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ORIGINAL COMMUNICATION

Lumbar Lordosis: Study of Patients With and Without Low Back Pain

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We used magnetic resonance imaging (MRI) to assess lumbar lordosis in 27 patients with low back pain and 19 patients and 10 volunteers with no known back pain. Our study aimed to investigate whether lordosis changes with age and is reduced in those with low back pain. Although our results confirm known observations that lumbar lordosis is more prominent in women ($P < 0.01$) and those with a higher body mass index ($P < 0.04$), we were unable to demonstrate any significant variation in lordosis with age. Nor could we demonstrate any difference in the degree of lordosis among women with or without back pain. Men with low back pain tended to have a less prominent lordosis, but this difference did not reach statistical significance. Therefore, a 'reduced lumbar lordosis' should be regarded as a very weak clinical sign. Clin. Anat. 16:144–147, 2003. © 2003 Wiley-Liss, Inc.

Key words: spine; lumbar; lordosis; symptoms; magnetic resonance imaging

INTRODUCTION

Standard neurosurgical, orthopedic, and rheumatological textbooks often imply that a 'reduced or flattened' lumbar lordosis may signify lumbar spine problems (McRae, 1997; Murtagh and Kenna, 1997). It is noted, however, that there is a wide range of variation in lordosis between individuals (Fig. 1). Studies have shown that the angle of lordosis can range from about 20–60° on radiographs of the erect spine in asymptomatic individuals (Voutsinas and MacEwen, 1986; Bernhardt and Bridwell, 1989; Vedantam et al., 1998). The reason for such variation is controversial. Mechanical loading and activity levels in youth have been implicated, in addition to the extent of athletic training (Wojtys et al., 2000). There is little information on the rate of development of the lordosis, although Chernukha et al. (1998) suggested there is an increase during the first year of life and at puberty. Effects of age, body mass index, and gender have been discussed but with no clear answers (Amonoo-Kuofi, 1992; Lin et al., 1992; Jackson and McManus, 1994; Tüzün et al., 1999).

Against this background, what are the effects of low back pain on the lumbar lordosis? It is claimed that flattening or loss of the normal lumbar lordosis is an important clinical sign of back problems (McRae et al., 1997; Murtagh and Kenna, 1997) as the patient is thought to keep the spine straight to reduce pain. This has been challenged by some radiological observations that suggest patients with chronic back pain have either no difference (Hansson et al., 1985) or increased lumbar lordosis when compared to controls (Christie et al., 1995). Much of this information, however, has come from non-standardized techniques on plain radiography in the sitting or standing position. Magnetic resonance imaging (MRI) offers a new perspective of the lordosis by examining the spine in the non-weight–bearing supine position. MRI is a non-invasive method of examining the lumbar spine in great detail and has shown that variations of the lumbar spine may or may not relate to reported symptoms (Boden et al., 1990; Beattie et al., 2000).

We wished to use MRI to compare the lumbar lordosis in patients with low back pain (LBP) to those

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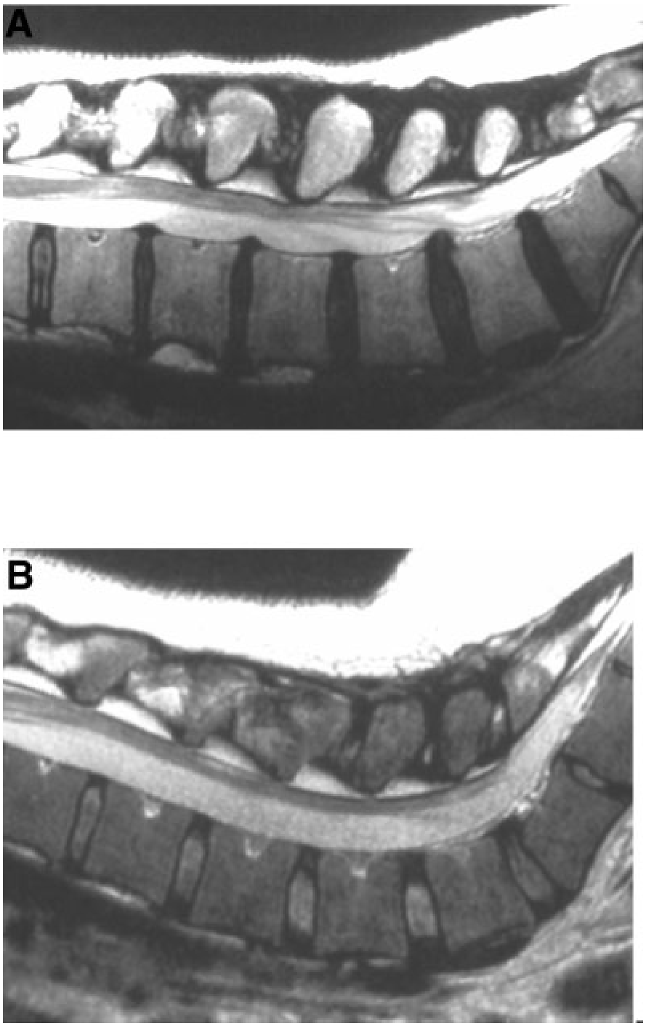

Fig. 1. Sagittal T2 weighted MR images showing the wide variation in lumbar lordosis. **A:** Male patient with a small angle of lordosis, several degenerative discs with annular bulges, and a small focal herniation at the L4/5 level. **B:** Female patient with a prominent lordosis. There is better hydration of the discs in this patient.

with no such history. This might help resolve some of the controversy and be useful in identifying patterns that may be associated with low back pain.

MATERIALS AND METHODS

The images of 46 patients (27 with chronic LBP, 19 without LBP) who had been referred routinely to our MRI unit and ten volunteers (staff within the unit for whom institutional permission had been obtained) were studied (56 in total; 27 with LBP, 29 without). Our MRI unit houses two 1.5 T IGE Sigma Medical Systems MRI machines (GE Medical Systems, Milwaukee, WI). Patients were recruited to two groups: those referred for lumbar spine investigation, and those referred for other investigations (e.g., abdomen). Height and weight of each subject were recorded at the time of MRI.

Patients were positioned supine on a firm mattress with a supportive cushion under the knees. Arms were placed alongside the body. All 27 undergoing imaging for spine problems received our routine lumbar spine protocol. Sagittal T1 weighted images: echos (E) 1; field of view (FOV) 28 cm; slice thickness (ST) 4 mm; spacing (S) 1 mm; time-to-repeat (TR) 450 msec; time-to-echo (TE) 14 msec (min); number of frequency encodes (FE) 512; number of phase encodes (PE) 256; number of signal averages (NSA) 3. Sagittal T2 weighted images: E 1; FOV 28 cm; ST 4 mm; S 1 mm; TR 3500–4500 msec; TE 102 msec; ETL 16; FE 512; PE 256; NSA 3. The 19 patients undergoing other investigations and the 10 volunteers received a standard 3-plane localizer. Localizer: E 1; FOV 40 cm; ST 5 mm; S 1 mm; FE 256; PE 128; NSA 2. The 3-plane localizer is a fast sequence (≈30–60 sec) typically used to test the orientation and position of the patient, but these images yield an image adequate to measure the lumbar lordosis in the sagittal plane.

The images were sent via an internal network to a workstation with GE browser software on a Sun Microsystems viewing monitor (GE Medical Systems).

The angle of lordosis was calculated as the angle formed between the L1/2 and L5/S1 disc spaces (Fig. 2). This modified Cobb angle was generated by drawing electronic ruler-lines along the superior margin of the vertebral end plates at these levels, which are easily visualized on MRI (Fig. 1).

All measurements were obtained by consensus (one experienced radiological consultant with formal train-

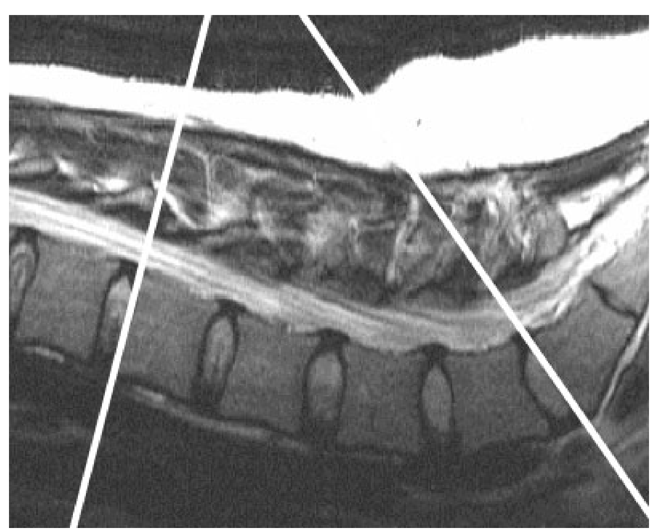

Fig. 2. The technique we used to measure the lumbar lordosis. The superior endplates of L2 and S1 were identified (solid white line). The angle between the two lines was the modified Cobb angle.

TABLE 1. Angle of Lordosis, BMI, and age in the Population of Patients and Volunteers[a]

	Women (n = 32)	Men (n = 24)
Angle of lordosis	51.7 (9.3)	44.0 (11.9)
Body mass index	26.7 (6.5)	27.3 (3.5)
Age	45.4 (11.9)	45.1 (16.1)

[a]Age ranged from 26–65 years (women) and 18–73 years (men). Of the women, 15 were imaged for LBP, 17 for non-spine conditions; in men 12 were imaged for LBP, 12 for non-spine conditions. Values are mean (SD).

ing; one research officer) with both observers unaware of back pain status (BPS = with/without low back pain). The image used to measure the angles was chosen by both observers for the best view of the discs (landmarks used) in the sagittal plane.

On completion of the measurements, 10 images from the sample population were selected at random and re-assessed using the same method. This step examined intra-observer reliability.

Average values of the angle of lordosis, BMI (BMI = weight in kilograms/square of height in meters), and age were calculated for men and women in the sample population. A comparison of these variables with BPS was also assessed. Finally, the sample population was grouped based on BPS and gender to detect any differences between the angle of lordosis, BMI, and age. Statistical analysis was undertaken using the statistical package for the social sciences (SPSS 10.0 for Windows 2001–02).

RESULTS

The angle of lordosis in the total sample population was found to vary over a large range from 20–80°. Table 1 shows the average values of the angle of lordosis, BMI, and age for men and women. A Mann-Whitney test confirmed a significant difference in the angle of lordosis between men and women ($P < 0.01$). Our findings also show a weak relationship between the angle of lordosis and BMI ($r = 0.27$, $P < 0.04$). No relationship was found between the lordosis and height or weight when analyzed as independent variables. No significant relationship was found between the angle of lordosis and age in the sample population ($r = -0.04$, $P < 0.8$).

When the population was analyzed according to BPS, the angle of lordosis, BMI and age did not vary significantly between those with and without low back pain.

On analyzing the BPS groups by gender (i.e., men with/without LBP, women with/without LBP), our results showed that women had no significant difference in angles between those with and without low back pain ($P < 0.7$) (Fig 3a). There was, however, a trend for men with low back pain to have a smaller angle of lordosis, but this did not reach statistical significance ($P < 0.08$) (Fig 3b). No differences were found with respect to BMI or age.

In the 10 images that were re-assessed to determine reproducibility of results, the greatest variation between measurements was 5° (one subject).

DISCUSSION

Our results shed some further light on the complex subject of variation in the angle of lordosis in the lumbar spine. It is of interest that some of these results are in broad agreement with those from previous workers in this field who have obtained measurements from radiographs of the erect lumbar spine (Hansson et al., 1985; Lord et al., 1997). This suggests our measurements from MR images of the subject in

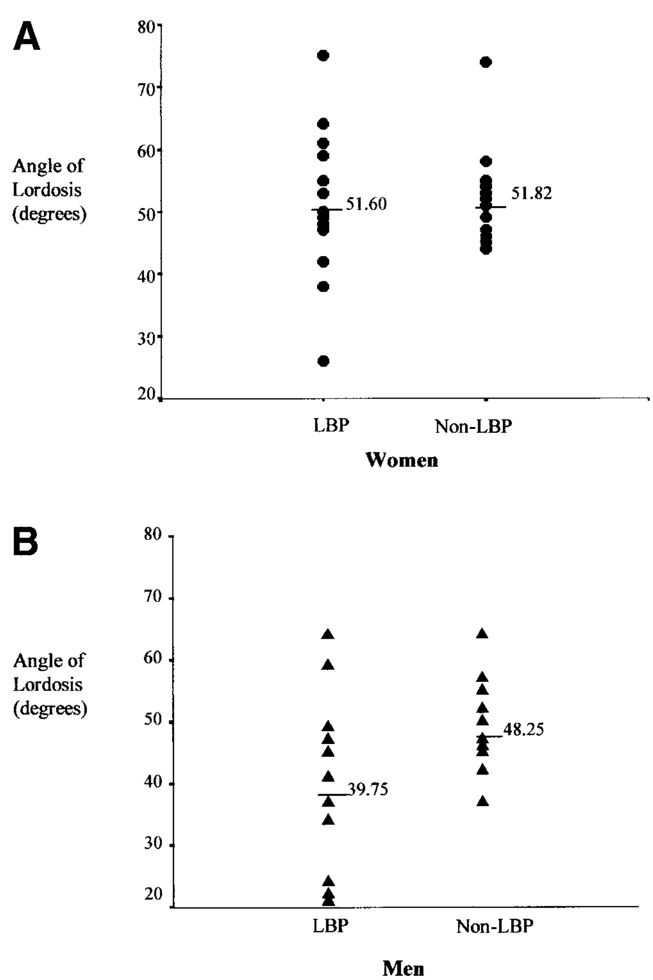

Fig. 3. Mean angles of lordosis shown for those patients with low back pain (LBP) and those without (Non-LBP) in women (**a**) and men (**b**).

the supine position reflect measurements made by other methods. The technique of measuring the angle between the superior end-plates of L2 and S1 (rather than L1 and S1) that was imposed on us by the limited field of view in some patients, does not appear to be a confounding problem. In those patients and volunteers where the lordosis could be measured both from L1 to S1 and from L2 to S1 the difference in estimated lordotic angle was less than 3°. It would be interesting to perform MRI and compare measurements in both the supine and erect positions. Very few MRI open systems are available that would allow observations in the erect position, however, and we do not have access to one.

Our results indicate women have a greater lordosis than men (7.7° difference between means, Table 1). This variation between the genders must be genetically determined and almost certainly reflects gender differences in the shape of the pelvis. Our findings also suggest a relationship between body mass index and lordosis. A simple explanation for this might be that excess central weight in the abdomen 'pulls' the lumbar spine anteriorly. No relationship between age and lordosis could be established. This observation is of interest. If, as has hitherto been widely assumed, the lumbar lordosis 'flattens' out with spinal problems and subsequent age-related degenerative changes, it would be expected that the lordosis would reduce with age. In the present study, however, ages ranged from 18–73 years but we did not observe a relationship. As our sample size was small, we cannot, with confidence, address the controversy in which Tüzün et al. (1999) (150 subjects) claimed that lordosis increases with age, whereas Amonoo-Kuofi (1992) (485 subjects) suggested a tendency to decrease after the sixth decade.

The key question as to whether patients with lumbar spine problems do/do not acquire a reduced lumbar lordosis also remains somewhat controversial. Although the answer seems clear-cut in women, where the lordosis angles in those with and without low back pain were similar (Fig. 3a), we did find smaller angles of lordosis in men with low back pain, although the differences did not reach statistical significance. Perhaps women, who have a greater inherent lordosis, manage to retain a lordosis even when symptomatic. It may also be relevant that none of the controls exhibited an angle $<30°$, but three male patients and one female patient had a lordosis of $\leq 30°$ (Fig. 3). A larger series might show a statistically significant result in men. Reasonable conclusions from this study, however, are that even if there is a difference in men, the mean difference will be slight (8.5° in our study) or that loss of lordosis affects only certain individuals. Thus a 'reduced' lumbar lordosis is deemed to be a very weak clinical sign.

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