A longitudinal study of back pain and radiological changes in the lumbar spines of middle aged women. II. Radiographic findings

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Abstract

The natural history of radiological changes in the lumbar spine was evaluated in two groups of middle aged Dutch women selected from the general population. One group (n=236) had recurrent back pain and the other (n=241) had never experienced back pain. At the beginning of the study disc degeneration was more common in the group with back pain. Osteoporotic vertebral fractures were equally common in both groups. Nine years later both groups showed an increase in prevalence of disc degeneration and osteoporotic fractures. The strongest predictor for change in disc degeneration was the presence of degeneration at the beginning of the study. The development of disc degeneration for the first time was related to body mass index.

Back pain is a common complaint¹ and a frequent cause of hospital referral.² The causes of back pain are legion and it is impossible to make a definite diagnosis in most patients having their first attack.³ Most acute attacks settle spontaneously, and spinal radiography is unnecessary at this stage, except in the presence of certain sinister features.⁴ Ten per cent of patients have back pain for more than six weeks and 5% for more than 3 months.⁵ It is this group who are most likely to seek medical advice concerning diagnosis and prognosis. A radiograph is then often requested. This can only be interpreted if the prevalence and natural history of radiological changes in the lumbar spine in the general population is known.

Common spinal radiological abnormalities include disc degeneration, osteoporotic fractures, Schmorl's nodes, pseudospondylolisthesis, and extra vertebrae. These changes may occur in symptomatic or asymptomatic subjects. Kellgren and Lawrence found that the prevalence of disc degeneration in the general population gradually increased with age, reaching 85% in men and 71% in women aged over 65.^{6,7} They found some association between radiological changes and past, but not present, symptoms. In a hospital based study Torgerson and Dotter found that current back pain was associated with disc space narrowing but not with osteophyte formation.⁸ Frymoyer, on the other hand, concluded that single disc space narrowing and spinal osteophytes were equally prevalent in symptomatic and asymptomatic men.⁹ The association between osteoporotic fractures and back pain is equally controversial.^{10,11}

There have been no longitudinal studies of

lumbar spine radiology. To clarify the relation between radiological findings and symptoms and to investigate the natural history of spinal radiological abnormalities we conducted a study in an open population over a nine year period. The original aim of the study was to look for risk factors for developing osteoporotic fractures, and so only middle aged women were included.

Subjects and methods

INITIAL POPULATION SURVEY

Between 1975 and 1978 a population survey of rheumatic and cardiovascular diseases was conducted in Zoetermeer, a suburb of The Hague.¹² Respondents were assessed by means of a self-administered questionnaire which included questions on back complaints, and by physical examination as detailed in the accompanying paper.¹³ Radiographs of the lumbar spine (lateral) and hands were taken on subjects aged 45 and over.

FOLLOW UP SURVEY

The initial survey included 1167 women aged 45-64. Nine years later 158 had died or moved away from the area. The remaining 1009 women were invited to participate in a follow up survey designed to look for risk factors for osteoporotic fracture. This survey included further radiographs of the lumbar spine and hands. By the end of 1986 full clinical details and radiographs were available on 742 women (74%). Two subgroups were chosen for this analysis as described in the accompanying paper.¹³ The first group comprised 236 women who, in 1975-8, had recurrent back pain. The second group comprised 241 women who had never experienced back pain up to 1975-8.

RADIOLOGICAL ASSESSMENT

Disc degeneration

The pairs of lumbar spine films were read for disc degeneration by two independent observers (DPMS, HAV) without knowledge of the subject's identity or medical history. Each film was scored for the presence of disc degeneration at each level (L1-2, L2-3, L3-4, L4-5, L5-S1) by the method of Kellgren¹⁴ (table 1). Kellgren scores of two or more were regarded as abnormal. Each disc space was also assessed for the presence of osteophytes. A delta (δ) score for change between the two films for osteophytes and disc space narrowing was estimated with a three point scale (0=same, 1=worse, 2=much worse).

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Table 1 Kellgren method of scoring for disc degeneration*

Grade	Definition
0	Normal disc space with no osteophytes
1	Slight anterior wear and osteophyte formation
2	Definite anterior wear and mild disc narrowing with osteophyte formation
3	Moderate disc narrowing with osteophytes and sclerosis
4	Large osteophytes, marked disc space narrowing, and sclerosis of the vertebral end plates

*The Kellgren method compares the films being assessed with standard films from an Atlas.¹⁴ A written description of the grading is shown in the table.

The two readers met regularly to discuss films in which there was a discrepancy of more than one Kellgren grade, or where one observer had scored 1 and the other had scored 2. The final analysis was based on the consensus reached after discussion. Where there was a discrepancy of only one grade (except between grades 1 and 2) the higher score was taken. The δ scores of the two observers were added together for the final analysis (range 0–8).

Interobserver variation

Kappa (κ) statistics¹⁵ were calculated for the Kellgren score readings before the consensus discussions for disc spaces L1–2, L2–3, L3–4, L4–5 on the earlier film of the first 44 and the last 44 pairs of films read. For the first 44 pairs there was 87.5% agreement ($\kappa=0.487$) and for the last 44 pairs there was 92.6% agreement ($\kappa=0.689$).

Osteoporotic fractures

A third observer (AMvH) read the lumbar spine radiographs (including D12) independently for the presence of osteoporotic fracture, and the hand radiographs for osteoporosis. A vertebral body wedge deformity was scored if the ratio of the anterior to posterior height was less than 0.8. A crush fracture was scored if an end plate

was crushed or if the vertebral body had collapsed. An incident vertebral fracture was scored on the second film if a new wedge became apparent, or if the anterior-posterior ratio decreased by 0.2 or more. The cortical thickness of the metacarpal bones (II, III, IV) was measured at the mid-shaft with a 7 $\times$ magnifying glass. The metacarpal cortical area was calculated as the mean of D^2-d^2 for the six metacarpals and the relative cortical area as the mean of $100 \times (D^2-d^2/D^2)$ for the six metacarpals, where D represents the outer diameter and d the medullary diameter of a metacarpal bone.^{16 17}

STATISTICS

Relative risks (RR) and test-based 95% confidence intervals (CI)¹⁸ were used to assess the differences between the groups with and without back pain. Predictors of radiological change were assessed with the BMDP programmes for logistic and linear regression.¹⁹

Results

CROSS SECTIONAL SURVEY 1975–1978

Disc degeneration

Two hundred and twenty two women (46.5%) had abnormal Kellgren scores at one or more disc space levels. The mean age of those with disc degeneration was 54.3 years (SD 5.7) and of those without disc degeneration 53.7 years (SD 5.8). Radiological disc degeneration was more common in those with back pain than in those without (RR=1.44; 95% CI 1.19 to 1.75). There was a trend towards degeneration of more disc space levels in the symptomatic women (Logit model χ^2 test for trend=12.4; $p<0.001$) (fig 1A). Maximum Kellgren scores of 3 or more were significantly more common in those with recurrent back pain than in those without (RR=2.51; 95% CI 1.39 to 4.53). For technical reasons not all disc spaces could be assessed radiologically. In particular the L5–S1 disc space could not be judged in 35.2% of films. Table 2 shows the proportion of assessable films which showed an abnormal Kellgren score at each disc space level. Degenerative changes

Figure 1 Number of abnormal disc spaces in women with (RBP) and without (NBP) recurrent back pain.

Table 2 Numbers and proportion of films of women with recurrent back pain (RBP) and of women who had never had back pain (NBP) which showed evidence of disc degeneration at each analysable level

	<i>RBP</i>		<i>NBP</i>		<i>RR*</i>	<i>(95% CI*)</i>
	<i>No</i>	<i>(%)</i>	<i>No</i>	<i>(%)</i>		
1975-8						
L1-2	22	(9.5)	17	(7)	1.33	(0.72 to 2.44)
L2-3	25	(11)	11	(5)	2.33	(1.20 to 4.51)
L3-4	38	(15)	35	(15)	1.10	(0.73 to 1.65)
L4-5	56	(25.5)	35	(16)	1.64	(1.13 to 2.38)
L5-S1	58	(37)	25	(11)	2.11	(1.43 to 3.11)
1985-6						
L1-2	35	(11)	29	(9)	1.21	(0.76 to 1.92)
L2-3	60	(25.5)	40	(17)	1.52	(1.07 to 2.16)
L3-4	68	(28.5)	64	(23)	1.08	(0.81 to 1.44)
L4-5	88	(39)	61	(26)	1.49	(1.14 to 2.90)
L5-S1	85	(56)	52	(30)	1.85	(1.38 to 2.40)

The percentages given are the percentages of analysable films showing a given abnormality.
*RR=relative risk; CI=confidence interval.

Table 3 Indices of osteoporosis in women with (RBP) and without (NBP) back pain

	RBP		NBP	
	Mean	SD	Mean	SD
1975-8				
Metacarpal cortical area (mm ²)	50.47	7.97	52.06	10.98
Relative cortical area (%mm ²)	78.29	8.16	77.57	7.76
1985-6				
Metacarpal cortical area (mm ²)	45.31	8.10	45.53	9.89
Relative cortical area (%mm ²)	71.98	8.18	72.02	9.16

were most common in the lower disc spaces, especially among those with recurrent back pain.

Osteophytes

Osteophytes were present in 85.5% of all disc spaces. They were no more common in the symptomatic (84.5% of disc spaces) than the asymptomatic (87%) women.

Osteoporosis

There was no difference in the mean metacarpal cortical area and relative cortical area of the two groups (table 3). A total of 83 women (17%) had vertebral fractures: 36 (15%) of those with and 47 (19.5%) of those without back pain. This difference was mainly due to the low prevalence of fractures in those with back pain and with no disc degeneration (fig 2). The relative risk (compared with all the other women) for this group having a fracture was 0.53 (95% CI 0.30 to 0.94).

CROSS SECTIONAL SURVEY 1985-6

By 1985-6 305 women (64%) had evidence of disc degeneration at one or more levels. Radiological disc degeneration remained more common in those who originally had recurrent back pain (RR=1.29; 95% CI 1.12 to 1.48). The number of disc spaces affected had increased in both groups. Osteophytes were almost ubiquitous by 1985-6. Only three women (0.6%) had no osteophytes at any disc space level. The metacarpal cortical area and relative

Figure 2 Relation between osteoporotic fractures and disc degeneration in the cross sectional survey 1975-8.

Figure 3 Natural history of radiological disc degeneration.

cortical area fell by an equivalent amount in both groups (table 3). By 1985-6 a total of 108 women (23%) had vertebral fractures. The prevalence had risen to 19% (46) in those with back pain and 36% (62) in those without previous back pain (RR=0.76; 95% CI=0.55 to 1.06). This study did not include the higher thoracic vertebrae and so the total prevalence of osteoporotic fracture is likely to have been higher than that recorded here.

CHANGE BETWEEN THE TWO SURVEYS

Disc degeneration

Deterioration of disc degeneration was defined as an increase in Kellgren score or an increase in disc space narrowing at any level. During the follow up period (mean 8.7 years) 216 women (45%) deteriorated at a total of 381 disc spaces (22.8% of those assessable). Deterioration was more common in those with pre-existing disc degeneration than in those with normal radiographs both in the group with pain (RR=1.67; 95% CI 1.29 to 2.16) and in those without pain (RR=1.92; 95% CI 1.41 to 2.62) (fig 3).

As the risk of deterioration in women with pre-existing disc degeneration was equivalent in both groups (RR 1.14; 95% CI 0.91 to 1.42) the results of the two groups have been amalgamated (fig 4). More than half (60%) of those with abnormal films in 1975-8 deteriorated, and more than half (68%) of normal films remained unchanged. Previously damaged disc spaces were much more likely to deteriorate than normal disc spaces (RR=4.09; 95% CI 3.36 to 4.97). A normal disc space in a spine with disc degeneration elsewhere was no more likely to deteriorate than a normal disc space in a normal spine. Deterioration was most common at the lower disc spaces.

Osteophytes

During follow up osteophytes increased in size at 31.9% of disc spaces. Growth of osteophytes was equally common in those with and those without back pain. The presence of osteophytes at an otherwise normal disc space predisposed to deterioration (RR=2.58; 95% CI 1.68 to 3.95).

Figure 4 Deterioration of disc degeneration in women with and without radiological disc degeneration in 1975-8.

Osteoporosis

Incident vertebral fractures occurred in 43 women (9%). Incident fractures occurred with similar frequency in those with and without back pain (RR=0.67; 95% CI 0.38 to 1.19) and in those with and without pre-existing disc degeneration (RR=0.75; 95% CI 0.42 to 1.34). Osteoporotic fractures most commonly affected the higher vertebrae.

PREDICTORS OF CHANGE

Disc degeneration

The following factors were considered as potential predictors of change in disc degeneration: age, body mass index (BMI) (weight/height²), extent of pre-existing damage indicated by maximum Kellgren score or number of abnormal disc spaces, back pain, smoking habits in 1975-8, and parity. Deterioration of pre-existing disc degeneration and its development de novo were analysed separately. For pre-existing disc degeneration both univariate and multivariate analyses found none of the variables tested to be predictors of deterioration. The degree of deterioration (total δ score) was positively related to the number of levels of pre-existing damage and negatively related to age. Univariate and multivariate analyses showed that BMI and multiparity were predictors of development of disc degeneration de novo. The development of disc degeneration was negatively correlated with the number of children—that is, multiparity had a protective effect.

Osteoporosis

Results of the analysis of risk factors for the development of osteoporosis are published elsewhere.²⁰

Discussion

There have been a number of previous cross sectional studies of spinal radiology in the general population,^{6 7 12} but as far as we know this is the first which has followed up subjects longitudinally. It is thus a unique assessment of the natural history of two common radiological abnormalities—disc degeneration and osteoporotic fracture. Two groups were selected from the 742 women in the study population: one group of 241 with no back symptoms

(32.5% of the whole) and one group of 236 with maximal symptoms (31.8% of the whole).

Disc degeneration was significantly more common in those with recurrent back pain, though it also occurred in 92 (38%) of asymptomatic women. The more severe and the more widespread the degenerative process the more likely it was to be associated with recurrent pain. We therefore conclude that disc degeneration, particularly when it is widespread and severe, may be an explanation of continuing symptoms in some middle aged women.

Radiological disc degeneration was more likely to develop at normal disc spaces with osteophytes than at those without. Some authors have suggested that osteophyte formation is part of the aging process,⁸ whereas others claim that it always occurs secondary to nuclear herniation or annular tears.²¹ Both observations are probably correct as necropsies have shown that pathological changes in the discs are present in all subjects by middle age, frequently with coexistent marginal osteophytes and osteoarthritis of the apophysial joints.²² We conclude that disc degeneration is a universal phenomenon and that osteophyte formation is the earliest radiological sign of the process.

The low prevalence of osteoporotic fracture in those with recurrent back pain and no disc degeneration (fig 2) is intriguing. Possibly, the back pain in some of these women is due to osteoarthritis of the apophysial joints—a condition which cannot be assessed from lateral radiographs. Osteoarthritis of the apophysial joints is related to generalised osteoarthritis.²³ The possibility that back pain in these women is due to osteoarthritis is supported by their high prevalence of hip and knee pain.¹³ Our results are thus in keeping with the hypothesis that osteoarthritis and osteoporosis are negatively associated.^{24 25} We found no association, positive or negative, between disc degeneration and osteoporotic fracture. In this respect our results contrast with those of Renier *et al*,²⁶ who found a lower prevalence of disc degeneration in 50 patients with biopsy proved osteoporosis than in controls.

The best predictor for deterioration of disc degeneration was the presence of pre-existing degeneration. Once disc degeneration is present deterioration seems to be autonomous, though the degree of deterioration was related to the number of levels of damage. Neither weight loss nor stopping smoking were preventative measures against further deterioration of disc degeneration in middle aged women. The BMI was however a predictor of the development of disc degeneration in those who did not have it in 1975-8.

Our results suggests that osteoporotic fracture is not a common cause of back pain in the general population as the prevalence of fractures was no higher in those with back pain than in those without. The natural histories of disc degeneration and osteoporotic fracture seem to be independent of one another.

1 Nachemson A L. The lumbar spine: an orthopaedic challenge. *Spine* 1976; 1: 59-71.
2 Benn R T, Wood P H N. Pain in the back: an attempt to

- estimate the size of the problem. *Rheumatology and Rehabilitation* 1975; 14: 121-8.
- 3 Dillane J B, Fry J, Kalton G. Acute back syndrome—a study from general practice. *Br Med J* 1966; ii: 82-4.
 - 4 Liang M, Komaroff A L. Roentgenograms in primary care patients with acute low back pain: a cost-effective analysis. *Arch Intern Med* 1982; 142: 1108-12.
 - 5 Frymoyer J W. Back pain and sciatica. *N Engl J Med* 1988; 318: 291-300.
 - 6 Kellgren J H, Lawrence J S. Osteoarthritis and disc degeneration in an urban population. *Ann Rheum Dis* 1958; 17: 388-96.
 - 7 Lawrence J S. Disc degeneration: its frequency and relationship to symptoms. *Ann Rheum Dis* 1969; 28: 121-38.
 - 8 Torgerson W R, Dotter W E. Comparative roentgenographic study of the asymptomatic and symptomatic lumbar spine. *J Bone Joint Surg [Am]* 1976; 58: 850-3.
 - 9 Frymoyer J W, Newberg A, Pope M H, Wilder D G, Clements J, MacPherson B. Spine radiographs in patients with low back pain. *J Bone Joint Surg [Am]* 1984; 66: 1048-55.
 - 10 Riggs B L, Melton J J. Involutional osteoporosis. *N Engl J Med* 1986; 314: 1676-86.
 - 11 Dixon A St J. Diagnosis of low back pain—sorting the complainers. In: Jayson M I V, ed. *The lumbar spine and back pain*. 2nd ed. Tunbridge Wells, UK: Pitman Medical, 1980: 135-55.
 - 12 Valkenburg H A, Haanen H C M. The epidemiology of low back pain. In: White A, Gordon S L, eds. *Symposium on idiopathic low back pain*. Miami: Mosby, 1980: 9-22.
 - 13 Symmons D P M, van Hemert A M, Vandenbroucke J P, Valkenburg H A. A longitudinal study of back pain and radiological changes in the lumbar spines of middle aged women. I. Clinical features. *Ann Rheum Dis* 1991; 50: 158-61.
 - 14 Kellgren J H, Jeffrey M R, Ball J R. The epidemiology of chronic rheumatism. *Atlas of standard radiographs of arthritis*. Vol II. Oxford: Blackwell, 1963; 20-3.
 - 15 Fleiss J L. *Statistical methods for rates and proportions*. New York: Wiley, 1973; 143-7.
 - 16 Garn S M, Rohmann C G, Wagner B. Bone loss as a general phenomenon in man. *Fed Proc* 1967; 26: 1729-36.
 - 17 Horseman A, Simpson M. The measurement of sequential changes in cortical bone geometry. *Br J Radiol* 1975; 48: 471-6.
 - 18 Miettinen O S. Estimability and estimation in case-referent studies. *Am J Epidemiol* 1976; 103: 226-35.
 - 19 Dixon W J, ed. *BMDP Statistical software*. Berkeley: University of California Press, 1983: 330-44.
 - 20 van Hemert A M, Vandenbroucke J P, Birkenhäger J C, Valkenburg H A. Prediction of osteoporotic fractures in middle aged women. A nine-year population based follow-up study. *Am J Epidemiol* (in press).
 - 21 Lipson S J, Muir H. Vertebral osteophyte formation in experimental disc degeneration. *Arthritis Rheum* 1980; 23: 319-24.
 - 22 Vernon Roberts B. Pathology of intervertebral discs and apophyseal joints. In: Jayson M I V, ed. *The lumbar spine and back pain*. 3rd ed. Edinburgh: Churchill Livingstone, 1987: 37-55.
 - 23 Kellgren J H, Moore R. Generalised osteoarthritis and Heberden's nodes. *Br Med J* 1952; i: 181-5.
 - 24 Weintraub S, Papo J, Ashkenazi M, et al. Osteoarthritis of the hip and fractures of the proximal end of the femur. *Acta Orthop Scand* 1982; 53: 261-4.
 - 25 Dequeker J. The relationship between osteoporosis and osteoarthritis. *Clin Rheum Dis* 1985; 11: 271-96.
 - 26 Renier J C, Bernat M, Fallah N. Etude correlative de l'osteoporose et de la discarthrose. *Rev Rhum Mal Osteoartic* 1981; 48: 323-30.