

Radiographic Features of Lumbar Disc Degeneration and Self-Reported Back Pain

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ABSTRACT. Objective. To characterize the occurrence of radiographic features of lumbar disc degeneration including the presence of osteophytes, endplate sclerosis, and disc space narrowing and to determine their relationship with self-reported back pain.

Methods. Subjects aged 50 years and over were recruited from a primary care based community health index in Aberdeen, UK. Subjects were invited to complete an interviewer administered questionnaire and to have lateral spinal radiographs performed. The questionnaire included questions concerning the occurrence of back pain, both ever and in the past year. The inter-vertebral disc spaces (L1/2 to L4/5) were evaluated for the presence and severity of anterior osteophytes, endplate sclerosis, and disc space narrowing using a semi-quantitative score (grade 0-3). Logistic regression was used to determine the association between these individual radiographic features of lumbar disc degeneration (using for each feature, the most severely affected vertebra) and back pain, with adjustments made for age and gender.

Results. There were 286 men (mean age 65.3 years), and 299 women (mean age 65.2 years) with spinal radiographs. Osteophytes were the most frequent radiographic feature. Osteophytes and endplate sclerosis were more frequent in men than women, but there was no gender difference in the frequency of disc space narrowing. All radiographic features increased in frequency with age; for osteophytes this was true only after excluding mild (grade 1) osteophytes. Compared to those without, those with disc space narrowing were more likely to report back pain both ever, [odds ratio (OR) = 2.1; 95% confidence interval (CI): 1.5 to 3.0] and in the past year (OR = 1.7) with the strength of the association increasing with increasing severity of narrowing. Endplate sclerosis was not linked with back pain although moderate (grade 2) sclerosis was associated with back pain, both ever and in the past year. Compared to those without, or those with mild osteophytes, those with more severe osteophytes (grade > 1) were more likely to report back pain ever (OR = 1.7; 95% CI: 1.2 to 2.5).

Conclusion. These data highlight the frequent occurrence, and the increase in frequency with age, of the individual radiographic features of lumbar disc degeneration in population samples of men and women. Disc space narrowing appeared more strongly associated with back pain than the other radiographic features. (J Rheumatol 2004;31:753-8)

Key Indexing Terms:

EPIDEMIOLOGY DISC DEGENERATION LUMBAR SPINE BACK PAIN
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Lumbar disc degeneration (LDD) is characterized radiologically by the presence of osteophytes, endplate sclerosis, and disc space narrowing. Classification criteria for LDD developed in the late 1950s used a composite score of these radio-

graphic features¹. Although widely used, there are inconsistencies with the criteria which limit their reproducibility and therefore application in clinical and epidemiological studies². More recent studies of disc degeneration have focused on assessment and classification of the individual radiographic features (IRF) of the disease including osteophytes, vertebral endplate sclerosis, and disc space narrowing³⁻⁵. The occurrence of these component features and their relationship with back symptoms is not, however, well characterized in population samples of men and women.

Our aim was to characterize the frequency of the IRF of LDD by age, gender, and vertebral level, and to explore the relationship between these features and self-reported back pain.

MATERIALS AND METHODS

Study design. The subjects included in this analysis were initially recruited

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for participation in a screening survey of vertebral osteoporosis in Aberdeen, UK: the European Vertebral Osteoporosis Study⁶. The sampling frame was a community health index based on primary care registrants⁷. Stratified random sampling was used with the aim of recruiting equal numbers of men and women in each of six 5 year age bands: 50-54, 55-59, 60-64, 65-69, 70-74 and 75 years and over. Subjects were invited by letter to attend for an interviewer administered questionnaire and for lateral spinal radiographs⁸. The questionnaire included questions concerning back pain: (1) Have you ever had back pain? (response set = yes/no) and (2) Have you ever had an episode of back pain in the past year? (response set = yes/no). Lateral lumbar spine radiographs were taken according to a standard protocol with the film centered on the second lumbar vertebra.

In all, 585 lumbar radiographs were available for review and were evaluated by a single observer for the presence of the individual radiographic features of disc degeneration. The observer was blinded to the subjects reporting of back pain. Each vertebral level from L1/2 to L4/5 was reviewed for the presence and severity of osteophytes (anterior), endplate sclerosis, and vertebral narrowing, using a reference atlas and semi-quantitative score (grade 0 = none; grade 1 = mild; grade 2 = moderate; grade 3 = severe). In this atlas, images were chosen to illustrate the cut-points for changes rather than a "typical appearance" for each. Intra-observer reproducibility was assessed by the same observer who reevaluated 60 films within one week of the first reading. The kappa score, a measure of agreement, was 0.83 for osteophytes, 0.75 for sclerosis, and 0.82 for vertebral narrowing, indicating good reproducibility for all features.

Analysis. In the analyses we defined each of the IRF to be present if the grade was mild, moderate, or severe (grade ≥ 1). Using this definition we calculated the prevalence of the IRF by vertebral level (L1/2 to L4/5). To analyze data at the subject level we defined, for each IRF, a summary statistic, "MAX", as the grade of the most severely affected vertebral level within an individual. Using this we calculated the frequency of the MAX value for each of the IRF by age and gender although we used the same cut-off (grade ≥ 1) to define prevalence. Because of the small proportion of subjects without osteophytes, in subsequent analysis of risk factors (age and back pain) we used a higher cutoff value for this feature (grade > 1).

Logistic regression was used to determine the association between each of the 3 IRF and age in men and women (with the IRF as dependent variable). To explore the association between the IRF and back pain (both ever and in the past year), back pain was used as the dependent variable with adjustments made for age and gender. The results of these analyses are expressed as odds ratios (OR) and 95% confidence intervals (CI). In interpreting the OR from the analysis it is important to note that because back pain is relatively common, the OR reported will tend to overstate the relative risk⁹. The degree of the discrepancy is dependent on both the prevalence of back pain and the value of the OR, increasing with both. As an example, given a prevalence of back pain of 50% and an OR of 2, the OR

will overstate the relative risk by 50%. Statistical analysis was performed using STATA¹⁰.

RESULTS

Subject characteristics. There were 286 men [mean age 65.3 years, standard deviation (SD) 8.9] and 299 women (mean age 65.2 years, SD 8.9). Back pain in the past year was reported by 115 (38.5%) women and 78 (27.3%) men ($p < 0.05$). Back pain "ever" was reported by 183 (61.2%) women and 158 (55.2%) men ($p = NS$).

Influence of gender and vertebral level. The distribution of the IRF (maximum grade per subject) in men and women is shown in Table 1. Osteophytes were the most frequent radiographic feature and were more common in men than women (97% vs 91%; $p < 0.05$). With increasing osteophyte grade the male:female ratio increased (1.1:1 for grade ≥ 1 to 2.8:1 for grade 3). Endplate sclerosis and narrowing were less frequent than osteophytes. Endplate sclerosis was more frequent in men than women (58% vs 43%; $p < 0.05$) though there was no gender difference in the frequency of disc space narrowing (61% vs 67%). Unlike osteophytes, for both disc space narrowing and endplate sclerosis the male:female ratio did not increase with severity of the feature.

In terms of their distribution by vertebral level, osteophytes were more frequent at L3/4, sclerosis at L2/3 and narrowing at L4/5 (Figure 1). The pattern of occurrence within the spine for these features was similar in men and women.

Influence of age. Using MAX grade ≥ 1 as the definition of case, the prevalence of disc space narrowing and endplate sclerosis increased with age in both men and women (Figure 2). Using the same definition, because of the very small numbers of individuals without osteophytes (3% in men), there was no real change in frequency of osteophytes with age. Using MAX grade > 1 as the definition of osteophytes, however, as with the other features, there was evidence of a progressive increase in frequency in both men and women

Table 1. Frequency of osteophytes, disc space narrowing, and endplate sclerosis in men and women. Maximum grade (MAX) per subject.

| Grade | Men, n = 286 | | Women, n = 299 | |
|-----------|--------------|-----------------------|----------------|-----------------------|
| | n (%) | Cumulative Number (%) | n (%) | Cumulative Number (%) |
| 0 | 9 (3.1) | 286 (100) | 171 (57.2) | 299 (100) |
| 1 | 102 (35.7) | 277 (96.9) | 96 (32.1) | 128 (42.8) |
| 2 | 104 (36.4) | 175 (61.2) | 21 (7.0) | 32 (10.7) |
| 3 | 71 (24.8) | 71 (24.8) | 11 (3.7) | 11 (3.7) |
| Narrowing | | | | |
| 0 | 113 (39.5) | 286 (100) | 100 (33.5) | 299 (100) |
| 1 | 99 (34.6) | 166 (58.1) | 123 (41.1) | 199 (66.5) |
| 2 | 42 (14.7) | 46 (16.1) | 36 (12.0) | 76 (25.4) |
| 3 | 32 (11.2) | 7 (2.5) | 40 (13.4) | 40 (13.4) |

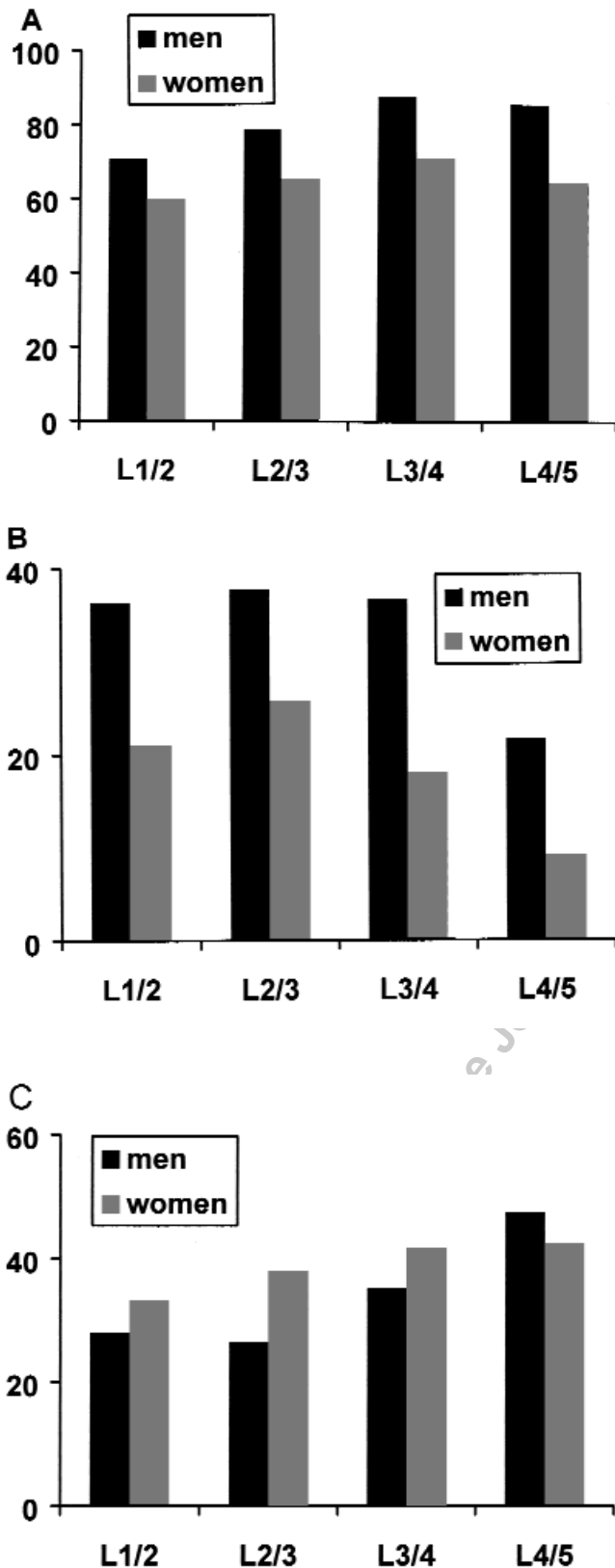


Figure 1. Prevalence of individual radiographic features of lumbar disc degeneration, by vertebral level, in men and women. A. Osteophytes; B. sclerosis; C. vertebral narrowing.

(Figure 2). Using these definitions the increase in risk with age appeared to be more marked in men than women for osteophytes and endplate sclerosis (Table 2).

Association with back pain. After adjusting for age and gender the presence of disc space narrowing was associated with back pain both ever (OR = 2.1; 95% CI: 1.5 to 3.0) and in the past year (OR = 1.7; 95% CI: 1.1 to 2.4) with the strength of the association increasing with increasing severity of disc space narrowing (Table 3). By contrast the presence of osteophytes (MAX grade ≥ 1) was not associated with back pain either ever or in the past year. Using the more stringent definition (MAX grade > 1), compared to those without, those with such osteophytes were more likely to report back pain ever (OR = 1.7), although only severe (MAX grade = 3) osteophytes were associated with back pain in the previous year (data not shown). The presence of endplate sclerosis was not linked with back pain either ever or in the past year, but compared to those without sclerosis those with moderate (MAX grade = 2) sclerosis were more likely to report back pain both ever (OR = 2.0) and in the past year (OR = 1.9) (Table 3).

DISCUSSION

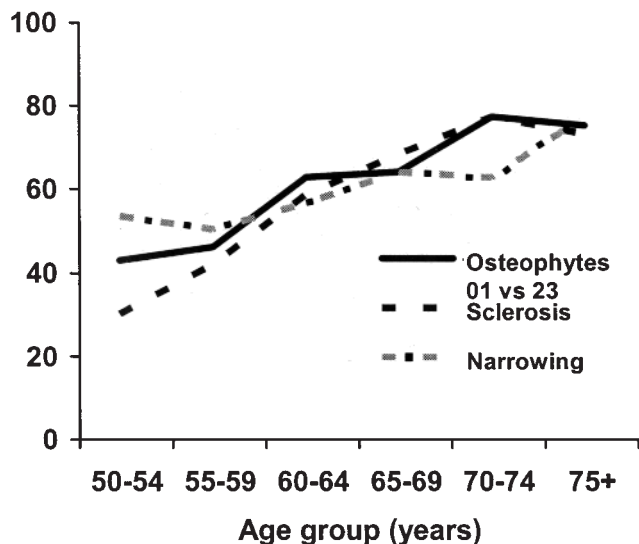
In this study, osteophytes were the most frequent radiographic feature of LDD. Osteophytes and endplate sclerosis were more common in men than women, although the frequency of disc space narrowing was similar. All IRF increased in frequency with age. Disc space narrowing appeared more strongly associated with back pain than the other radiographic features.

Our study had several advantages: it was population based and used standardized methods in assessment of the radiographs. There are, however, several limitations that need to be considered when interpreting the findings. The response rate for participation in the main study was 61%¹¹. It is possible that those who participated may have had a different frequency of IRF of LDD than those who declined to take part and so the data, in relation to prevalence, needs to be interpreted with some caution. Given that the analysis of the influence of age, gender, and back pain was based on an internal comparison of responders, however, non-participation is unlikely to have had a major effect on these results.

We used a semi-quantitative score (using standard radiographs) to characterize the presence and severity of disc degeneration. Reproducibility of assessment was good for all of IRF and kappa values for disc space narrowing and osteophytes higher than values reported in a recent population study⁵. Assessment of the radiographs was undertaken without knowledge of the questionnaire data and so errors in classification are likely to have been non-directional and would, if anything, tend to reduce the chance of finding true biological associations.

The question concerning back pain did not ask specifically about low back (lumbar) pain and it is likely that much

A. Men
Prevalence (%)



B. Women
Prevalence (%)

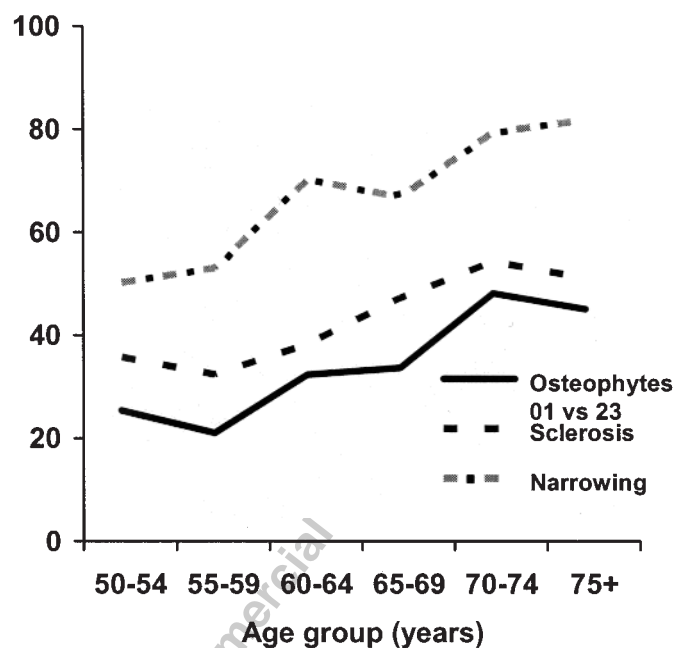


Figure 2. Prevalence of individual radiographic features of lumbar disc degeneration in men and women. By age group.

self reported pain was unrelated to the occurrence of lumbar disc degeneration. The effect of this would be again, to reduce the chance of finding a significant association between back pain and IRF of LDD. Finally, our results

were derived from a predominantly Caucasian population in north-eastern Scotland and the data, particularly in relation to prevalence, should be extrapolated beyond this population with caution.

How do these findings compare with those of other studies? Our data confirm findings from recent population-based radiographic surveys showing a high prevalence of osteophytes in men and women^{2,5}, and are similar to findings reported in a large autopsy series in which osteophytes were observed in 95% of spines by age 70 years¹². In a previous study that included subjects reported here, we observed a lower prevalence of osteophytes. However, in that study different classification criteria were used¹³. Our results are consistent with some but not all studies that suggest a greater frequency and severity of osteophytes in men than in women^{4,5,13,14} and studies suggesting that disc space narrowing is equally common in men and women^{4,5}.

Data from many studies suggest an association with disc degeneration (classified using composite features) and back pain^{2,15,16}. Several studies have looked at the relationship between component radiographic features of the disease and back symptoms, though we are not aware of data from population-based samples that have looked systematically at all 3 radiographic features and self reported back pain. Some, but not all, studies suggest an association between back pain and osteophytes^{2,13,17,18} and there are data suggesting an association with disc space narrowing^{18,19}. Our data confirm an association between back pain and disc space narrowing, with the strength of the association increasing with increasing severity of disc space narrowing. The OR, however, were similar for grades 1 and 2 (for both back pain ever and in the past year) suggesting that the distinction between these grades may not be clinically relevant in terms of back pain. Our data suggest an association with osteophytes only when a more stringent definition (MAX grade > 1) is used. This observation, together with the almost universal presence of mild (grade 1) osteophytes by age 50 years, suggests that at least in the age group studied, that the finding of minor osteophytes is not of clinical importance. The presence of endplate sclerosis *per se* was not associated with back pain, but moderate (grade 2) sclerosis was. There was no evidence of a dose-response relationship. Further studies are required to confirm the findings concerning the association between back pain and the individual radiographic features of disc degeneration and to determine the temporal nature of the relationship with these features.

The explanation for the stronger association between back pain and disc space narrowing compared with the other radiographic features is unknown. It is possible that disc space narrowing may be more likely to be related to extrusion of disc material or bulging of the disc with resulting pressure on transiting or exiting spinal nerve roots. We did not have any information on the occurrence of sciatica or leg pain that might support this hypothesis. It may also be that

Table 2. Association between individual radiographic features of lumbar disc degeneration and age group in men and women.

| | Total n | Osteophytes* n OR (95% CI) | Sclerosis** n OR (95% CI) | Narrowing** n (95% CI) |
|--------------|---------|-------------------------------|------------------------------|---------------------------|
| Men | | | | |
| Age, yrs | | | | |
| 50–54 | 47 | Referent | 14 Referent | 25 Referent |
| 55–59 | 48 | 2.2 (0.5, 2.6) | 20 1.7 (0.7, 3.9) | 24 0.9 (0.4, 2.0) |
| 60–64 | 48 | 3.0 (0.9, 5.1) | 28 3.3 (1.4, 7.7) | 27 1.1 (0.5, 2.5) |
| 65–69 | 47 | 3.0 (1.0, 5.5) | 32 5.0 (2.1, 12.1) | 30 1.6 (0.7, 3.5) |
| 70–74 | 48 | 4.5 (1.9, 11.0) | 37 7.9 (3.2, 19.9) | 30 1.5 (0.6, 3.3) |
| 75+ | 48 | 4.1 (1.7, 9.7) | 35 6.3 (2.6, 15.5) | 37 3.0 (1.2, 7.2) |
| Women | | | | |
| Age, yrs | | | | |
| 50–54 | 48 | Referent | 17 Referent | 24 Referent |
| 55–59 | 53 | 0.8 (0.3, 2.0) | 17 0.9 (0.4, 2.0) | 28 1.1 (0.5, 2.4) |
| 60–64 | 50 | 1.4 (0.6, 3.4) | 19 1.1 (0.5, 2.5) | 35 2.3 (1.0, 5.3) |
| 65–69 | 51 | 1.5 (0.6, 3.6) | 24 1.6 (0.7, 3.6) | 34 2.0 (0.9, 4.5) |
| 70–74 | 48 | 2.8 (1.2, 6.6) | 26 2.1 (0.9, 4.9) | 38 3.8 (1.5, 9.3) |
| 75+ | 49 | 2.4 (1.0, 5.8) | 25 1.9 (0.8, 4.3) | 40 4.4 (1.8, 11.1) |

OR: odds ratio; CI: confidence interval. * Defined as maximum grade (L1/2–L4/5) dichotomized into grades 0 and 1 (referent) against grades 2 and 3. ** Defined as maximum grade (L1/2–L4/5) dichotomized into grade 0 (referent) against grades 1, 2 and 3.

Table 3. Association between individual radiographic features of lumbar disc degeneration and back pain (BP) ever and BP in the past year.

| | BP Ever OR (95% CI) | BP Past Year OR (95% CI) |
|-------------------|------------------------|-----------------------------|
| Osteophyte | | |
| 123 vs 0 | 0.9 (0.4, 1.8) | 0.7 (0.4, 1.4) |
| 23 vs 01 | 1.7 (1.2, 2.5) | 1.1 (0.8, 1.6) |
| 0 | Referent | Referent |
| 1 | 0.7 (0.3, 1.4) | 0.7 (0.3, 1.4) |
| 2 | 1.2 (0.5, 2.5) | 0.6 (0.3, 1.3) |
| 3 | 1.3 (0.6, 3.0) | 1.3 (0.6, 2.9) |
| Sclerosis | | |
| 123 vs 0 | 1.2 (0.9, 1.7) | 1.0 (0.7, 1.4) |
| 0 | Referent | Referent |
| 1 | 1.1 (0.7, 1.5) | 0.9 (0.6, 1.3) |
| 2 | 2.0 (1.1, 3.7) | 1.9 (1.1, 3.4) |
| 3 | 1.5 (0.6, 4.2) | 0.8 (0.3, 2.3) |
| Narrowing | | |
| 123 vs 0 | 2.1 (1.5, 3.0) | 1.7 (1.1, 2.4) |
| 0 | Referent | Referent |
| 1 | 1.7 (1.2, 2.6) | 1.5 (0.9, 2.2) |
| 2 | 1.8 (1.0, 3.1) | 1.5 (0.9, 2.7) |
| 3 | 6.2 (3.1, 12.3) | 2.9 (1.6, 5.3) |

OR: odds ratio (adjusted for age and gender); CI: confidence interval.

the reduction in physical space between the vertebra as a consequence of the degenerative disc is more likely to lead to alteration in spine biomechanics: there may be increased pressure on adjacent structures, including adjacent disc spaces, facet joints, and spinal ligaments, with pain arising from pressure on affected nociceptors.

Our finding of a stronger association with back pain ever,

than for pain in the past year is broadly similar to findings in a previous population survey where the association with disc degeneration (defined using a composite score of features) was greater for past episodes of back pain rather than to current pain¹⁵. One possible explanation for this is that back pain linked with disc degeneration may be episodic, and may have occurred many years earlier and not in the past year.

In conclusion, our data highlight the frequent occurrence, and the increase in frequency with age, of the IRF of LDD in population samples of men and women. Minor osteophytes are, however, almost universal by the age of 50 years and do not appear to be associated with back pain. Disc space narrowing is more strongly associated with back pain than the other radiographic features of the disease.

REFERENCES

1. Kellgren JH, Jeffrey MR, Ball JR. The epidemiology of chronic rheumatism. Atlas of standard radiographs for arthritis. Vol II. Oxford: Blackwell; 1963.
2. Symmons DPM, van Hemert AM, Vandenbroucke JP, Valkenburg HA. A longitudinal study of back pain and radiological changes in the lumbar spines of middle aged women. II. Radiographic findings. *Ann Rheum Dis* 1991;50:162-6.
3. Lane NE, Nevitt MC, Genant HK, Hochberg MC. Reliability of new indices of radiographic osteoarthritis of the hand and hip and lumbar disc degeneration. *J Rheumatol* 1993;20:1911-8.
4. Jones G, Nguyen T, Sambrook PN, Kelly PJ, Eisman JA. A longitudinal study of the effect of spinal degenerative disease on bone density in the elderly. *J Rheumatol* 1995;22:932-6.
5. Yoshimura N, Dennison E, Wilman C, Hashimoto T, Cooper C. Epidemiology of chronic disc degeneration and osteoarthritis of the lumbar spine in Britain and Japan: A comparative study. *J Rheumatol* 2000;27:429-33.
6. O'Neill TW, Felsenberg D, Varlow J, Cooper C, Kanis JA, Silman

- AJ, and the European Vertebral Osteoporosis Study Group. The prevalence of vertebral deformity in European men and women. The European Vertebral Osteoporosis Study. *J Bone Miner Res* 1996;11:1010-8.
7. Garton MJ, Abdalla MI, Reid DM, Russell IT. Estimating the point accuracy of population registers using capture-recapture methods in Scotland. *J Epidemiol Community Health* 1996;50:99-103.
 8. O'Neill TW, Cooper C, Algra D, et al. Design and development of a questionnaire for use in a multicentre study of osteoporosis in Europe. The European Vertebral Osteoporosis Study. *Rheumatol Europe* 1995;24:75-81.
 9. Davies HTO, Crombie IK, Tavakoli M. When can odds ratios mislead? *BMJ* 1998;316:989-91.
 10. Stata Corporation. Statistical Software Release 6.0. College Station, TX, 1999.
 11. O'Neill TW, Marsden D, Matthis C, Raspe H, Silman AJ, and the European Vertebral Osteoporosis Study Group. Survey response rates: national and regional differences in a European multicentre study of vertebral osteoporosis. *J Epidemiol Comm Health* 1995;49:87-93.
 12. Schmorl G, Junghanns H. The human spine in health and disease. New York, London: Grune and Stratton; 1971.
 13. O'Neill TW, McCloskey EV, Kanis JA, et al. The distribution, determinants, and clinical correlates of vertebral osteophytosis: A population based survey. *J Rheumatol* 1999;26:842-8.
 14. Nathan H. Osteophytes of the vertebral column. *J Bone Joint Surg* 1962;44A:243-68.
 15. Lawrence JS. Disc degeneration. Its frequency and relationship to symptoms. *Ann Rheum Dis* 1969;28:121-38.
 16. van Tulder MW, Assendelft WJJ, Koes BW, Bouter LM. Spinal radiographic findings and nonspecific low back pain. A systematic review of observational studies. *Spine* 1997;22:427-34.
 17. Biering-Sorensen F, Hanson FR, Schroll M, Runeborg O. The relation of spinal x-ray to low back pain and physical activity among 60 year old men and women. *Spine* 1985;10:445-51.
 18. Frymoyer JW, Newberg A, Pope MH, Wilder DG, Clements J, McPherson B. Spine radiographs in patients with low back pain. *J Bone Joint Surg Am* 1984;66:1048-55.
 19. Togerson WR, Dotter WE. Comparative roentgenographic study of the asymptomatic and symptomatic lumbar spine. *J Bone Joint Surg* 1976;58A:850-3.