NHANES studies showed that African Americans had a higher prevalence of radiographic knee OA than Caucasians[6,8–10]. A previous Japanese community-based study, although with a rather small sample size, also showed that the prevalence of KL ≥ 2 knee OA of elderly Japanese women living in a seacoast area, Hizen-Oshima, was higher than that of Caucasian women in the Framingham study[13] (OR = 1.96, 95% CI = 1.50–2.56). Although the prevalence in the present study was higher than that in the Hizen-Oshima study, it was not much different from that of KL ≥ 2 knee OA of women in the seacoast area of the present study (46.4 vs 57.5%, Table II). Knee OA is a major public health issue causing impairment of activities of daily living and the number of patients with knee OA is suggested to be increasing with the advancing age of the population in Japan. According to the National Livelihood Survey of the Ministry of Health, Labour and Welfare in Japan, this disease is now ranked second among the diseases that cause disabilities requiring support with activities of daily living.

In the present study, the prevalence of unilateral and bilateral KL ≥ 2 knee OA was 12.3% and 49.5%, respectively, while it was 12.5 and 34.1% in the Beijing study and 15.2 and 19.7% in the Framingham study, respectively[11]. The high prevalence of bilateral OA in this study was comparable to that in the Beijing study, but higher than that in the Framingham study. The high prevalence of bilateral knee OA may indicate that environmental or ethnic factors have an important role in knee OA in Japan and China. Zhang *et al.* described that the higher prevalence of bilateral knee OA in China could be due to the much more physically active lifestyle of the Chinese compared with US whites, especially among those who are elderly[11]. The higher prevalence of bilateral knee OA in Japan could also be due to lifestyle factors, because the Japanese traditional lifestyle includes sitting on the heels on a mat and using Japanese-style lavatories; these positions may cause mechanical stress to the knee joint and possibly lead to the acceleration of OA[26,27]. On the other hand, the prevalence of medial and lateral knee OA in the present study was 20.4 and 2.1% in men and 34.0 and 3.1% in women, respectively. The ratio of lateral to medial knee OA was 0.10 and 0.09 in men and women, respectively, while it was 0.13 and 0.20 in the Framingham study and 0.80 and 0.64 in the Beijing study, respectively[28]. In the present study, the prevalence of lateral knee OA was much lower than that of medial knee OA, which was comparable to that in the Framingham study, but lower than that in the Beijing study. There may be different etiologies of medial and lateral compartment OA in different ethnic populations. Further study is required to elucidate the underlying background of this disease.

Contrary to KL ≥ 2 OA, the prevalence of KL ≥ 3 OA was not much different in men from that in Caucasians, although it was still higher in women[4,5,7] (Supplementary Table SII). This indicates that the prevalence of KL = 2 knee OA is particularly high in the present study, especially in men. Considering the definition of the KL grade, this may mean that osteophytosis is more prevalent in elderly Japanese men, while JSN is comparable between the two ethnic groups. There is accumulating evidence that osteophytosis and JSN have distinct etiologic mechanisms. A recent cross-sectional study has shown that osteophytosis was unrelated not only to JSN on plain radiographs, but also to cartilage loss measured by quantitative MRI[17]. Furthermore, our study on an experimental mouse model for OA has identified a cartilage specific molecule, carminerin, that regulates osteophytosis without affecting joint cartilage destruction during the OA progression[18,19]. Hence, there may be some risk factors that are specific to osteophytosis in elderly Japanese men.

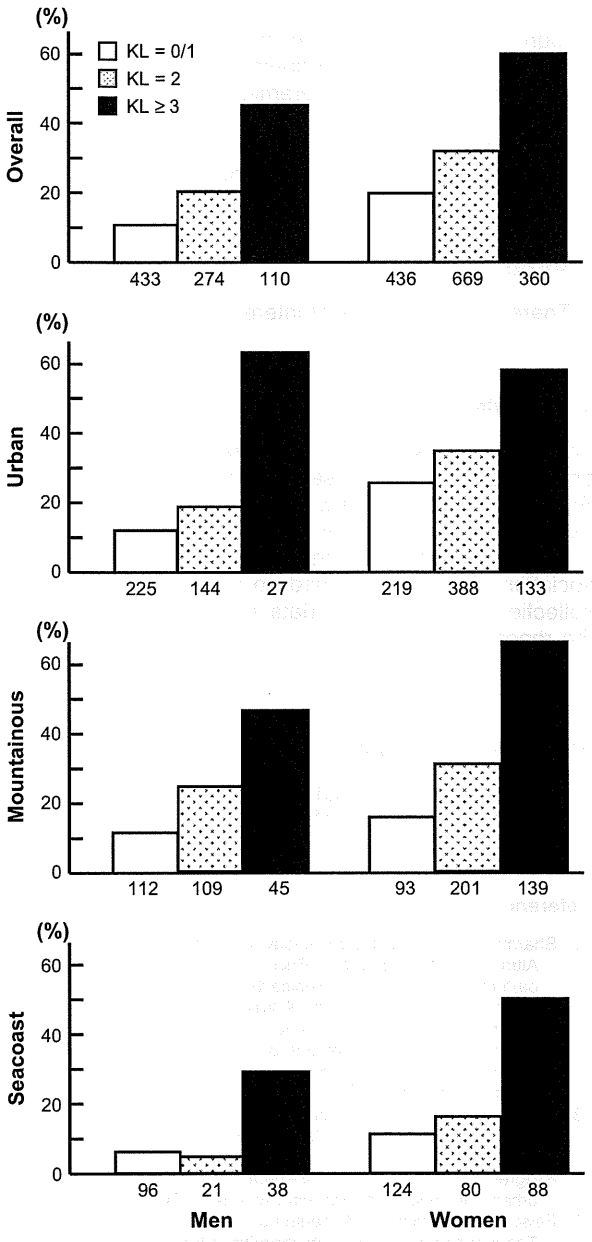

Fig. 2. Percentage of subjects with knee pain in each subgroup classified by the KL grade in the overall population and communities. The number of subjects in each subgroup is shown under the bars.

This study, the first analysis of the baseline data of the ROAD study, found that age and BMI were risk factors of radiographic knee OA (Table III), consistent with previous epidemiologic studies[1,29,30]. These factors may be related to the accumulation of mechanical stress on the knee joint. Female sex was also shown to be a strong risk factor, as in previous studies[4–8], possibly implicating an involvement of muscle strength to compensate the mechanical stress, as women are known to have less muscle strength than men in all decades[31]. Rural residency was also a risk factor of radiographic knee OA even after adjustment for age and BMI, indicating the involvement of other environmental factors like nutrition or occupation as well as genetic factors. In fact, the principle industries in the rural communities were

Table IV
Association of KL grade with knee pain according to age

	Overall		<65		65–69		70–74		75–79		≥80	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Men												
KL = 2	1.96	1.27–3.05†	4.16	0.61–31.78	1.31	0.37–4.49	2.51	1.12–5.74	2.87	1.29–6.82*	0.58	0.24–2.11
KL ≥ 3	8.55	5.00–14.84†	9.39	0.52–231.69	7.91	1.72–41.02†	5.44	1.77–17.02	13.49	4.91–39.86†	8.24	2.77–27.02†
Women												
KL = 2	1.55	1.15–2.09†	1.45	0.53–4.04	1.36	0.62–3.06	1.59	0.92–2.79	1.45	0.84–2.58	1.87	0.92–4.04
KL ≥ 3	4.37	3.09–6.21†	4.13	1.17–14.80*	3.16	1.18–8.73*	5.60	2.93–10.97†	2.82	1.49–5.43†	7.36	3.25–17.66†

The odds ratio was calculated by logistic-regression analysis compared with subjects with KL grade 0 or 1 after adjustment for age, BMI and communities.
*$P < 0.05$; †$P < 0.01$.

farming, forestry and fishing, each of which demands physical activity and repetitive laborious use of the knee joints. Because the database of the ROAD study includes such detailed information of environmental factors including occupational career, lifestyle, and physical activity, as well as genetic information, further analyses will allow us to elucidate the risk factors and backgrounds of knee OA in more detail.

The present study also showed that the odds ratio for knee pain of KL $\geq$ 3 OA was much higher than that of KL = 2 OA in both genders (Table IV), suggesting that JSN was more closely associated with the pain than osteophytosis. On the other hand, approximately 10% of men and 20% of women without radiographic knee OA (KL = 0/1) had knee pain. Although the prevalence of knee pain and radiographic OA with pain was approximately double in women what it was in men (Table II), the association of knee pain with radiographic knee OA, especially with KL $\geq$ 3 OA, was stronger in men (Table IV). Furthermore, the odds ratio for knee pain of women compared with men in the subgroup without radiographic knee OA (KL = 0/1) was comparable to or greater than that in those with radiographic knee OA (Supplementary Table SI). This suggests the existence of a cause of pain that is independent of OA in women, while the pain in men may be more dependent on JSN by OA. Radiographic JSN represents not only joint cartilage destruction, but also meniscal loss or extrusion. In addition, knee pain may arise from a variety of structures other than joint cartilage, like menisci, synovium, ligaments, bursae, bone and the bone marrow[32–36]. Hence, comprehensive mechanistic studies for the knee pain taking various tissues in and around the knee joint into consideration will be needed to elucidate the relationship between radiographic OA and symptomatic OA.

Although the prevalence of radiographic knee OA increased with age in both genders, that of knee pain was age-dependent only in women (Fig. 1). This might be due to the accumulated mechanical stress to the knee due to the Japanese traditional lifestyle and the decreased muscle strength as described above, both of which women may experience more than men. Alternatively, elderly men generally retire from their occupations around 60 to 70 years, while women must continue to do household chores even after the age of 70.

There are several limitations in this study. First, the radiographic investigators did not have readers calibrate themselves to readings from other studies. Although we reported higher prevalence of radiographic knee OA than in previous studies, radiographic acquisition, scoring techniques and methodology across studies limit strict comparisons between our results and previous reports. Differences across studies in the thresholds used by readers to define osteophytes may have a substantial impact on their prevalence. The high prevalence of knee OA in our study compared to that in other populations may be due to such differences. Second, our analysis did not include patellofemoral joint radiographs, which would likely increase the prevalence of radiographic outcomes and perhaps increase the concordance between radiographic knee OA and its pain. Third, because the KL system emphasizes osteophytosis, it is unclear how to handle knee OA with JSN but no osteophytosis. The investigation of the relationship among knee OA features including JSN and osteophytosis is the next task in the ROAD study.

In conclusion, the present cross-sectional study using a large-scale population from the ROAD study revealed a high prevalence of radiographic knee OA in the Japanese elderly. Knee pain was more strongly associated with KL $\geq$ 3 OA with JSN than with KL = 2 with osteophytosis, although it was distinctly associated with radiographic OA between genders. Further progress in developing an accurate method for surrogate measurement of the structural severity of knee OA, along with continued longitudinal survey in the ROAD study, will elucidate the environmental and genetic backgrounds of knee OA and its relation to knee pain.

Conflict of interest

There are no conflicts of interest.

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Supplementary material

Supplementary material for this article may be found, in the online version, at doi:10.1016/j.joca.2009.04.005.

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Prevalence of radiographic lumbar spondylosis and its association with low back pain in elderly subjects of population-based cohorts: the ROAD study

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ABSTRACT

Objectives: Although lumbar spondylosis is a major cause of low back pain and disability in elderly people, few epidemiological studies have been performed. The prevalence of radiographic lumbar spondylosis was investigated in a large-scale population study and the association with low back pain was examined.

Methods: From a nationwide cohort study (Research on Osteoarthritis Against Disability; ROAD), 2288 participants aged ≥60 years (818 men and 1470 women) living in urban, mountainous and coastal communities were analysed. The radiographic severity at lumbar intervertebral levels from L1/2 to L5/S was determined by Kellgren/Lawrence (KL) grading.

Results: In the overall population the prevalence of radiographic spondylosis with KL≥2 and ≥3 at the severest intervertebral level was 75.8% and 50.4%, respectively, and that of low back pain was 28.8%. Although KL≥2 spondylosis was more prevalent in men, KL≥3 spondylosis and low back pain were more prevalent in women. Age and body mass index were risk factors for both KL ≥2 and KL≥3 spondylosis. Although KL = 2 spondylosis was not significantly associated with low back pain compared with KL = 0 or 1, KL≥3 spondylosis was related to the pain only in women.

Conclusions: This cross-sectional study in a large population revealed a high prevalence of radiographic lumbar spondylosis in elderly subjects. Gender seems to be distinctly associated with KL≥2 and KL≥3 lumbar spondylosis, and disc space narrowing with or without osteophytosis in women may be a risk factor for low back pain.

Lumbar spondylosis is considered a major public health issue causing chronic disability of elderly people in most developed countries.[1 2] Despite the urgent need for strategies for the prevention and treatment of this condition, epidemiological data on lumbar spondylosis such as its prevalence and association with symptoms are sparse. With the goal of establishing epidemiological indices to evaluate clinical evidence for the development of disease-modifying treatment, we set up a large-scale nationwide cohort study for bone and joint disease called ROAD (Research on Osteoarthritis Against Disability) in 2005. We have to date created a baseline database with detailed clinical and genetic information on three population-based cohorts in urban, mountainous and coastal communities of Japan.

Lumbar spondylosis is characterised by disc degeneration and osteophytosis.[2 3] Although this disorder has been widely studied in a clinical setting, few population-based radiological studies have been attempted.[4–11] The reported prevalence of radiographic lumbar spondylosis differs greatly in these reports from about 40% to 85%. This may be due to limitation of the sample size and variability in age. The present study therefore initially investigated the prevalence and distribution of this disorder according to age, gender and community using cohorts of 2288 participants aged ≥60 years in the baseline survey of the ROAD study.

The most popular grading system for the radiographic severity of osteoarthritis is the Kellgren/Lawrence (KL) system with classification into five grade scales (0–4) where KL≥2 is the conventional standard of the diagnosis.[12] For lumbar spondylosis, KL grade 2 is defined as osteophyte formation and grade 3 as disc space narrowing in addition to osteophyte formation,[12] although few epidemiological studies have applied the KL system to evaluate the lumbar spine.[5 6 9] Hence, to assess osteophyte formation alone and disc space narrowing with or without osteophytosis separately, this study examined not only the prevalence of KL≥2 spondylosis but also that of KL≥3 spondylosis.

Although low back pain is believed to be the principal clinical symptom of lumbar spondylosis, its association with the radiographic severity remains unclear. The correlation was not as strong as one would expect, and there is often a disconnection between them.[7 8] In previous reports radiographic spondylosis was determined at the severest intervertebral level, but it is possible that other levels with milder spondylotic change might give rise to low back pain. This study therefore assessed the radiographic severity at all intervertebral levels of the lumbar spine by the KL system, and examined the association between radiographic severity and low back pain.

METHODS

Participants

The ROAD study is a nationwide prospective cohort study for bone and joint diseases consisting of population-based cohorts established in several communities in Japan. To date we have created a baseline database which includes clinical and genomic information of 3040 inhabitants (1061 men, 1979 women) in the age range 23–95 years (mean 70.6) in three communities: an urban region in Itabashi, Tokyo; a mountainous region in Hidakagawa, Wakayama; and a coastal region in

Taiji, Wakayama. Participants in the urban region were recruited from those of a cohort study[13] in which the participants were randomly drawn from the register database of Itabashi ward residents, with a response rate in the age group ≥60 years of 75.6%. Participants in the mountainous and coastal regions were recruited from resident registration lists, with response rates in the groups aged ≥60 years of 68.4% and 29.3%, respectively.

Participants completed an interviewer-administered questionnaire of 400 items which included lifestyle information such as smoking habits, alcohol consumption, family history, past history, physical activity, reproductive variables and health-related quality of life. Anthropometric measurements included height, weight, arm span, bilateral grip strength and body mass index (BMI, kg/m^2). Medical information was taken by experienced orthopaedic surgeons (SM and HO) on systemic, local and mental status including information on low back, knee and hip pain, swelling and range of motion of the joints, and patellar and achilles tendon reflex. All participants were interviewed regarding low back pain by asking: "In the past month, have you had pain on most days lasting?", and those who answered yes were defined as having low back pain. Blood and urine samples were collected for biochemical and genetic examinations. Plain radiographs of the lumbar spine, knee and hip were taken for all participants. Participants were confirmed to be comparable to the Japanese general population according to the national nutrition survey by the Ministry of Health, Labour and Welfare (Japan). The height of the men and women in the ROAD study was 162.5 cm and 149.7 cm, respectively, compared with 162.6 cm and 149.9 cm in the Japanese general population. Weight was 61.3 kg and 51.8 kg, respectively, compared with 61.6 kg and 53.8 kg. The percentage of the men and women in the study population with a smoking habit was 26.4% and 3.2%, respectively, compared with 29.4% and 4.0% in the general population. From the baseline data of the overall participants, the present study analysed 2288 subjects (818 men and 1470 women) aged ≥60 years.

Radiographic assessment

Plain radiographs of the lumbar spine were taken in the anteroposterior and lateral positions and the images were downloaded into Digital Imaging and Communication in Medicine (DICOM) format files to assess radiographic spondylosis. Contrast-adjusted images were used to detect osteophytes and intervertebral spaces when the original images were obscure. Osteophytes were analysed at endplates. The severity of lumbar spondylosis was determined according to the KL grading[12] at each intervertebral level from L1/2 to L5/S by a single experienced orthopaedic surgeon (SM) who was blind to the background of the patients. To evaluate the intra-observer variability of the KL grading, 100 randomly selected radiographs of the lumbar spine were scored by the same observer more than 1 month after the first reading. Furthermore, 100 other radiographs were scored by two experienced orthopaedic surgeons (SM and HO) using the same radiographic atlas for inter-observer variability. The intra- and inter-observer variabilities were evaluated by kappa analysis. The variability in KL grading of the lumbar radiographs was found to be sufficient for assessment (0.84 and 0.76, respectively).

Statistical analysis

The non-paired *t* test was used to examine the difference in age and BMI between men and women. To compare the percentage of patients with radiographic spondylosis (KL≥2 or ≥3 at the severest level) and low back pain between men and women, logistic regression analysis was performed after adjustment for age and BMI. The differences in prevalence among the age groups were determined using one-way analysis of covariance and Scheffe's test after adjustment for BMI. The association of the variables such as age, BMI, gender and community with radiographic spondylosis and low back pain was evaluated by multivariate logistic regression analysis. The association of radiographic spondylosis at each intervertebral level with low back pain was determined by logistic regression analysis after adjustment for age and BMI. The association of the number of intervertebral level with KL≥3 with low back pain was determined by multiple regression analysis after adjustment for age and BMI. Data analyses were performed using SAS Version 9.0 (SAS Institute, North Carolina, USA).

RESULTS

Table 1 shows the overall characteristics of the 2288 participants aged ≥60 years in the three cohorts of the ROAD study. Although the men were significantly older than the women in the overall population and in some communities, BMI was comparable between them.

Table 2 shows the prevalence of radiographic lumbar spondylosis and low back pain in the overall population and subgroups classified by gender and age strata. In the overall population the prevalence of radiographic spondylosis with KL≥2 and ≥3 at the severest intervertebral level was 75.8% and 50.4%, respectively, and that of low back pain was 28.8%. The prevalence of osteoporotic fracture at the lumbar spine was 10.7%. Logistic regression analysis after adjustment for age and BMI showed that the prevalence of radiographic spondylosis with KL≥2 was higher in men than in women, while the prevalence of KL≥3 radiographic spondylosis and low back pain was higher in women than in men. When the prevalence was

Table 1 Characteristics of study participants

	Men				Women			
	Overall	Urban	Mountainous	Coastal	Overall	Urban	Mountainous	Coastal
No of subjects	818	397	266	155	1470	742	434	294
Age (years)	74.7 (6.1)	77.3 (4.1)	72.1 (6.2)	72.7 (7.4)	74.0 (6.4)*	76.4 (4.8)*	72.1 (7.1)	70.9 (6.8)*
Height (cm)	161.3 (6.3)	161.2 (5.9)	160.3 (6.6)	163.0 (6.1)	148.6 (6.2)	148.6 (5.8)	146.8 (6.4)	151.2 (5.9)
Weight (kg)	60.1 (9.9)	59.8 (8.3)	59.3 (11.4)	62.2 (10.6)	50.9 (9.0)	50.7 (8.4)	49.8 (9.8)	53.1 (8.8)
BMI (kg/m^2)	23.0 (3.2)	23.0 (2.7)	23.0 (3.8)	23.3 (3.3)	23.0 (3.7)	22.9 (3.4)	23.1 (4.2)	23.2 (3.5)
Current smoker (%)	24.6	25.2	26.3	20.0	3.1*	3.1*	4.4*	1.0*
Current drinker (%)	61.2	60.0	67.0	54.8	20.2*	21.0*	22.1*	15.3*

Data are mean (SD).
*$p<0.05$ vs men in the corresponding group by the non-paired *t* test.
BMI, body mass index.

Table 2 Number (%) of participants with radiographic lumbar spondylosis and low back pain according to gender and age

		Radiographic lumbar spondylosis		
		KL≥2	KL≥3	Low back pain
Overall	2288	1728 (75.8)	1149 (50.4)	659 (28.8)
Men	818	688 (84.1)	383 (46.8)	201 (24.6)
<70	154	114 (74.0)	51 (33.1)	35 (22.7)
70–79	491	419 (85.3)*	232 (47.3)*	119 (24.2)
≥80	173	155 (89.6)*	100 (57.8)*	47 (27.2)
Women	1470	1040 (70.7)†	766 (52.1)†	458 (31.2)†
<70	356	196 (55.1)	128 (36.0)	80 (22.5)
70–79	818	612 (74.8)*	456 (55.7)*	273 (33.4)*
≥80	296	232 (78.3)*	182 (61.5)*	105 (35.5)*

Radiographic spondylosis was determined at the severest level among L1/2–L5/S1.
*p<0.05 vs subjects aged <70 years by Scheffe's test after adjustment for body mass index.
There was no significant difference between ages 70–79 and ≤80 in both genders.
†p<0.05 vs men by logistic regression analysis after adjustment for age and body mass index.
K/L, Kellgren/Lawrence grading.

compared among the generations, radiographic spondylosis (KL≥2 and ≥3) and low back pain tended to increase with age. Interestingly, the difference was greater between ages <70 and 70–79 years than between 70–79 and ≥80 years.

To identify risk factors for the radiographic spondylosis and low back pain, we further performed the logistic regression analysis to estimate odds ratios and confidence intervals (table 3). Age and BMI were significantly associated with radiographic spondylosis. Male sex was confirmed to be a risk factor for KL≥2 spondylosis while female sex was a risk factor for KL≥3 and low back pain. Among the communities, residents of the mountainous area had a lower risk for KL≥3 spondylosis than urban residents.

We then examined the association between radiographic spondylosis and low back pain. Considering that intervertebral levels other than the severest level of radiographic spondylosis might possibly cause low back pain, spondylosis at all intervertebral levels from L1/2 to L5/S was evaluated: KL≥2 spondylosis was found to be comparably prevalent at L2/3, L3/4 and L4/5 while KL≥3 spondylosis was remarkably prevalent at L4/5 in both men and women (table 4). In fact, among the five levels L4/5 was most frequently determined to be the severest level in both genders (men: L1/2 49.4%, L2/3 59.5%, L3/4 58.0%, L4/5 64.5%, L5/S 48.3%; women: L1/2 49.5%, L2/3 58.0%, L3/4 58.6%, L4/5 65.5%, L5/S 44.3%). We then looked at the percentage of subjects with low back pain in three groups: KL = 0 or 1, KL = 2, and KL≥3, at each intervertebral level and the severest level in the overall population and the three communities (fig 1). When odds ratios of KL = 2 and KL≥3 spondylosis compared with KL = 0 or 1 for pain were estimated by logistic regression analysis after adjustment for age and BMI, KL = 2 spondylosis was not significantly associated with pain in either gender at any intervertebral level (table 5). However, KL≥3 spondylosis was related at all levels in women while in none of the levels in men. Furthermore, the number of intervertebral levels with KL≥3 spondylosis was significantly associated with low back pain in women (p<0.01) but not in men by multiple regression analysis after adjustment for age and BMI. The association between KL≥3 spondylosis at the severest level and low back pain in women was evident at younger ages (<70 and 70–79 years; see table 1 in online supplement) and in the urban community (see table 2 in online supplement).

DISCUSSION

This study showed that the prevalence of radiographic lumbar spondylosis with KL≥2 and KL≥3 in elderly people (≥60 years) was 75.8% and 50.4%, respectively, and that of low back pain was 28.8% in the overall population. Although KL≥2 spondylosis was more prevalent in men (84.1%) than in women (70.7%), KL≥3 spondylosis and low back pain were more prevalent in women. This study also showed that KL = 2 spondylosis was not significantly associated with low back pain compared with KL = 0 or 1, while KL≥3 spondylosis was related to the pain only in women.

Most previous epidemiological studies on lumbar spondylosis focused on middle-aged or younger populations, reporting the prevalence to be 46.5–83.7%.[4 6–8 10 11] Our previous small-scale study on a younger population reported the prevalence to be 76.3% and 37.4%.[9] Interestingly, the subjects were living in a mountainous area in Japan, which was shown to have a lower risk for spondylosis in the present study. The variability may therefore be due to the differences in age, community, the sample size and ethnic variation. In fact, a study on elderly people (≥65 years) showed that the prevalence of KL≥2 spondylosis was 84.8% and 70.6%, similar to the present results, although in a relatively small number of subjects.[5] We have reported a different prevalence of lumbar spondylosis in Japan and the UK in a small-scale comparative study,[9] which may in part relate to ethnic variation. It should be noted that this is the first population-based study to investigate the age-related prevalence of lumbar spondylosis in elderly people. Although KL≥2 and KL≥3 spondylosis tended to increase with age, a significant difference was detected between the 60s and the 70s, but not thereafter. However, this cross-sectional

Table 3 Association of gender and community with radiographic lumbar spondylosis and low back pain

	Radiographic lumbar spondylosis		
	KL≥2	KL≥3	Low back pain
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (years)	1.07 (1.06 to 1.09)†	1.05 (1.04 to 1.07)†	1.02 (1.00 to 1.04)*
BMI (kg/m²)	1.06 (1.03 to 1.09)†	1.04 (1.01 to 1.06)†	1.02 (0.99 to 1.05)
Women (vs men)	0.68 (0.61 to 0.76)†	1.13 (1.03 to 1.23)†	1.19 (1.08 to 1.31)†
Community (vs urban)			
Mountainous	0.82 (0.65 to 1.04)	0.56 (0.45 to 0.69)†	0.87 (0.69 to 1.08)
Coastal	1.24 (0.93 to 1.66)	1.06 (0.84 to 1.34)	0.86 (0.66 to 1.11)

Radiographic spondylosis was determined at the severest level among L1/2–L5/S1.
The odds ratios were calculated by logistic regression analysis after adjustment for all other variables.
*p<0.05; †p<0.01.
BMI, body mass index; KL, Kellgren/Lawrence grading; OR, odds ratio; CI, confidence interval.