Eur Spine J (1997) 6:106–114

ORIGINAL ARTICLE

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The relationship between the magnetic resonance imaging appearance of the lumbar spine and low back pain, age and occupation in males

Received: 6 May 1996
Revised: 22 July 1996
Accepted: 6 August 1996

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Abstract The purpose of this study was to undertake a critical review of the potential role of magnetic resonance imaging (MRI) in the evaluation of low back pain (LBP) and to determine if there were differences in the MRI appearances between various occupational groups. The study group, 149 working men (78 aged 20–30 years and 71 aged 31–58 years) from five different occupations (car production workers, ambulance men, office staff, hospital porters and brewery draymen), underwent MRI of the lumbar spine. Thirty-four percent of the subjects had never experienced LBP. Twelve months later, the examination was repeated on 89 men. Age-related differences were seen in the MRI appearances of the lumbar spine. Disc degeneration was most common at L5/S1 and was significantly more prevalent ($P < 0.01$) in the older age group (52%) than in the younger age group (27%). Although LBP was more prevalent in the older subjects there was no relationship between LBP and disc degeneration. No differences in the MRI appearance of the lumbar spine were observed between the five occupational groups. Overall, 45% had 'abnormal' lumbar spines (evidence of disc degeneration, disc bulging or protrusion, facet hypertrophy, or nerve root compression). There was not a clear relationship between the MRI appearance of the lumbar spine and LBP. Thirty-two percent of asymptomatic subjects had 'abnormal' lumbar spines and 47% of all the subjects who had experienced LBP had 'normal' lumbar spines. During the 12-month follow-up period, 13 subjects experienced LBP for the first time. However, there was no change in the MRI appearances of their lumbar spines that could account for the onset of LBP. Although MRI is an excellent technique for evaluating the lumbar spine, this study shows that it does not provide a suitable pre-employment screening technique capable of identifying those at risk of LBP.

Key words Magnetic resonance imaging · Lumbar spine · Disc disease

Introduction

In the United Kingdom, approximately 20 million working days are lost each year because of low back pain (LBP) [34]. LBP accounts for 30–40% of time lost due to industrial injury [13]. It is generally agreed that the heavier the work, the more likely it is that back pain will develop [9, 26, 31]. However, the mechanisms that cause LBP are poorly understood [11].

Plain radiography of the spine is of little use in determining the cause of LBP [14, 25]. Magnetic resonance imaging (MRI) offers a new approach to the evaluation and study of LBP. It is a noninvasive technique with no known harmful effects. Consequently, it can be used in longitudinal studies. Images may be produced in any plane and exhibit excellent soft tissue contrast. In the lumbar spine, the paraspinal muscles, intervertebral discs and nerve roots can be seen in remarkable detail. The size and shape of the spinal canal are readily apparent. MRI allows the assessment of intervertebral disc hydration, enabling early signs of disc degeneration to be detected. Disc degeneration induces a gradual loss of water from the nucleus pulposus, which manifests itself on a T2-weighted MR image as decreased signal from the disc. Protrusion of the intervertebral discs may also be delineated on MRI.

The purpose of this study was to undertake a critical review of the potential role of MRI in the evaluation of LBP. In the first phase of the study, baseline data pertaining to lumbar spines of working men were obtained and the relationship to age, occupation and LBP was considered. A follow-up study was performed 1 year later. Changes in the MRI appearance of the lumbar spine were assessed and related to any incidence of LBP reported by each subject.

Materials and methods

Subjects

The study population consisted of 149 male volunteers from five different occupations (Table 1), who gave fully informed written consent to the investigators. The occupations were chosen because they imposed different loads and stresses on the lumbar spine.

Ambulance men

The lumbar spines of ambulance men were exposed to a high level of dynamic loading, caused by lifting and carrying immobile patients and supporting infirm ambulatory individuals. Much of their day was spent driving and travelling in an ambulance, exposing their spines to vibration and multiple minor impacts.

Hospital porters

Hospital porters were involved in the manual handling and lifting of heavy equipment including gas cylinders, rubbish, laundry and medical supplies. They also transported patients in wheelchairs and on trolleys.

Table 1 Number of subjects in each occupation and age group

Occupation	Number	Age (years)	
		20–30	31–58
All subjects	149	78	71
Ambulance men	24	18	6
Hospital porters	16	7	9
Car production workers	40	20	20
Draymen	12	–	12
Office staff	57	33	24

Car production workers

Car workers were exposed to postural stress due to the spatial constraints of their working environment. All were involved in the fitting of interior trim of cars. The tasks included the installation of dashboard controls, roof lining, door seals, sun roofs, carpets and seat belts. Consequently they spent much of their working day bending and stretching in sitting, lying, kneeling and crouching positions inside the car. Men who were employed on the trim line but worked on the outside of the car were excluded from the study.

Brewery draymen

The group of brewery draymen were exposed to postural stresses and spinal loading as a result of manoeuvring and lifting heavy beer barrels. Their spines were also subjected to vibration and multiple impacts as a consequence of driving and travelling in delivery lorries.

The subjects were recruited into two age bands:

1. The younger age group: 20–30 years of age, mean age 25.6 years (SD 2.7 years), employed in their current job for a mean of 5 years (SD 3.5 years)
2. The older age group: 31–58 years, mean age 47.9 years (SD 5.6 years), employed in their current job for a mean of 20 years (SD 9.0 years)

Methods

Low Back Pain (LBP) history was obtained by questionnaire on the day of the MRI scan. The subjects were then classified into four mutually exclusive groups on the basis of their replies. These groups were:

1. No LBP: subjects who had never experienced LBP
2. Past LBP: subjects who had experienced LBP in the past, but not in the 12 months preceding the MRI scan
3. LBP-12: subjects who had experienced LBP in the 12 months preceding the MRI examination, but not every month
4. LBP monthly: subjects who had experienced LBP at least once a month in the 12 months preceding the MRI scan

The subjects who had experienced LBP in the 12 months preceding the MRI scan were asked how many days they had been off work during their worst attack of LBP.

The questionnaire also asked how often the subject had played sport in the 12 months preceding the MRI scan and the type of sport. The subjects were then divided into two recreational groups: those who rarely or never played sport and those who played sport or were involved in physical training almost every week.

Follow-up study

Twelve months after the first scan, the MRI examination was repeated on 89 of the subjects (60% of the original study population). No draymen had follow-up scans. The number of subjects from each occupation and age group are shown in Table 2. At the time of the second MRI scan, all subjects completed a questionnaire concerning the presence and features of LBP during the preceding year. Evaluation of the second MRI scan was carried out without the observers knowing whether the scan was an initial or follow-up scan.

Magnetic resonance imaging

The MRI scans of the lumbar spine were performed with a 1.5-T IGE Signa system, using a rectangular surface coil. From a coronal

Table 2 Follow-up study. Number of subjects from each occupation and age group

Occupation	Number	Age (years)	
		20–30	31–58
All subjects	89	52	37
Ambulance men	14	10	4
Hospital porters	12	5	7
Car production workers	21	10	11
Office staff	42	27	15

localizer scan, 5-mm sagittal images were prescribed with a 1.5-mm gap. A variable echo multiplanar (VEMP) spin echo sequence (TE 30 and 90 ms, TR 1500 ms) was used to give proton density and T2-weighted images, using a 256 × 256 matrix and a 24-cm field of view. From the midline sagittal image, axial slices were prescribed obliquely through each intravertebral disc. A T1-weighted pulse sequence (TE 2 ms TR 500 ms) was used with a 256 × 256 matrix, 24 cm field of view and respiratory gating.

All scans were independently assessed by two experienced radiologists. Quantification of the imaging findings were made as follows:

Disc degeneration was assessed subjectively by observing the signal intensity of each lumbar disc on the T2-weighted images. A disc was classified as being 'normal' or 'degenerate'.

Disc configuration was classified according to the system described by Jensen et al. [15]. The terms used were: 'normal', no disc extension beyond the interspace; 'bulge', circumferential symmetrical extension of the disc beyond the interface, 'protrusion', focal or asymmetrical extension of the disc beyond the interface, with the base against the disc of origin broader than any other dimension of the protrusion; and 'extension', more extreme extension of the disc beyond the interspace, with the base against the disc of origin narrower than the diameter of the extruding material itself or with no connection between the material and the disc of origin.

The facet joints were assessed for hypertrophic change on the axial images, using a three-point grading system: 0 = normal, 1 = mild, 2 = marked.

Nerve root compression was assessed on the sagittal and axial images and graded on a three-point scale: 0 = normal, 1 = no clear fat interface around nerve root on either sagittal or axial images, 2 = compression of nerve root, with or without deviation, on both sagittal and axial series.

Results

LBP history

Thirty-four percent of all the subjects had never experienced LBP, 13% were in the past-LBP group, 25% were in the LBP-12 group and 28% experienced LBP every month. LBP was more common in the older than in the younger subjects (Fig. 1), only 19% of the older subjects having never experienced LBP compared to 46% of the younger age group.

LBP history and occupation

LBP was least common in the office staff, 47% of whom had never experienced LBP, and most common in the car production workers, over three-quarters (78%) of whom had experienced LBP at some time (Fig. 2). The percentage of draymen in each LBP category is not comparable with the other occupational groups because only draymen in the 31–58 year group were studied.

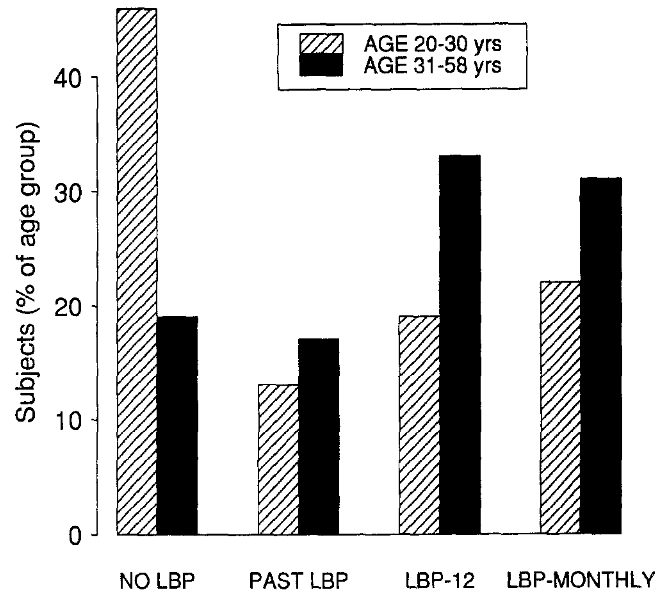

Fig. 1 Relationship between age and low back pain (LBP) history (*No LBP* never experienced LBP, *Past LBP* LBP in the past but none in the 12 months preceding the MRI scan, *LBP-12* LBP at some point in the 12 months preceding the MRI scan, *LBP-monthly* LBP at least once a month in the 12 months preceding the MRI scan)

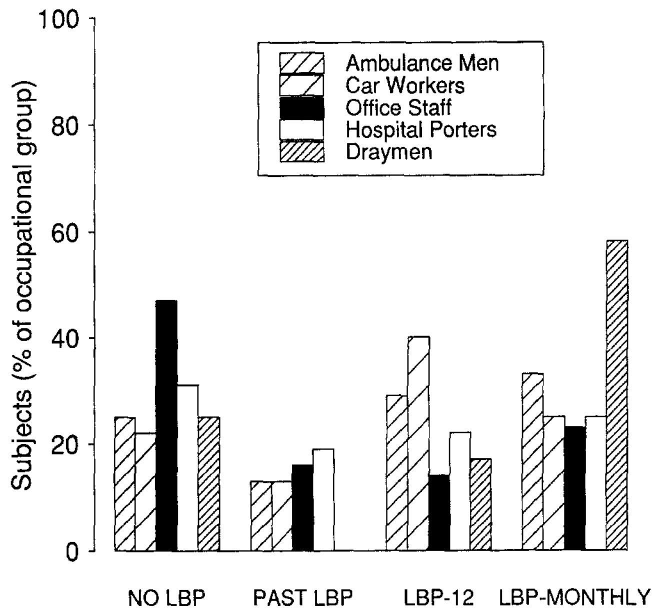

Fig. 2 Relationship between occupation and LBP history

Sickness absence due to LBP

A total of 28 subjects had taken more than 3 days off work: 5 had been off work for more than 2 weeks and 6 for more than 30 days. Significantly more ($P < 0.001$) of the 31–58 year-olds than the 20–30 year-olds had taken at least 3 days off work during their worst attack of LBP: in percentage terms, 58% of the older age group compared to 20% of the younger age group.

Sporting activity

Significantly more ($P < 0.001$) of the 20–30 year-olds (67%) played sport than the 31–58 year-olds (34%). However, there was no significant difference in sports participation between the occupational groups or the four LBP history groups.

MRI findings

There was a 94% agreement in the independent assessment of the initial and follow-up MRI scans by the two radiologists. The overall level of agreement expected by chance was calculated as being 53.6%. The kappa coefficient, which estimated how much better than chance was the agreement between the two assessors, was 0.87. This kappa value is regarded as a very good strength of agreement [34]. The cases with disagreement between assessors were reclassified following collusion.

The MRI scans of the lumbar spine were classified as 'abnormal' if one or more of the following features were present: disc degeneration, disc herniation, facet joint hypertrophy or evidence of nerve root compression. Lumbar spines that did not display any of these abnormal features were termed 'normal'. Over half (54%) of all subjects were found to have normal lumbar spines on MRI. Fifty-two (66%) of the 20–30 year-olds and 29 (41%) of the 31–58 year-olds had normal lumbar spines.

The percentage of subjects in each occupation with normal lumbar spines was as follows: ambulance men (50%), hospital porters (56%), car production workers (62%), draymen (33%), office workers (56%).

Two-thirds of the subjects had experienced LBP and of these just over half (53%) had abnormal spines (Fig. 3). Of the subjects who had never suffered LBP, almost one-third (32%) had abnormal lumbar spines. Of the 68 men who had abnormal lumbar spines, 24% had never experienced LBP.

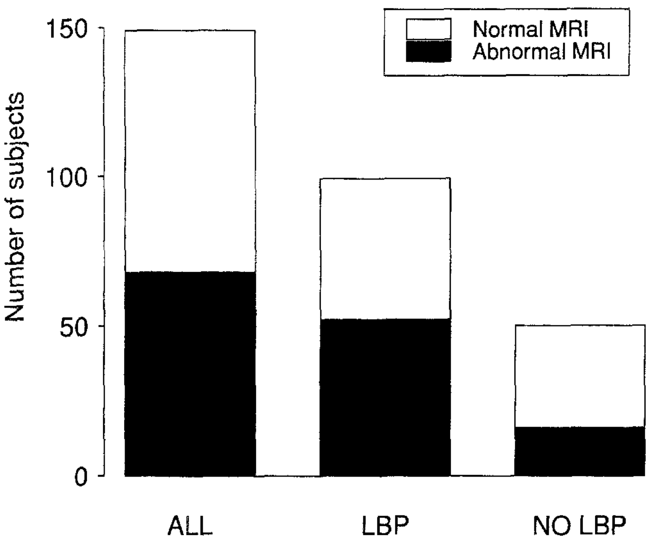

Fig. 3 Number of abnormal lumbar spines on MRI in all subjects, in subjects who had experienced LBP, and in subjects who had never experienced LBP

Disc degeneration

Disc degeneration was present in one or more lumbar levels in 39% of all subjects. The most commonly affected level was L5/S1, where 31% of the discs at this level displayed evidence of disc degeneration (Figs. 4, 5).

Disc degeneration and age. Disc degeneration at one level or more was significantly more common ($P < 0.01$) in the older group (52%) than in the younger age group (27%). The number of degenerated discs in the older group was greater at every disc level (Fig. 6), although the difference was not significant at the L5/S1 level.

Disc degeneration and occupation. A chi-squared test showed that there was no significant difference in the prevalence of disc degeneration between the five occupational groups (Fig. 7).

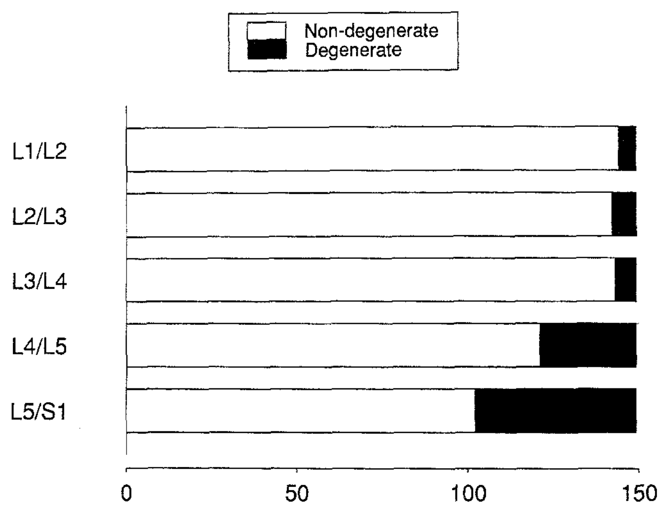

Fig. 4 Number of normal and degenerated discs at each level

Fig. 5 MR scan: midline sagittal section of lumbar spine on T2-weighted image. Reduced signal intensity is apparent in the L4/5 disc with slight posterior bulging, indicative of disc degeneration

Disc degeneration and LBP. A chi-squared test showed that LBP history was not related to the prevalence of disc degeneration (Fig. 8).

Disc herniation

Twenty-two percent ($n = 33$) of all subjects had bulging of one or more discs. Disc protrusion at one level or more was seen in 15 subjects (10% of the study population). The most commonly affected level was L5/S1. There were no disc protrusions at L1/2 or L3/4.

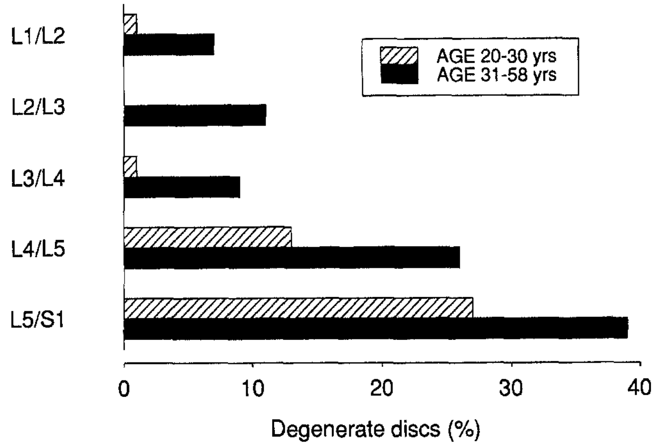

Fig. 6 Percentage prevalence of disc degeneration at each level as a function of age

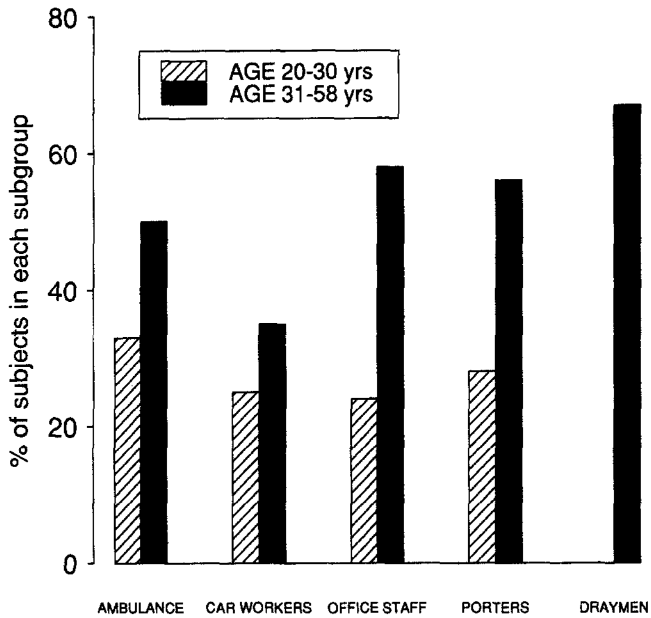

Fig. 7 Percentage prevalence of disc degeneration at one level or more as a function of occupation and age

Disc protrusion and age. Disc protrusions were observed in 6% ($n = 5$) of the younger age group and 15% ($n = 10$) of the older age group.

Disc protrusion and LBP. Two of the subjects with disc protrusions had never experienced LBP and one subject had been free of LBP in the year preceding the MRI scan. Eight of the subjects experienced LBP at least once a month and the remaining four had experienced LBP at least once during the preceding year. A chi-squared test showed no significant difference in the prevalence of disc bulges between the asymptomatic subjects and those who had experienced LBP.

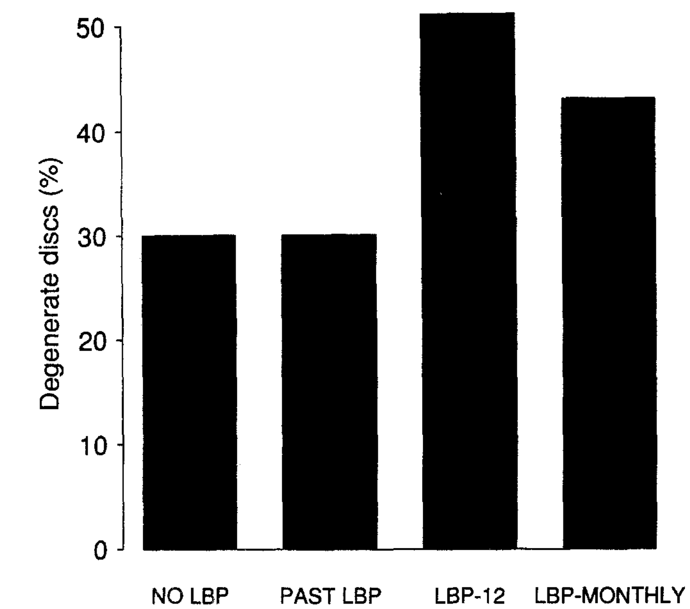

Fig. 8 Percentage prevalence of disc degeneration at one level or more as a function of LBP history

Disc herniation and disc degeneration. All of the bulging and protruded discs showed disc degeneration.

Facet hypertrophy

Facet hypertrophy at one level or more was observed in 11 subjects (7% of the study population). Facet hypertrophy was generally bilateral, although two unilateral occurrences were observed. Two subjects had facet hypertrophy and disc degeneration at the same level.

Facet hypertrophy and age. Facet hypertrophy was present in 4% (n = 3) of the younger group and 11% (n = 8) of the older age group.

Facet hypertrophy and LBP. Two of the subjects with facet hypertrophy had never experienced LBP. The other nine subjects had experienced LBP in the year preceding the MRI scan, six of them at least once a month.

Nerve root compression

Nerve root compression at one level or more was observed in seven subjects (57% of the study population). All were in the 31–58 year-old age group. The affected levels were L4/5 (3 cases) and L5/S1 (4 cases).

Nerve root compression and LBP. Two of the subjects with nerve root compression on the MRI scan had never experienced LBP. Five of the subjects had experienced LBP in the year preceding their MRI scan, three of whom also had sciatica. Four of the subjects experienced LBP at least once a month.

Follow-up study

Four subjects developed disc degeneration during the 12 month period between the two MRI scans and one subject developed facet hypertrophy (Table 3).

During the 1-year follow-up period, 13 subjects experienced LBP for the first time (Table 4). Only one of these subjects, an office worker, exhibited MRI changes during the 12-month follow-up period, developing disc degeneration at L3/4, L4/5 and L5/S1. Three other subjects out of the 13 presented with positive findings on the first MR scan: one had a central disc protrusion and degeneration at L5/S1, another had disc degeneration and a lateral protrusion on the right at L5/S1 and the third had disc degeneration at L5/S1.

Discussion

In this study of working men, disc degeneration was a common MRI feature. Slightly over one third of all subjects demonstrated disc degeneration. The most common-

Table 3 Data on individuals with changes on MRI over 1 year

Occupation	Age (years)	Original MR scan	Change on second scan	Symptoms at time of first scan	Symptoms between scans
Office worker	52	Normal	Disc degeneration L3/4, L4/5, L5/S1	None	LBP for 1 week
Office worker	49	Normal	Disc degeneration L4/5, L5/S1	One episode of LBP in previous year	None
Office worker	21	Normal	Disc degeneration L5/S1	None	None
Office worker	48	Normal	Disc degeneration L5/S1	LBP once a month for 1 day	More frequent and severe LBP lasting up to 1 week
Ambulance man	44	Normal	Facet joint hypertrophy L3/4	LBP almost daily	LBP more severe

Table 4 Case histories of subjects who experienced LBP for the first time during the follow up period

Age (years)	Occupation	LBP frequency	No. days off sick	Symptoms	Medical advice sought
52	Office worker	Once	0	Bilateral leg and LBP	Yes
22	Ambulance man	A few times	0	Bilateral LBP	No
26	Car worker	Monthly	15	Bilateral LBP	Yes
48	Car worker	Every day	0	Bilateral LBP	Yes
29	Office worker	Once	0	Bilateral LBP	No
29	Office worker	Weekly	0	Right LBP	Yes
23	Office worker	A few times	0	Bilateral LBP	No
24	Office worker	A few times	0	Left leg and LBP	Yes
23	Office worker	A few times	0	Bilateral LBP	No
48	Ambulance man	Every day	0	Bilateral LBP	No
31	Car worker	A few times	0	Bilateral LBP	No
30	Hospital porter	A few times	0	Left LBP	No
31	Car worker	A few times	0	Bilateral LBP	No

ly affected discs were L4/5 and L5/S1. These observations are in agreement with previous pathological [30] and MRI [12] studies.

It has been postulated that disc degeneration results from an intrinsic defect in the nuclear proteoglycans, which become unable to form macromolecular aggregates and thus lose their water binding capacity. This leads to cracks and fissures within the nucleus, which may secondarily disrupt the annulus and lead to herniation. Another possible cause is degeneration starting within the annulus fibrosus, which then fissures [16]. Degeneration with a grossly intact annulus results in an annular bulge, seen as a general extension of the disc margin beyond the margin of the vertebral end plate [17].

The increasing prevalence of disc degeneration with age [6, 10] was confirmed, disc degeneration being significantly more common in older than younger subjects in this study. Many authors believe that disc degeneration is a normal consequence of ageing and that biochemical and structural changes occur simultaneously during ageing and degeneration. At autopsy, 85–90% of individuals over the age of 50 years show evidence of disc degeneration [5].

Despite the mechanical stresses applied to the lumbar spine during lifting and manual handling, this study showed that disc degeneration was no more prevalent in men employed in manual occupations than in men with sedentary occupations.

Many studies have been performed in an attempt to obtain knowledge about the spinal degenerative process and the role of different occupations in its causation. The collective results are difficult to interpret because the definition and classification of degenerative changes vary from one study to another. Several studies have concluded that heavy work is related to the development of disc degeneration [4, 24, 27].

Mechanical loading of the intervertebral joints may lead to disc degeneration [28]. It has been proposed that compressive loading of the joint causes fatigue induced microfractures at the end plates, leading to reduced diffusion through the end plates and hence impaired disc nutrition. Alternatively, dynamic loading of the joint induces breakdown of the annular lamellae, thus accelerating annular degeneration and even nuclear prolapse. A recent study [1] was based on lifetime discordance in suspected environmental risk factors for disc degeneration, using MRI, within a series of male identical twins. Lifetime exposure to regularly performed activities involving heavy material handling, lifting, bending and twisting, tended to be associated with MRI findings of greater disc degeneration in the upper lumbar spine. Sedentary work was associated with less degeneration. However, the effects of physical loading factors on disc degeneration were small, being dwarfed by those of familial aggregation, which reflect primarily genetic and shared early environmental factors.

A previous study [12] used MRI to compare the prevalence of disc disease in ambulatory and sedentary groups. It was found that ambulatory females had no degenerative discs and the sedentary group had a large number of degenerative discs. Although this is contrary to the hypothesis that mechanical loading provokes degenerative changes, the authors proposed that repetitive stretching and relaxation of the annular fibres during ambulation enhances the strength of the disc collagen, promotes lumbar disc nutrition and slows the normal age-related disc degeneration. However, the number of subjects in this study is small and the relationship between disc degeneration and occupation was not demonstrated in male subjects. There was no evidence from our study that disc degeneration was more prevalent in subjects who had experienced LBP than in asymptomatic subjects. Disc degeneration occurred in 30% of asymptomatic subjects, in agreement with other series [6, 18]. Degeneration, as seen on MRI, must therefore be interpreted with caution and does not necessarily collate with LBP. However, one study [21], comparing young adult males with healthy controls, found that LBP patients had an increased incidence of degenerative disease. In this particular study, it is noteworthy that two extreme study groups were considered: patients referred to hospital for LBP and men who had never experienced LBP. In contrast, none of the subjects in the present study were imaged because they had sought medical advice and all were actively working. An association between LBP and disc degeneration may not have been found because the LBP group was comprised of subjects with diverse back pain histories. It has been postulated that LBP could be produced by the degenerative processes leading to inflammatory pain [7, 19, 20].

In regard to disc protrusion, the present study, in agreement with others [6, 10], revealed that L4/5 and L5/S1 were the most commonly affected levels. More men in the older group than the younger group had disc protrusions, suggesting that disc protrusion is age related. The subjects with disc protrusion were evenly distributed among the occupational groups. No inferences could therefore be drawn about the causal effects on disc protrusion of risk factors associated with each occupation. It has been suggested that lumbar disc protrusions can be a direct mechanical consequence of prolonged sitting in static or vibrational environments [33]. Disc protrusion was not necessarily associated with pain. The seven subjects who had nerve root compression were all in the older age group and the affected levels were L4/5 and L5/S1. There were insufficient numbers to suggest that nerve root compression was age related.

A recent study [15] on MRI appearances of the lumbar spine in a group of men and women aged between 20 and 80 years without LBP found that 36% of the group had normal discs at all levels, 52% had a bulge at one level at least, 27% had a protrusion and 1% had an extension. In our series, 22% had at least one bulging disc and 10% had a disc protrusion. While our figures for bulging and protruding discs were lower, both studies conclude that the discovery of disc bulges and protrusions in subjects with LBP may frequently be coincidental.

It is considered that degeneration of the facet joints follows disc degeneration and is secondary to mechanical changes in the loading of motion segments [8]. It should be noted that computed tomography is a more accurate method than MRI in evaluating facet joints. There were too few subjects with facet joint hypertrophy to conclusively assess the effects of facet joint hypertrophy on LBP.

It was hoped that the experimental design of the study would enable changes in the MRI appearance of the lumbar spine to be related to changes in LBP symptoms. However, the follow-up study showed that degenerative changes developed in only four subjects over the period of 1 year. Three of these subjects were in the older age group and the fourth was only 21 years old and had never experienced LBP. The time-scale for incipient disc degeneration may therefore be relatively slow. There is no evidence to suggest that disc degeneration was accelerated by manual work, all four subjects being in sedentary occupations. During the 12-month follow-up period, 13 subjects experienced LBP for the first time. With the exception of one who displayed disc degeneration, there was no difference in the MRI appearance of the lumbar spine between the two examinations. The follow-up MRI examination therefore did not explain why they developed LBP. However, two subjects who had asymptomatic disc protrusions on the first scan developed symptoms during the follow-up year with no change on the second scan. Neither subject had sciatic pain that could be related to the disc protrusion.

Despite the extraordinary ability of MRI to delineate the spine, this study suggests that there is not a clear relationship between the MRI appearance and LBP. This conclusion is supported by several other investigations [6, 10, 12, 15, 18, 21]. The causes of LBP are numerous, diverse and poorly understood. LBP is frequently thought to be muscular in origin and may be due to a postural muscle strain or protective muscle spasm. Such an injury cannot be detected by MRI and neither can referred pain from viscera. Many of the subjects in this study who experienced LBP had normal MRI appearances. Conversely, disc degeneration was common in the asymptomatic and disc protrusion was occasionally present.

Working conditions influence the risk of accidents and the possibility of developing LBP. In most work situations, potential hazards can be identified and controlled. Careful investigation can lead to redesign of the workplace and changes in working practices in order to achieve a safer working environment. Ergonomic design relies heavily on age- and sex-related data pertaining to the normal anatomical dimensions of the human body. Such measurements can easily be obtained with MRI in living healthy individuals. For example, when constructing biomechanical models of the spine, it is necessary to know the cross-sectional area and position of the muscles in order to calculate forces on intervertebral joints and within muscles [30]. Previously this information had been obtained from cadaveric studies [3, 22] and computed tomography [23]. More recently, MRI has been used to gather such information [29].

Conclusions

Disc degeneration was more common at L5/S1 and was significantly more prevalent ($P < 0.01$) in the older age group (52%) than in the younger age group (27%).

No difference in the MRI appearances of the lumbar spine was observed between the five occupational groups. There was not a clear relationship between the MRI appearance of the lumbar spine and LBP history. Forty-five percent of the working men studied had 'abnormal' lumbar spines, i.e. disc degeneration, disc herniation, facet hypertrophy or evidence of nerve root compression. Almost one-third (32%) of the asymptomatic subjects had 'abnormal' lumbar spines on MRI. Just under half of all subjects who had experienced LBP had 'normal' lumbar spines on MRI. During the 12-month follow-up study, 13 subjects experienced LBP for the first time. However, there was no change in the MRI appearance of their lumbar spines that could account for the onset of LBP.

This study suggests that MRI does not provide a suitable pre-employment screening technique capable of identifying those who are at risk of developing LBP.

Acknowledgements This study was funded by the Health and Safety Executive. The authors wish to thank the following for their co-operation: The Ford Motor Company, Liverpool; Liverpool Metropolitan Ambulance Service; Tetley-Walker Ltd., Warrington; porters at the Royal Liverpool University Hospital and the staff from the University of Liverpool who volunteered to take part in this study. The authors thank Professor R. H. T. Edwards, Dr. J. B. Kenny, Dr. D. Manning and Dr. J. D. G. Troup for their help and advice.

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