SPINAL ABNORMALITIES IN YOUNG FAST BOWLERS

P. HARDCASTLE, P. ANNEAR, D. H. FOSTER, T. M. CHAKEREA,
C. MCCORMICK, M. KHANGURE, A. BURNETT

From the University of Western Australia

The action of fast bowling in the game of cricket is known to cause injuries to the lumbar spine. We studied a group of 16- to 18-year-old fast bowlers, selected for special training in Western Australia. All 24 had MR scans of the spine, 22 had radiographs and CT scans; in 20 the bowling technique was analysed biomechanically.

There was a high incidence of back pain and this was always associated with a radiological abnormality. Pars interarticularis defects were diagnosed in 54% and intervertebral disc degeneration in 63%. Bowling actions which involved counter-rotation were associated with a higher incidence of both injuries.

The earliest record of a game similar to cricket dates from 1150 AD. It became popular in the 19th century and is now the national summer game in many countries of the old British Commonwealth. The action of fast bowling applies large forces to the spine, taking place as many as 300 to 500 times each week, and involving extension, lateral flexion and thoracolumbar rotation (Cotta and Niethard 1984). Low back pain is common and many young fast bowlers are lost to the game because of this (Evans, Jobe and Seibert 1989).

The reported incidence of isthmic spondylolysis in populations varies from 1.1% in black women (Hensinger 1983) to over 50% in Eskimos (Stewart 1953; Simper 1986); in European populations it is about 5% to 7% (Wynne-Davies and Scott 1979). Other congenital anomalies of the spine are found in about 5% to 10% of the normal population (Roche and Rowe 1952; Wynne-Davies and Scott 1979), but spina bifida occulta is found in 25% of patients with isthmic defects (Jackson, Wiltse and Cirincione 1976; Wynne-Davies and Scott 1979; Hensinger 1983). There is a higher incidence of spondylolysis and spondylolisthesis in sportsmen and women (Jackson et al 1976; Lowe et al 1987; Foster et al 1989; Annear et al 1992, in press).

The most accurate means of diagnosing acute spondyloletic fractures is 99Tc bone imaging (Papanicolaou et al 1985). Reverse-gantry CT scans (Fig. 1) can now show most of these fractures, and can also demonstrate stress reaction in the pars interarticularis.

We studied 24 young fast bowlers, by radiography, CT and MR scans looking for stress fractures and degenerative changes in relation to pain. Twenty of them also had a biomechanical study of their bowling action.

SUBJECTS AND METHODS

The 24 fast bowlers had been selected for special training in a Western Australian squad. All were Caucasian and aged 16 to 18 years (mean 17.9). All were examined and questioned about low back pain and its association with cricket. All 24 had MR scans, and 22 had plain radiographs and CT scans with reverse-gantry views of L3, L4 and L5 pars interarticularis (Fig. 1). Twenty had Sagittal plane CT scan to show the planes of the reverse-gantry 25° slices taken at L3, L4 and L5 levels.
video and high-speed film analyses of their bowling actions, the details of which have been presented elsewhere (Burnett 1990). A control group of 13 batsmen from the same age group had clinical assessment and MR scans.

**Imaging.** Radiographs and CT scans were assessed by three experienced radiologists (Fig. 2), for evidence of spondylolisthesis or pars interarticularis defects. No congenital anomalies were seen on any of the radiographs.

Sclerosis of the pars interarticularis was recorded when there was increased CT density of the pars interarticularis, the pedicle and, sometimes, the postero-lateral margin of the vertebral body in the absence of any fracture or widening of the pars (Fig. 3).

MRI scans were reported independently. We noted vertebral displacement and disc degeneration or desiccation, shown by loss of normal signal intensity on the T2-weighted image (Fig. 4a).

**RESULTS**

**Pars interarticularis defects.** Twelve of the 22 subjects had pars interarticularis defects. Six were bilateral at L5, and four of these showed spondylolisthesis. The other six were unilateral defects, two at L4 and four at L5; of these five were on the side opposite to the bowling arm and one was on the same side. All the unilateral defects were associated with sclerosis of the adjacent pedicle extending to the posterolateral corner of the vertebral body. Three bowlers had sclerosis of the pars interarticularis with no defect. In two of them the sclerosis extended anterolaterally to the pedicle and posterolateral corner of the body (Fig. 3). One unilateral defect was associated with elongation of the pars interarticularis on the other side, resulting in slight spondylolisthesis (see Fig. 2).

**Disc degeneration.** Fourteen of the 22 bowlers examined radiographically had disc degeneration (Table I), but none had evidence of disc protrusion likely to cause root compression. Of the two examined by MR but not by CT, one subject had disc degeneration and the other had a normal spine.

Five of seven subjects with a normal pars interarticularis also had disc degeneration at the same level as did eight of 15 with an abnormal pars interarticularis. One subject with unilateral spondylolisthesis had disc degeneration at the level below the isthmic defect. Two of the three bowlers with sclerosis of the pars interarticularis without a defect had associated disc degeneration. Three
of the six bowlers with unilateral spondyloysis had normal discs and three had abnormal discs at the level of the defect. The two subjects with bilateral pars interarticularis defects but no spondylolisthesis had no evidence of disc degeneration. Three of the four with spondylolisthesis had degeneration at the level of displacement.

Seven of the 13 batsmen had MR evidence of disc degeneration (Table I). None had spondylolisthesis, but spondylysis could not be excluded without radiography (Fig. 4a).

**Pain.** Only two of the bowlers had completely normal spinal images and neither had any pain. Of the 14 with evidence of degenerative disc disease, 11 had pain (eight of these also had pars interarticularis defects).

<table>
<thead>
<tr>
<th>Table 1. Incidence of imaging abnormalities in young cricketers</th>
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<tbody>
<tr>
<td><strong>Group</strong></td>
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<td>-----------</td>
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<tr>
<td>14 bowlers*</td>
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<td></td>
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<tr>
<td>22 bowlers</td>
</tr>
<tr>
<td>13 batsmen†</td>
</tr>
</tbody>
</table>

* 15 cases, † control series

Eleven of the 12 subjects with pars interarticularis defects had pain when bowling; five had to stop because of it. Three subjects, all without degeneration of their discs on MR scan, have subsequently had an operative repair of the defects with bone grafts and screw fixation.

Of the 12 subjects with pars interarticularis defects, only one did not experience pain on bowling. Analysis of his rather unusual bowling action showed that he had no counter-rotation movement.

Of the eight players with degenerative disease and no pars interarticularis defect or sclerosis, six complained of pain on bowling. Of the six with degenerative disease and defects, five had back pain on bowling.

**Bowling action.** Bowling actions were classified into three major techniques (Elliott, Foster and Blanksby 1989; Burnett 1990) as follows:

- **Side-on.** At the end of his run the bowler lands with his back foot parallel to the bowling crease; a line through his shoulders and hips points down the wicket, and he is looking over the outside of his front arm before his front foot makes impact with the ground.

- **Front-on.** Both feet point down the wicket; he is chest-on to the batsman. The non-bowling arm is almost vertical and he is looking inside this arm before delivery.

- **'Mixed'.** A combination of the above techniques is very common. It involves the rotation of the shoulders in relation to the pelvis during the action. The lower half of the bowler’s body is front-on, but his top half attempts to rotate to a side-on position. Despite his leg position the

Figure 4a – MR scan (T2-weighted sagittal image) showing an abnormal disc signal at L5-S1. Figure 4b – Reverse-gantry CT scan of the L5 pars interarticularis of the same subject. There is a hairline fracture through the sclerotic pars interarticularis on the right.
bowler looks at the batsman outside his front arm. This counter-rotation can be sub-classified according to the amount of rotation between the line of the shoulders and that of the back foot. It is either greater or less than 10°.

Of the 20 bowlers who had biomechanical analyses of their technique, four had side-on actions, and 16 used a 'mixed' action (Table II).

Table II. Bowling technique related to imaging results (see text)

<table>
<thead>
<tr>
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<th>Mixed</th>
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<tr>
<td></td>
<td>Side-on</td>
</tr>
<tr>
<td>Normal</td>
<td>n = 4</td>
</tr>
<tr>
<td>Spondylolisthesis</td>
<td>2</td>
</tr>
<tr>
<td>Degeneration</td>
<td>1</td>
</tr>
<tr>
<td>Pars interarticularis defect</td>
<td>1</td>
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</table>

Of the four who bowled side-on, two had normal spinal images and one had disc degeneration and a spondylolisthesis due to a unilateral pars defect on the side opposite to his bowling arm and elongation of the other pars interarticularis (Fig. 2c). The fourth side-on bowler developed bilateral defects at L5 and had to stop bowling because of pain.

Twelve of the 16 with a mixed technique had low back pain. All but one of those who rotated less than 10° had radiological abnormalities (Table II), two having both a spondylolisthesis and degeneration. Only one of the six bowlers in this group was free of low back pain. All ten who rotated more than 10° had abnormal imaging: one had spondylolisthesis, three had disc degeneration alone, three had disc degeneration and a defect, while three had pars interarticularis defects alone (Table II). Eight had low back pain, and the two with no pain had evidence of disc degeneration.

**DISCUSSION**

At cricket, fast bowling requires complex spinal movements which may take place several hundred times each week. A previous study of fast bowlers showed a 38% incidence of back injuries with stress fractures in 11% (Foster et al 1989) but this series comprised younger players, all of whom had symptoms.

We found a 54% incidence of pars interarticularis defects, and pars interarticularis sclerosis in another 13.5%. There was a 19% incidence of spondylolisthesis, a much higher figure than that in the normal Caucasian population (5% to 7%). Spondylolysis was seen in 35% but no figure for normal incidence is available. Jackson et al (1976) reported 5% spondylolysis in 100 female gymnasts, and another 6% had spondylolisthesis, but their study used plain radiography only. Porter and Park (1982) showed that unilateral spondylolysis may not be visible even on tomograms unless they are accurately aligned. Jackson et al (1976) found a high incidence of underlying congenital anomalies in gymnasts with spondylolysis; we found no congenital anomalies. We used CT scans only from L3 to S1 and may have missed some stress reactions or fractures above this level on the plain radiographs (Jackson, Kirwan and Sullivan 1978). Denis Lillee, one of Australia's best fast bowlers, had to cease fast bowling for nearly two years because of stress fractures at L2.

In five of the six subjects with unilateral defects of the pars interarticularis the defect was on the opposite side to the bowling arm. This appears to exclude repetitive extension as the cause since this movement is greatest on the side of the bowling arm. Repetitive rotation is more likely to be the reason, as is suggested also by the sclerosis of the pedicle and posterolateral vertebral body (Fig. 4b). Pedicle sclerosis was first described by Sherman, Wilkinson and Hall (1977) and CT has shown that it may extend into the vertebral body. Repetitive extension may, however, be implicated as the cause of the high incidence of spondylolisthesis.

Porter and Park (1982) in a post-mortem study showed that unilateral defects were associated with vertebral body wedging and deviation of the spinous process. We found no evidence of this; all the spinous processes remained in the midline.

The absence of congenital anomalies in our subjects, linked with a similar finding in retired fast bowlers (Annear et al 1992, in press), may mean that adolescents with such anomalies soon develop symptoms and do not continue in the sport. Scheuermann's disease has been associated with a high incidence of spondylolysis because of the compensatory increase in lumbar lordosis (Cotta and Niethard 1984; Ogilvie and Sherman 1987). We found no evidence of this disease.

None of the 13 young batsmen in our control group had signs of spondylolisthesis on MR scans, but we cannot comment on the incidence of spondylolysis. Our results suggest, however, that there is a significant difference between the batsmen and the bowlers.

As regards degenerative disc disease demonstrated on MR1, Evans et al (1989) found degenerative disease in 12 of 35 asymptomatic men with a mean age of 29 years, all at L3-L4, L4-L5 or L5-S1. Boden et al (1990) found a 35% incidence of degenerative disc disease at 20 to 39 years of age. Walsh et al (1990) did low lumbar discograms on ten asymptomatic volunteers aged between 18 and 32 years, and found that only five of 30 discs were morphologically abnormal. We found a much higher incidence of degenerative disease (bowlers 63%, batsmen 53%), evenly distributed throughout the lumbar spine, but more common at the lower levels.

The reason for these differences is not clear especially since the incidence of degenerative disease was not significantly higher in the bowlers than the batsmen. Both groups, however, were very active young sportsmen, and batsmen do sometimes bowl. There was also a
difference between the incidence in fast bowlers with a side-on action and in those with a mixed action, but the groups were too small for statistical analysis.

Disc degeneration and an isthmic defect were associated only when there was spondylolisthesis. This suggests that the causes of disc degeneration and spondylolysis are different, but once there is forward slip of the vertebra, secondary disc degeneration is no doubt inevitable.

Our recent radiological study of 21 former Western Australian fast bowlers showed striking similarities with their young successors. The incidence of pain was similar, four had spondylolisthesis or spondylolysis and five had pars interarticularis sclerosis. Degenerative changes were seen in a similar proportion but were more evenly distributed throughout the lumbar spine in the retired bowlers.

In our series, pain was always associated with an underlying radiological abnormality. Only fast bowlers who had pars interarticularis defects had to cease bowling. We found a significantly higher incidence of degenerative disease in bowlers with a mixed action. Foster et al (1989) also showed a higher incidence of back pain and stress fractures in fast bowlers who rotated more than 10°.

Conclusions.
1) Young fast bowlers have a high incidence of disc degeneration and pars interarticularis defects.
2) Pain was always associated with a radiological abnormality.
3) Abnormal rotation and/or hyperextension before delivery of the ball appears to cause a significantly higher incidence of both conditions. Rotation seems to be the main cause of unilateral defects.

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