Radiographic case definitions and prevalence of osteoarthrosis of the hip

A survey of 4 151 subjects in the Osteoarthritis Substudy of the Copenhagen City Heart Study

Steffen Jacobsen[1,4], Stig Sonne-Holm[2,4], Kjeld Søballe[3], Peter Gebuhr[2,4] and Bjarne Lund[1]

Departments of Orthopaedic Surgery, [1]Copenhagen University Hospital, Rigshospitalet, [2]Copenhagen University Hospital, Hvidovre Hospital, [3]Aarhus University Hospital, Aarhus Amtssygehus; [4]The Copenhagen City Heart Study: Osteoarthritis Substudy
Correspondence SJ: sjac@dadlnet.dk
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Background The diagnosis of osteoarthrosis (OA) is founded on radiographic evidence of joint degeneration and characteristic subjective symptoms. Due to the lack of consensus radiographic case definitions, the prevalence and incidence of OA reported in the literature varies. The aims of the current study were to establish an accurate and workable radiographic definition of OA in hip joints and to examine the association of OA (thus defined) with self-reported pain.

Methods Radiographic features of hip OA were classified in pelvic radiographs of 3 807 subjects (1 448 males and 2 359 females) according to the OA classifications of Kellgren and Lawrence (1957) and Croft (1990), and according to minimum joint space width (JSW) of 2.0 mm regardless of other radiographic features of OA. The relationships between these radiographic discriminators and self-reported hip pain were investigated.

Results Formation of cysts, osteophytes and subchondral sclerosis was significantly more frequent in men. Average minimum JSW was narrower in women than in men ($p < 0.001$). In both sexes, minimum JSW decreased after the fourth decade of life, but progressively more so in women. Women reported hip pain more frequently than men ($p < 0.001$). When the cut-off JSW value of 2.0 mm was applied regardless of other radiographic features of OA, prevalences of hip OA ranged from 4.4% to 5.3% in subjects ≥ 60 years of age. The radiographic discriminator with the strongest association with self-reported hip pain in men and women ≥ 60 years of age was minimum JSW ≤ 2.0 mm; OR = 3.3 (95% CI 1.9–5.7) for men, and OR = 3.2 (95% CI 1.9–5.2) for women.

Interpretation We found that minimum JSW ≤ 2.0 mm was the radiographic criterion having the closest association with self-reported hip pain. Using composite OA scores emphasizing the relatively inconsequential formation of cysts, osteophytes and subchondral sclerosis runs the risk of over-inflating the prevalence of hip OA in men and of underestimating hip OA prevalence in women.

The diagnosis of osteoarthrosis (OA) is based on a combination of radiographic evidence of joint degeneration and characteristic subjective symptoms. The incidences and prevalences reported for OA vary throughout the literature, which is due to the lack of a radiographic consensus definition. Researchers use global radiographic scores or assessments of individual radiographic features to discriminate between healthy and degenerative joints. However, the widely used classifications of Kellgren and Lawrence (1957) (K-L) or Croft et al. (1990) are not equally suitable for assessment of OA at all sites, emphasising the relatively unimportant formation of cysts, osteophytes and subchondral sclerosis. Furthermore, the reproducibility of readings has been problematic (Spector and Cooper 1993, Sun et al. 1997). The nomenclature of the K-L classification is not precise,

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using terms such as "possible", or "gross" for characterization of reduced joint space. The notion of a chronological sequence of degeneration is implicit: narrowing of joint space precedes the development of osteophytes which precedes subchondral sclerosis, which precedes the formation of cysts. To our knowledge, this causality has not been shown in the literature. Recognizing these limitations, several authors have used minimum joint space width (JSW) as the primary criterion of hip OA (Dougados et al. 1996, 1997, Danielsson and Lindberg 1997, Ingvarsson et al. 1999). However, the minimum values for JSW defining hip OA have ranged from 1.5 to 4.0 mm, and until recently the natural distribution of JSW had not been evaluated in asymptomatic subjects (Goker et al. 2003, Lanyon et al. 2003).

We assessed radiographic features of hip OA in 4 151 standing, standardized pelvic radiographs from the Osteoarthritis Substudy cohort of the third Copenhagen City Heart Study (CCHS III). Prevalence of radiographic hip OA was estimated according to the global scores of Kellgren and Lawrence and Croft (Croft et al. 1990) and also according to minimum JSW ≤ 2.0 mm. Associations between these radiographic discriminators of OA and self-reported pain were examined.

Subjects and methods

The CCHS is a health survey of a predominantly Caucasian cohort recruited from the county of Österbro in Copenhagen using a random social security number algorithm. The survey has been performed four times since its inception in 1976 (Schnohr et al. 2001).

The CCHS III survey (1991–1994) consisted of 10 135 participants (4 437 male) who completed a musculoskeletal questionnaire covering past and present joint and muscular disorders. From the main cohort, 2 949 (1 023 male) subjects were selected for radiography of the pelvis, the knees, the hands, the wrists and the lumbar spine. The inclusion criteria for radiography were positive answers in 4 or more of 50 main questions. In addition, 1 202 subjects (533 male) of the main CCHS III cohort with positive answers in 3 or less questions were selected as sex- and age-matched controls. 4 151 subjects (41%) of the main cohort were thus selected for radiography. According to independent sample t tests, the subjects of the radiography protocol did not differ from the rest of the main cohort with regard to occupational profile or physical characteristics.

Independent sample t-tests were performed to ensure that control subjects and subjects primarily selected for radiography did not differ significantly with regard to recorded parameters, and that all subjects in the radiography protocol constituted a united cohort for the purpose of the present study. The combined cohort consisted of 1 533 men with an average age of 63 (23–93) years, and 2 618 women with an average age of 65 (22–92) years.

Two radiographers performed all examinations. Antero-posterior (AP) pelvic and lateral lumbar spine radiographs were recorded standing. The feet were pointing straight forward, and the lower extremities were positioned in neutral abduction-adduction along the functional axis. In AP pelvis radiographs, the X-ray beam was centered two fingerbreadths over the symphysis pubis in the vertical midline. The X-ray beam in lateral lumbar spine radiographs was centered at the apical midpoint of the iliac crista. Tube-to-film distance was 120 cm in all cases.

Radiographic evaluation

Minimum JSW was measured at three locations: 1) at the lateral margin of the subchondral sclerotic line ('the sourcil'), 2) at the apical transection of the weight-bearing surface by a vertical line through the center of the femoral head, and 3) at the medial margin of the weight-bearing surface bordering on the fovea. Minimum JSW was selected as the smallest of these three measurements. Maximum subchondral sclerosis was measured at one location. The presence of osteophytes and subchondral cysts was recorded. For assessment of JSW and thickness of sclerosis, one observer (SJ) performed all measurements using a 0.1-mm graded magnifying glass (Peak, Japan).

Absence or presence of OA was determined according to Croft (grade 3°–5°), and to Kellgren and Lawrence (grade 2°–4°), using a radiographic atlas (Kellgren 1963), and to minimum JSW ≤ 2.0 mm regardless of other radiographic features of OA.

Pelvic inclination was measured on the lateral lumbar spine radiographs as the angle between the horizontal plane and a line parallel to the cranial articulating surface of the sacrum. Extreme pelvic inclination during standing pelvic X-ray recordings is a possible source of error in JSW measurements. Thus, radiographs with pelvic inclinations outside 2 standard deviations of the mean were omitted from the study (Jacobsen et al. 2004). Median pelvic inclination was 38° (0°–82°), and 1 SD was 9.4°. Inclusion limits of pelvic inclination thus ranged from 19° to 56°.

Assessment of hip pain

At the baseline examination, subjects were asked the following questions: 1) "Have you experienced recurrent hip pain during the past 12 months?", 2) "Have you experienced frequent and recurrent deep pain in the groins during the past 12 months?", and 3) "Have you experienced frequent and recurrent deep pain in the buttocks during the past 12 months?". Whether hip pain was unilateral or bilateral was not recorded.

Subjects included

The study primarily included 3 807 subjects. There were 1 448 men (32%) with mean age of 61 (23–93) years, and 2 359 women, also with a mean age of 61 (22–92) years. The following criteria for exclusion were applied: 1) pelvic inclination outside two SD of the median value, 2) former hip surgery of any kind, 3) former hip fractures, 4) former treatment of childhood hip disorders, 5) a history of rheumatoid arthritis (RA) of any joint, 6) radiographs which due to obesity made measurements of minimum JSW inaccurate, and 7) subjects with total hip replacements (THR).

According to the Danish Hip Replacement Register, approximately 78% of inserted total hip replacements are inserted because of primary, idiopathic OA. An unknown number of cases may, however, be due to secondary causes of hip OA: monoarticular arthritis, unrecognized childhood hip disorders and so forth. It was not possible to determine the precise causes of replacement surgery from our material, or the age at which the replacement had been implanted. In men ≥ 65 years of age, there were 5 right-hip THR and 4 left-hip THR (0.6%). In females, there were 23 right-hip and 22 left-hip THR (1.2%). If we estimate that 75% of these were indicated by primary OA, the prevalence of hip OA would have increased by 0.4% in male hips and 0.9% in female hips—if these subjects had been included in the study.

Statistics

Independent samples t-tests were performed to assess sex-related differences in minimum JSW and thickness of subchondral sclerosis. Chi-squared tests were performed to assess sex-related differences in formation of cysts, osteophytes, subchondral sclerosis and pathologically reduced JSW according to predefined limits of pathology. Relationships between age and radiographic features of OA were evaluated by linear regression analysis. Chi-squared tests were performed to assess association between different radiographic discriminators of hip OA and self-reported hip pain. A significance level of $p < 0.05$ was chosen for all calculations. All statistical analyses were performed with the SPSS version 11.5 statistical software (SPSS, Chicago, IL).

Intraobserver repeatability of measurements of JSW and subchondral sclerosis was assessed by blinded re-reading of a subset of 50 CCHS III radiographs 1 month after the first reading, using intraclass correlation coefficients (SJ). Intraobserver repeatability assessment of Croft, and Kellgren and Lawrence (K-L) OA grade assignments was performed in another subset of 100 radiographs after 4 weeks. Repeatability of OA grading was assessed by Kappa statistics.

Results

Repeatability of measurements and AO grading

Repeatability of measurements of minimum JSW and maximum subchondral sclerosis was acceptable: intraclass correlation coefficients of minimum JSW were r = 0.92 for right hips and r = 0.88 for left hips, and corresponding figures for maximum subchondral sclerosis were r = 0.74 for right hips and r = 0.84 for left hips. Repeatability of Croft's OA grading was moderate; weighted Kappa coefficients were 0.56 for right hips, and 0.46 for left hips. If dichotomized into grades 0°–2° denoting absent or slight OA, and grades 3°–5° denoting

Table 1. The distribution of radiographic features of OA, and sex-related differences in distribution

	Men (n = 1 448)		Women (n = 2 359)		Differences					
	Right (%)	Left (%)	Right (%)	Left (%)	p right	OR	95% CI	p left	OR	95% CI
Total number of features [a]*:*										
Minimum JSW										
≤ 2.0 mm	49 (3.4)	55 (3.8)	85 (3.6)	79 (3.3)	0.9	1.0	0.7–1.5	0.5	0.8	0.6–1.2
Subchondral sclerosis										
≥ 5.45 mm	68 (4.8)	91 (6.5)	42 (1.8)	61 (2.6)	<0.001	2.6	1.8–3.8	<0.001	2.4	1.7–3.3
Osteophytes	82 (5.6)	81 (5.6)	74 (3.1)	72 (3.0)	<0.001	2.0	1.5–2.7	<0.001	1.9	1.4–2.5
Cysts	15 (1.0)	21 (1.4)	11 (0.4)	9 (0.3)	0.2	0.7	0.4–1.2	<0.001	3.0	1.6–5.6
Features found in isolation [b]*:*										
Minimum JSW										
≤ 2.0 mm	18 (36.7)	20 (36.3)	46 (54.1)	46 (58.2)	0.06	1.5	0.9–2.7	0.1	1.4	0.8–2.3
Subchondral sclerosis										
≥ 5.45 mm	42 (61.7)	63 (69.2)	21 (50.0)	29 (47.5)	<0.001	3.2	1.9–5.5	<0.001	2.3	1.6–3.4
Osteophytes	67 (81.7)	56 (69.1)	49 (66.2)	41 (56.9)	<0.001	1.8	1.3–2.6	0.003	1.7	1.1–2.5
Cysts	6 (40.0)	6 (28.5)	5 (45.4)	4 (44.4)	0.2	0.9	0.9–1.0	0.13	0.9	0.9–1.0

[a] Total number of individual features of hip joint OA.
[b] Number and percentages of the total number of individual radiographic features of hip OA found in isolation; i.e. in hip joints without other distinguishing features. JSW = minimum joint space width. OR = odds ratio. 95% CI = 95% confidence interval of odds ratio.

definite OA, Kappa values increased to 0.65 for right hips, and 0.65 for left hips. Repeatability of the K-L OA grading was of the same order: ? = 0.55 for right hips, and r = 0.51 for left hips. If dichotomized into grades 0°–1° denoting absent or doubtful OA, and grades 2°–4° denoting definite OA, Kappa values increased to 0.82 for right hips, and 0.85 for left hips.

Gender and radiographic AO

Overall, cyst formations, osteophyte formations and increased subchondral sclerosis were recorded more frequently in male hip joints. Distribution of radiographic features of OA, and sex-related differences are presented in Table 1. Average minimum JSW was significantly narrower in women than in men: 3.9 mm (SD = 0.8) in male right hips and 3.9 mm (SD = 0.9) in male left hips, and 3.7 mm (SD = 0.8) in female right and left hips ($p < 0.001$). Average subchondral sclerosis was significantly thicker in male hip joints: 3.0 mm (SD = 1.2) in male right hips and 3.2 mm (SD = 1.3) in male left hips, and 2.6 mm (SD = 1.1) in female right hips and 2.8 mm (SD = 1.2) in female left hips ($p < 0.001$). We found an inverse relationship between age and minimum JSW in both sexes (male right hip $p < 0.001$, male left hip $p = 0.004$, and female right hip $p < 0.001$, female left hip $p < 0.001$). In both sexes the decrease in minimum JSW was marked after the fourth decade, but progressively more so in women (Figure 1).

In defining a pathological cutoff value of minimum JSW, we used the male mean values of minimum JSW and subtracted 2 SD, thus arriving at values between 2.0 mm and 2.1 mm. To facilitate calculations and clinical application, we chose the pathological cutoff value of minimum JSW ≤ 2.0 mm in both hips and in both sexes, which correspond with the ones arrived at by Lanyon et al. (2003). In defining a pathological cutoff value of maximum subchondral sclerosis, two standard deviations (SD) were added to the mean values of subchondral sclerosis. Mean resultant pathological limit of subchondral sclerosis was calculated to be ≥ 5.45 mm for both sexes. A considerable proportion of cysts, osteophytes and pathologically increased subchondral sclerosis were found in isolation, and especially in male hip joints (Table 1).

Prevalences of hip OA according to predefined radiographic discriminators are presented in Table 2. Using the Croft or K-L OA classifications, emphasising the formation of cysts, osteophytes and sclerosis, the prevalences of hip OA were higher in

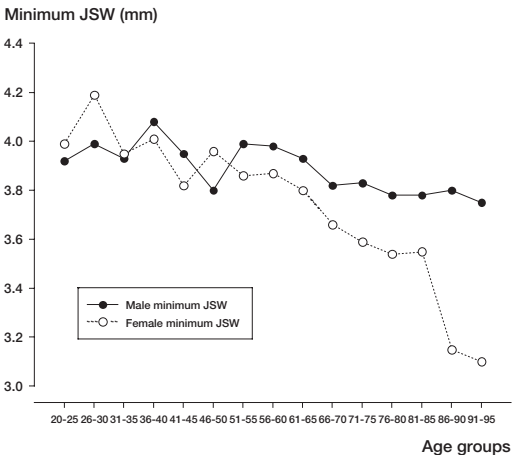

Figure 1a. Distribution of right hip minimum joint space width (JSW) by age group.

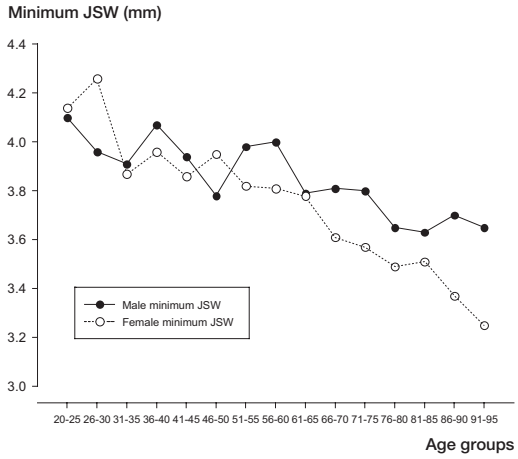

Figure 1b. Distribution of left hip minimum joint space width (JSW) by age group.

Table 2. Prevalences of hip OA according to different radiographic discriminators

	< 60 years of age						≥ 60 years of age					
	Men (n = 607)			Women (n = 841)			Men (n = 892)			Women (n = 1 452)		
	Right n (%)	Left n (%)	Bilateral n (%)	Right n (%)	Left n (%)	Bilateral n (%)	Right n (%)	Left n (%)	Bilateral n (%)	Right n (%)	Left n (%)	Bilateral n (%)
JSW	14 (2.3)	13 (2.2)	4 (0.7)	9 (1.0)	11 (1.2)	3 (0.3)	36 (4.4)	42 (5.1)	17 (2.1)	77 (5.3)	70 (4.9)	29 (2.0)
K–L	14 (2.3)	10 (1.7)	7 (1.2)	6 (0.7)	5 (0.6)	2 (0.2)	55 (6.7)	46 (5.6)	25 (3.1)	47 (3.3)	43 (3.0)	15 (1.0)
C	13 (2.2)	9 (1.5)	5 (0.8)	5 (0.6)	5 (0.6)	2 (0.2)	55 (6.7)	51 (6.2)	29 (3.5)	43 (3.0)	42 (2.9)	17 (1.2)

JSW = minimum joint space width ≤ 2.0 mm
K–L = Kellgren and Lawrence ≥ 2°
C = Croft ≥ 3°

men than in women ($p < 0.001$). Using the cutoff JSW value of 2.0 mm regardless of other features of OA, prevalences between the sexes equalized, in accordance with common clinical experience (Figure 2). As mentioned earlier, we excluded subjects with THR. Applying a conservative estimate of 75% of THR being caused by primary hip OA, the prevalences of OA should be raised by 0.4% in male subjects and 0.9% in female subjects.

Self-reported pain

23% of men complained of hip pain, 13% complained of groin pain and 17% complained of gluteal pain. The corresponding percentages for women were 30% for hip pain, 14% for groin pain and 28% for gluteal pain. More women than men

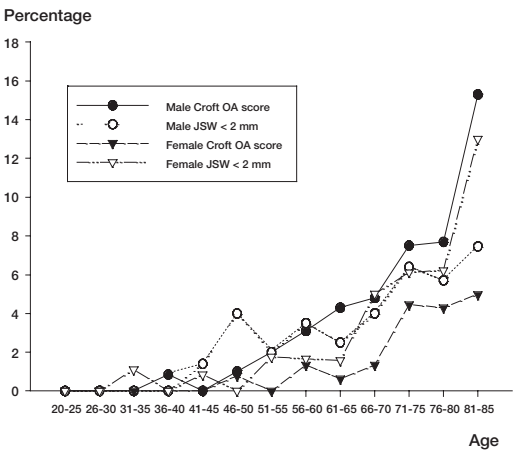

Figure 2. Prevalences of hip OA according to Croft's OA score 3°–5°, and minimum JSW ≤ 2 mm.

Table 3. Associations between radiographic hip OA discriminators and self-reported pain in subjects ≥ 60 years of age

	Men (n = 892)			Women (n = 1.452)		
	Hip pain n/n	Groin pain n/n	Gluteal pain n/n	Hip pain n/n	Groin pain n/n	Gluteal pain n/n
JSW ≤ 2.0 mm	218/32	111/16	140/9	445/53	210/26	382/30
p-value	< 0.001	0.004	0.4	< 0.001	0.01	0.4
OR (95% CI)	3.3 (1.9–5.7)	2.4 (1.3–4.5)	0.8 (0.3–1.7)	3.2 (1.9–5.2)	1.7 (1.1–2.7)	0.9 (0.6–1.4)
K-L ≥ 2°	218/35	111/13	140/11	445/41	210/20	382/26
p-value	< 0.001	0.2	0.3	< 0.001	0.004	0.06
OR (95% CI)	2.6 (1.6–4.2)	1.3 (0.7–2.5)	0.8 (0.4–1.5)	2.8 (1.8–4.6)	2.2 (1.3–3.8)	1.5 (0.9–2.4)
Croft ≥ 3°	218/35	111/13	140/11	445/39	210/20	382/25
p-value	<0.001	0.2	0.3	< 0.001	< 0.001	0.03
OR (95% CI)	2.5 (1.5–4.1)	1.3 (0.7–2.5)	0.7 (0.4–1.5)	1.9 (1.3–2.8)	2.5 (1.5–4.4)	1.6 (0.9–2.7)

Abbreviations, see Table 2

complained of hip pain ($p < 0.001$), and of gluteal pain ($p < 0.001$).

Radiographic OA and self-reported pain

Associations between applied discriminators of radiographic hip OA and self-reported pain for subjects ≥ 60 years of age are summarized in Table 3. Since bilaterality or unilaterality of self-reported hip pain was not recorded at the baseline examination, hips with narrowest minimum JSW and hips with the highest Croft or K-L score were chosen as index hips. All three radiographic OA discriminators were significantly associated with self-reported hip and groin pain. The associations with self-reported gluteal pain were very weak, which reflects clinical experience. In men and women, minimum JSW ≤ 2.0 mm was more closely associated with self-reported hip pain than K-L and Croft scores, while associations regarding groin pain were less well defined.

Discussion

In this study, we have made 2 important observations. Firstly, the measurement of pathologically reduced minimum JSW ≤ 2.0 mm had the closest association with self-reported pain in or around the hip joint, as compared with composite radiographic OA scores. Secondly, application of composite OA scores for the hip joint (which emphasize the formation of cysts, osteophytes and subchondral sclerosis) in epidemiological research runs the risk of inflating the prevalence of male hip OA and underestimating the prevalence of female hip OA.

Our study has two weaknesses. Firstly, a number of subjects had received THR and it was not possible to ascertain the indications for surgery retrospectively. However, a conservative estimate of 75% for primary hip OA being the major indication means that prevalences of hip OA should be adjusted upward by 0.4% in men and 0.9% in women, which is not of a scale that seriously challenges the conclusions of the study. Secondly, information concerning uni- or bilaterality of hip pain was not obtained at the 1991–1994 CCHS III survey. This is unfortunate, because we were forced to select index hips singularly or bilaterally according to the most severe radiographic recordings of OA features for each individual. However, the distribution and sex-related differences in hip pain reported in our study are in close accordance with other recent surveys (Christmas et al. 2002, Chen et al. 2003).

Contrary to the K-L classification of hip OA, an inherent chronological sequence of radiological features of OA is not implicit in Croft's classification. However, the Croft classification was based solely on the analysis of 1 315 male urograms and may be biased in its emphasis on formation of osteophytes, cysts and subchondral sclerosis. Such changes are encountered more frequently in male hips than in female hips (Croft et al. 1990).

The majority of osteophyte and sclerosis formations are actually found in isolation. In this study we found that approximately 75% of male osteophyte formations were recorded in hips without other radiological features of OA. The corresponding percentage in women was approximately 60%. In males, approximately 63% of cases with pathologically increased subchondral sclerosis were found in hips with no other features of OA. The corresponding percentage in women was approximately 48%.

An inverse relationship between osteoporosis and radiographic hip OA has been amply documented in the literature. One might speculate that men—and women receiving hormone replacement therapy (HRT)—will respond to degeneration with sclerosis and osteophyte formation, thereby scoring high in radiological classifications emphasizing these features, while differences with regard to incident symptomatic hip OA and minimum JSW between these subjects and postmenopausal women not receiving HRT, are not discernible (Jordan et al. 2000).

Hip pain can be caused by conditions other than degenerative disease. The prevalence of self-reported hip pain was 23% in men, and 30% in women ≥ 60 years of age. This is in accordance with the prevalences of hip pain reported in other recent surveys. Chen et al. (2003) reported a hip pain prevalence of 39% in 1 489 women over the age of 70, and Christmas et al. (2002) reported a prevalence of 18% in 6 596 participants of the HANES III survey. Significantly more women than men reported hip pain. In our study, the prevalence of hip OA by radiography ranged from 4.4% to 5.3% in subjects ≥ 60 years of age, if the criterion of minimum JSW ≤ 2.0 mm was applied. Thus, the perfect match between radiographic hip OA and symptomatic OA is basically unattainable. However, we found a close association between the radiographic discriminator of minimum JSW ≤ 2.0 mm and self-reported pain. In a study of associations between individual radiographic features of hip OA and pain in 1 363 female pelvic radiographs of the Study of Osteoporotic Fractures, Scott et al. (1992) found the best correlation between minimum JSW, combined with osteophytes, and reported hip pain; OR 4.3 (95% CI 1.9–9.6). These findings are in accordance with our study.

As with the study of Lanyon et al. (2003), we found that female minimum JSW decreases more progressively with age than does male JSW. Thus, we found that male prevalences of hip OA according to the Croft and K-L scores (with their emphasis on osteophytes, sclerosis and cysts) were higher than female prevalences, but that prevalences equalized if discriminators based on minimum JSW were used, which is in accordance with most surveys of hip OA (Hochberg et al. 1995, Oliveira et al. 1995). We will use minimum JSW ≤ 2.0 mm as our primary radiographic discriminator in future epidemiological studies of hip OA in the CCHS III population survey.

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Chen J, Devine A, Dick I M, Dhaliwal S S, Prince R L. Prevalence of lower extremity pain and its association with functionality and quality of life in elderly women in Australia. J Rheumatol 2003; 30: 2689-93.

Christmas C, Crespo C J, Franckowiak S C, Bathon J M, Bartlett S J, Andersen R E. How common is hip pain among older adults? Results from the Third National Health and Nutrition Examination Survey. J Fam Pract 2002; 51: 345-8.

Croft P, Cooper C, Wickham C, Coggon D. Defining osteoarthritis of the hip for epidemiologic studies. Am J Epidemiol 1990; 132: 514-22.

Danielsson L, Lindberg H. Prevalence of coxarthrosis in an urban population during four decades. Clin Orthop 1997; (342): 106-10.

Dougados M, Gueguen A, Nguyen M, Berdah L, Lequesne M, Mazieres B et al. Radiological progression of hip osteoarthritis: definition, risk factors and correlations with clinical status. Ann Rheum Dis 1996; 55: 356-62.

Dougados M, Gueguen A, Nguyen M, Berdah L, Lequesne M, Mazieres B et al. Radiographic features predictive of radiographic progression of hip osteoarthritis. Rev Rhum (Engl Ed) 1997; 64: 795-803.

Goker B, Sancak A, Arac M, Shott S, Block J A. The radiographic joint space width in clinically normal hips: effects of age, gender and physical parameters. Osteoarthritis Cartilage 2003; 11: 328-34.

Hochberg M C, Lane N E, Pressman A R, Genant HK, Scott J C, Nevitt M C. The association of radiographic changes of osteoarthritis of the hand and hip in elderly women. J Rheumatol 1995; 22: 2291-4.

Ingvarsson T, Hagglund G, Jonsson H, Jr., Lohmander L S. Incidence of total hip replacement for primary osteoarthrosis in Iceland 1982-1996. Acta Orthop Scand 1999; 70: 229-33.

Jacobsen S, Sonne-Holm S, Lund B, Søballe K, Kiær T, Rovsing H, Monrad H. Pelvic orientation and assessment of hip dysplasia in adults. Acta Orthop Scand 2004; 75: 716-24.

Jordan J M, Kington R S, Lane N E, Nevitt M C, Zhang Y, Sowers M. Systemic risk factors for osteoarthritis. Ann Intern Med 2000; 133: 637-9.

Kellgren J H. The epidemiology of chronic rheumatism. Volume II: Atlas of standard radiographs of arthritis. Oxford, Blackwell Scientific Publications 1963: 1-44.

Kellgren J H, Lawrence J S. Radiological assessment of osteo-arthritis. Ann Rheum Dis 1957; 16: 494-502.

Lanyon P, Muir K, Doherty S, Doherty M. Age and sex differences in hip joint space among asymptomatic subjects without structural change: implications for epidemiologic studies. Arthritis Rheum 2003; 48: 1041-6.

Oliveria S A, Felson D T, Reed J I, Cirillo P A, Walker A M. Incidence of symptomatic hand, hip, and knee osteoarthritis among patients in a health maintenance organization. Arthritis Rheum 1995; 38: 1134-41.

Schnohr P, Jensen G, Lange P, Scharling H, Appleyard M. The Copenhagen city heart study - Österbroundersøgelsen - tables with data from the third examination 1991-1994. Eur Heart J (3 Suppl.) H 2001: 1-83.

Scott J C, Lane N E, Genant H, Hochberg M. Association of individual radiographic features of hip osteoarthritis with pain. Arthritis Rheum (Suppl.); 1992; 35: S81.

Spector T D, Cooper C. Radiographic assessment of osteoarthritis in population studies: whither Kellgren and Lawrence? Osteoarthritis Cartilage 1993; 1: 203-6.

Sun Y, Günther K P, Brenner H. Reliability of radiographic grading of osteoarthritis of the hip and knee. Scand J Rheumatol 1997; 26: 155-65.

The Danish Hip Replacement Register. The University Hospital of Aarhus. Department of Orthopaedic Surgery, County of Aarhus hospital 2002: 1-49.