Injuries to the lower back in elite fast bowlers

ACUTE STRESS CHANGES ON MRI PREDICT STRESS FRACTURE

C. A. Ranson, A. F. Burnett, R. W. Kerslake

From Queen’s Medical Centre, Nottingham, United Kingdom

In our study, the aims were to describe the changes in the appearance of the lumbar spine on MRI in elite fast bowlers during a follow-up period of one year, and to determine whether these could be used to predict the presence of a stress fracture of the posterior elements. We recruited 28 elite fast bowlers with a mean age of 19 years (16 to 24) who were training and playing competitively at the start of the study. They underwent baseline MRI (season 1) and further scanning (season 2) after one year to assess the appearance of the lumbar intervertebral discs and posterior bony elements. The incidence of low back pain and the amount of playing and training time lost were also recorded.

In total, 15 of the 28 participants (53.6%) showed signs of acute bone stress on either the season 1 or season 2 MR scans and there was a strong correlation between these findings and the later development of a stress fracture (p < 0.001). The prevalence of intervertebral disc degeneration was relatively low. There was no relationship between disc degeneration on the season 1 MR scans and subsequent stress fracture. Regular lumbar MR scans of asymptomatic elite fast bowlers may be of value in detecting early changes of bone stress and may allow prompt intervention aimed at preventing a stress fracture and avoiding prolonged absence from cricket.

Injuries to the lower back account for most of the loss of playing time in professional cricket.1-3 The most common cause in fast bowlers is a lumbar stress fracture which often occurs in the posterior bony elements (pedicles and pars interarticularis) of the lower lumbar vertebrae on the opposite side to the bowling arm.4,6

Other radiological abnormalities such as chronic bone stress6,7 and premature disc degeneration6,9 also occur commonly. However, these result in less lost playing time than stress fractures.2,10 Furthermore, the relationship between these findings, low back pain and injury is unclear both in the general population11-14 and in fast bowlers.8

The clinical presentation of a stress fracture of the lumbar spine in fast bowlers is characterised by the gradual onset of localised low back pain on the opposite side to the bowling arm.5,15 Symptoms can be reproduced by manoeuvres involving lumbar extension, for example the Stork Test which combines extension of the lumbar spine with side flexion and rotation while standing on the leg of the symptomatic side.16

MRI is currently considered to be the investigation of choice.17 As well as identifying the changes of acute bone stress such as bone marrow oedema, periostitis and a fracture line,18-21 it also provides high-resolution images of the intervertebral discs, neural tissues, lumbar facet joints and paraspinal muscles22 and can detect stress fractures early.23,24

Therefore, our aim in this study was firstly to describe changes in the MRI appearance of the lumbar spine of elite fast bowlers between their season 1 and season 2 scans. We hoped to determine whether MRI could be used to predict the occurrence of stress fractures of the lumbar spine in this group. Secondly, we investigated the relationship between the MRI appearances and the incidence of low back injury (particularly acute stress fracture), low back pain and missed playing time over a period of two years.

Patients and Methods

We included 28 members of the England and Wales Cricket Board Elite Fast Bowling Group. At the time of baseline (season 1) testing their mean age was 19 years (16 to 24), their mean height was 186 cm (175 to 198) and their mean weight was 80 kg (69 to 95). Each had been identified by the National Lead Fast Bowling Coach as having a good
chance of playing international cricket within the next five years, or of being a member of the England U19 or senior men’s team at the time of season 1 testing. At baseline testing during season 1, participants were bowling for three days each week in matches or training sessions and all were considered to be fit to bowl by either their County or England team physiotherapist. Ethical approval for the study had been provided by the Local Regional Ethics Committee.

Season 1 testing was carried out at the end of the summer cricket season in the United Kingdom in 2005, 2006 or 2007. There were therefore effectively three groups of fast bowlers in the study. Each bowler had a further MR scan one year later.

Each player was scanned using a GE Medical Systems 1.5 Tesla MRI scanner (GE Healthcare, Little Chalfont, United Kingdom). Sagittal and axial T1-weighted and sagittal short T1 inversion recovery (STIR) sequences were obtained. The sagittal sections included all the posterior elements between the lateral borders of the pedicles, laminae and partes inter-articulares and were 3 mm in thickness. Sequence parameters were TR 500, TE 13 ms for the T1-weighted images and TR 8000, TE 50 ms, and T1 130 ms for the STIR images. The axial T1-weighted sections were obtained in a block covering the superior vertebral end-plate of L4 to the inferior vertebral end-plate of S1.

The MR scans at seasons 1 and 2 were assessed by the same radiologist (RWK) using the grading systems shown in Table I and Table II which classified the appearance of the posterior bony elements and intervertebral discs, respectively, and have been found to be reliable. Full details of these procedures have been reported elsewhere.

In the interval between season 1 testing and a point six months after season 2 MRI, they were contacted by telephone every six weeks and a structured questionnaire was used to obtain information about the presence of any low back pain or back injury, the severity of the pain using a modified visual analogue scale in which zero represented ‘no pain’ and a score of 10 ‘very severe pain’ and, if necessary, the amount of time lost from cricket. They were asked if they had suffered any back pain or back injuries during the previous six weeks. Those who reported having low back pain or injury were asked if it caused them to be unavailable to train or play fully at any time. If so, the number of days was recorded. In addition, the highest level of pain experienced on the day in which they were first unavailable to train or play was recorded. They were considered to have an injury to the lower back if they missed seven or more consecutive days of cricket, whether playing or training, because of low back pain.

Permission was obtained to contact the players’ relevant County or England Team medical staff for information on the clinical nature of any reported lower back injury. Lumbar stress fracture was recorded only if the typical history was corroborated by MRI and/or subsequent CT which confirmed acute bone stress changes associated with partial or complete fracture of the posterior elements of the lumbar spine. Lower back injuries which were not thought to be associated with stress of the acute posterior bony elements were ascribed a clinical diagnosis by the relevant County or England cricket medical staff.

Statistical analysis. Descriptive statistics were used to describe the prevalence of any MRI abnormalities apparent in the lumbar posterior bony elements and intervertebral discs as well as pain scores and the duration of lost cricket because of injury to the lower back. Fisher’s exact test was used to examine the relationship between acute bone stress abnormalities identified on MRI, intervertebral disc degeneration and lumbar stress fracture. All statistical tests were carried out using SPSS version 15 software (SPSS Inc., Chicago, Illinois). A p-value of 0.05 was considered statistically significant.

Results

Of the 28 bowlers, 12 (42.9%) had a stress fracture of the lumbar spine during the two-year follow-up period. In
three of these there was a recurrence within 12 months, giving a total of 15 stress fractures during the study.

In ten of the 12 injured players (83.3%) the stress fracture was on the opposite side to the bowling arm. The other two had bilateral fractures. In five players (41.7%) the fracture was at L4, all on the non-dominant side. In five (41.7%) it was at L5, with four on the non-dominant side and one bilateral, and in the remaining two (16.7%) at L3, with one on the non-dominant side and the other bilateral. Six other injuries to the lower back occurred during the study period. The clinical diagnoses ascribed to these were sprain of the lumbar facet joint (three) and intervertebral disc derangement (three). Two of these occurred in the same individual and one in a bowler who had also suffered a stress fracture. The mean amount of time lost per stress fracture was 169 days (90 to 270), while the mean time lost due to other injury to the lower back was 37 days (10 to 56).

The mean maximum level of pain recorded on the first day that the bowler was unavailable to play or train because of stress fracture was 7.66 (7 to 10). This decreased to a mean of 0.73 (0 to 4) after six weeks. For those with back pain, but no stress fracture, the mean level of pain on the first day was 7.5 (7.0 to 8.0) which decreased to a mean of 2.5 (0.0 to 6.0) after six weeks.

There were 15 players (53.6%) who had MR scans which included the presence of acute bone stress on either their season 1 or season 2 scan. Of these, 11 had a partial or complete stress fracture within a mean of ten weeks (1 to 30) from the scans. This relationship was highly significant (Fisher’s exact test, p < 0.001, Table III).

No fracture line was seen on MRI in nine of the 15 bowlers with changes of acute bone stress. Five of these (55.6%) subsequently developed a stress fracture between one and 28 weeks (mean 11 weeks). All six bowlers with either a partial or complete acute stress fracture on initial scanning became symptomatic within the following four weeks. The four players with MRI appearances of acute bone stress who did not develop a symptomatic lesion bowled until the end of the season (two to four weeks) and then did not bowl for six to 12 weeks.

Only one individual who did not have signs of acute bone stress on his season 1 scan developed a stress fracture within 12 months. He had chronic stress changes on his season 1 scan, but developed an acute partial stress fracture at L4 on the non-dominant side nine months later. He had follow-up MR scans two months later. These showed that bone oedema was still present but without a visible fracture.

Seven bowlers had bilateral fractures at L5 on season 1 scans. In five of these, the fractures were considered to be chronic (no acute bone stress apparent) on both season 1 and season 2 scans. Two of the seven had the appearances of acute bone stress, in one bilaterally, which healed completely by the time of the season 2 scan and in the other only on the dominant side which persisted for both seasons.

One other bowler had bilateral acute fractures at L3 which had not healed on season 2 scans. He missed four months of play because of injury early in the second season.

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**Table II. MRI classification of lumbar intervertebral disc degeneration**

<table>
<thead>
<tr>
<th>Degree of degeneration</th>
<th>Structure</th>
<th>Distinction of nucleus and annulus</th>
<th>Signal intensity (STIR)</th>
<th>Height intervertebral disc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>I</td>
<td>Homogenous, bright white</td>
<td>Clear</td>
<td>Hyperintense, isointense to CSF</td>
</tr>
<tr>
<td></td>
<td>Ia</td>
<td>Homogenous, bright white</td>
<td>Clear</td>
<td>Hyperintense, isointense to CSF</td>
</tr>
<tr>
<td>Mild</td>
<td>II</td>
<td>Inhomogenous, with or without horizontal bands</td>
<td>Clear</td>
<td>Hyperintense, isointense to CSF</td>
</tr>
<tr>
<td>Moderate</td>
<td>III</td>
<td>Inhomogenous, grey</td>
<td>Unclear</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Severe</td>
<td>IV</td>
<td>Inhomogenous, grey to black</td>
<td>Lost</td>
<td>Intermediate to hypointense</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Inhomogenous, black</td>
<td>Lost</td>
<td>Hypointense</td>
</tr>
</tbody>
</table>

* CSF, cerebrospinal fluid

**Table III. Details of the relationship between acute MRI bone stress and subsequent stress fracture in the 28 bowlers**

<table>
<thead>
<tr>
<th>Subsequent stress fracture injury</th>
<th>No stress fracture injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute stress changes on MRI*</td>
<td>11</td>
</tr>
<tr>
<td>No acute stress changes on MRI</td>
<td>4</td>
</tr>
</tbody>
</table>

* Fisher’s exact test, p < 0.001 (one-tailed)
and these fractures can become chronic. However, once a fracture has fully healed. Full union does not always occur and the player unable to bowl. However, the level of pain was particularly high for the 12 bowlers (42.9%) who developed a symptomatic acute lumbar stress fracture. They missed a mean of 169 days (90 to 270) per episode. These injuries, as previously described, predominantly occurred in the lower lumbar spine on the opposite side to the bowling arm. They were usually painful enough to render the player unable to bowl. However, the level of pain often decreased rapidly once bowling had ceased. This may be one reason why some players with undiagnosed stress fractures have prolonged periods lost from bowling. They return to bowling once the pain has eased, but before the fracture has fully healed. Full union does not always occur and these fractures can become chronic. However, once the acute phase of the injury has passed, bowlers can often return to play with persistent chronic partial or complete fractures of a posterior lumbar bony element.

Our principal finding was that acute stress changes such as oedema and periostitis in the posterior bony elements are related to the subsequent development of a stress fracture. This confirmed the suspicions of previous investigators. This association may be of value in the screening of fast bowlers as well as participants in other sports in which lumbar stress fractures occur commonly. For example, coaching and medical staff could advise a bowler to reduce, or even stop, bowling if an acute stress change was identified on routine MRI. This might help to prevent the development of a stress fracture and thus avoid long periods away from the game. Furthermore, the recurrence of stress fractures in three of the participants in our study was of concern, and suggested that coaches need to be careful in managing the conditioning and workload of bowlers who have had a previous lumbar stress fracture.

Regular MRI screening of the lumbar spine of sub-elite athletes is not logistically or financially viable. However, the results of our study suggest that MRI is the investigation of choice for fast bowlers with lower back pain.

In our study, lumbar disc degeneration was not as prevalent, widespread or as severe as that previously reported in senior elite fast bowlers, nor were the MRI appearances of disc degeneration associated with low back pain. Consequently, identifying disc degeneration on MRI is probably of limited value in the day-to-day medical management of bowlers.

Previous authors have suggested that there is a relationship between disc degeneration, the subsequent loss of disc height and an increased risk of bone stress, but this is not supported by our findings.

While the small number of bowlers in our study may initially be perceived as a limitation, it should be appreciated that recruiting a large and relatively homogenous sample of high-level fast bowlers is difficult. Increasing the sample size would require either multicentre (international) collaboration or the recruitment of more groups of bowlers in successive years. However, even with the small sample size, our principal finding reached a high level of statistical significance.

Discussion

Fast bowlers are known to be at high risk of injury to their lower back. In our study, this occurred in 16 (57.1%) of all fast bowlers. The amount of playing and training time lost was particularly high for the 12 bowlers (42.9%) who developed a symptomatic acute lumbar stress fracture.

They missed a mean of 169 days (90 to 270) per episode. These injuries, as previously described, predominantly occurred in the lower lumbar spine on the opposite side to the bowling arm. They were usually painful enough to render the player unable to bowl. However, the level of pain often decreased rapidly once bowling had ceased. This may be one reason why some players with undiagnosed stress fractures have prolonged periods lost from bowling. They return to bowling once the pain has eased, but before the fracture has fully healed. Full union does not always occur and these fractures can become chronic. However, once the acute phase of the injury has passed, bowlers can often return to play with persistent chronic partial or complete fractures of a posterior lumbar bony element.

| Table IV. Details of the MRI appearance of the intervertebral disc in regard to disc degeneration at season 1 and season 2 testing in the 28 bowlers |
|----------------|----------------|
| Disc appearance | Season 1 | Season 2 |
| Normal          | 18       | 18       |
| Disc degeneration | 10       | 10       |

| Table V. Details of the relationship between the MRI appearance of the intervertebral disc and concurrent acute lumbar bone stress changes in the 28 bowlers |
|----------------|----------------|
| Disc appearance | Acute stress on MRI | No acute stress on MRI |
| Normal          | 10       | 8         |
| Disc degeneration | 5       | 5         |

* Fisher’s exact test, p = 0.544 (one-tailed)

| Table VI. Details of the relationship between the MRI imaging appearance of the intervertebral disc and subsequent stress fracture in the 28 bowlers |
|----------------|----------------|
| Disc appearance | Symptomatic stress injury | No symptomatic stress injury |
| Normal          | 9       | 9         |
| Disc degeneration | 2       | 8         |

* Fisher’s exact test, p = 0.124 (one-tailed)

but the fractures and acute bone stress changes persisted on follow-up MRI although he had returned to bowling.

The prevalence of lumbar disc degeneration on MRI is shown in Table IV. There was no association between the appearance of the intervertebral disc and either MRI changes of bone stress (Fisher’s exact test, p = 0.544, Table V) or a subsequent stress fracture (Fisher’s exact test, p = 0.124, Table VI).

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References