During a four-month period we observed 12 stress fractures of the inferior pubic ramus in 11 military recruits undergoing basic training. Eleven of these were in women. This high number was considered to be caused by the introduction of mixed training of male and female recruits; this forces women to increase their stride length when marching.

The presenting symptom was chronic groin pain which failed to settle with rest, and the clinical diagnoses were confirmed by radiographs in all but one patient who was diagnosed by 99mTc bone scanning. Since the required stride length has been reduced there have been no new cases of stress fracture of the pelvis.

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Stress fracture of the pubic ramus was first described in three male military recruits by Wachsmuth in 1937 (Meurman 1980). Stress injuries in normal bone due to repeated cyclic loading are a well-recognised complication of military training. Breithaupt, a Prussian military surgeon, first described the symptoms of stress fractures in military recruits in 1855, and in 1897 Stechow identified these injuries radiologically (Stoneham and Morgan 1991).

There are many studies of the incidence, aetiology and treatment of stress fractures (Lancet 1986). The incidence in military recruits has been reported to range from 12% in female Caucasian American recruits to less than 2% in male recruits (Brudvig et al 1983). Factors known to increase the incidence include female gender (Prozman and Griffis 1977; Hulkko and Orava 1987), youth (Milgrom et al 1994), Caucasian race (Brudvig et al 1983), lack of pre-entry physical conditioning (Gilbert and Johnson 1966) and mixed training of men and women (Oxburn and Nichols 1981; Jones et al 1993). The anatomical distribution in a training population of 20 422 over a 12-month period was reported by Brudvig et al (1983). An overall incidence of 3.41% in women included 25% in the calcaneum, 23% in the tibial plateau, 18% in the metatarsals and 10% in the pelvis.

We report 12 stress fractures of the pelvis in military recruits undergoing basic training.

PATIENTS AND METHODS

From September to December 1994 a total of 11 military recruits were treated at the Cambridge Military Hospital, Aldershot for stress fractures of the inferior pubic ramus. All were Caucasians undergoing basic training. None had previously been a competitive athlete; their average age, weight and height are summarised in Table I. There was a training population of 891 men and 158 women during this period.

The training consisted of a ten-week programme designed to teach basic military skills such as weapon handling, discipline, field craft and drill. It also aimed to improve physical stamina by gym work, sport, marching and running with and without backpacks. Fitness was assessed by the completion of distance runs in certain times as laid down in Army Training Directives. There were two five-week periods of training interrupted by a long weekend. The intensity of the training increased progressively until the recruits sat their examinations and took their physical tests during the ninth week.

All the recruits had complied with the medical requirements for Army entrance and were within the normal range for height and weight. All the women had a normal menstrual history.

Stress fracture of the pubic ramus was diagnosed from tenderness over the inferior pubic ramus and the insertion of the adductor muscles, and a decreased range of painful abduction. There was also pain on resisted adduction and external rotation of the hip and an antalgic gait. Standard
anteroposterior radiographs of the pelvis were taken and in one patient we performed a $^{99m}$Tc bone scan to confirm the diagnosis when the initial radiographs were inconclusive.

RESULTS

There were 12 stress fractures of the inferior pubic ramus in the 11 recruits; these were left-sided in six, right-sided in four and bilateral in one (Table I and Fig. 1). Ten of the 11 patients were women, involving 6.3% of female recruits. The mean onset of symptoms was in the fifth week of training, with the diagnosis established in the eighth week. The activities at the onset of symptoms are listed in Table II.

All the fractures were in the inferior pubic ramus, near to the pubic symphysis (Fig. 2a). Radiographs usually showed some callus formation around the fracture site, indicating healing (Fig. 2b), but one patient had an apparently normal radiograph and the diagnosis was confirmed by $^{99m}$Tc bone scanning (Fig. 3). Management included rest, physiotherapy and non-steroidal anti-inflammatory drugs. All patients had full resolution of all symptoms.

Table I. Details of 11 patients, one of them male*, who had stress fractures of the inferior pubic ramus

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>Side</th>
<th>Week of onset of symptoms</th>
<th>Week of diagnosis</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>1.79</td>
<td>71</td>
<td>Bilateral</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>1.66</td>
<td>60</td>
<td>Right</td>
<td>6</td>
<td>10</td>
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<tr>
<td>3</td>
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<td>1.58</td>
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<td>Left</td>
<td>5</td>
<td>7</td>
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<tr>
<td>4</td>
<td>20</td>
<td>1.58</td>
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<td>Left</td>
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<td>7</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>1.69</td>
<td>71</td>
<td>Right</td>
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<td>9</td>
</tr>
<tr>
<td>6</td>
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<td>1.74</td>
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<td>7</td>
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<td>Left</td>
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<td>70</td>
<td>Right</td>
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<td>6</td>
</tr>
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<td>63.7</td>
<td></td>
<td>4.8</td>
<td>8</td>
</tr>
</tbody>
</table>

Fig. 1
Bilateral stress fractures of the inferior pubic rami.

Fig. 2a
Stress fracture of the right inferior pubic ramus (a) showing callus formation six weeks after presentation (b).

Fig. 2b
DISCUSSION

The cluster of pelvic stress fractures almost exclusively in women in four months led to an investigation of causes and of the delay between the onset of symptoms and diagnosis.

The joint training of male and female recruits was introduced in the Army in April 1993, and one of the main complaints of our female patients was that they had difficulty in keeping up with male recruits when marching together in squads. The standard stride length in the Army is 30 inches (76.2 cm). Oxburn and Nichols (1981) also found an increase in the number of stress fractures of female pelvic rami during integrated training in the USA. They considered that the relatively short females in mixed squads were obliged to overstretch and recommended that soldiers should be allowed to march with a stride length consistent with their height and body build. Jones et al (1993) also considered that body stature was a factor in injuries related to exercise and running; they recommended that short women should march at the front of columns to reduce the overstriding needed to keep pace with their colleagues. After the series of pubic stress fractures had been noted, in January 1995 the stride length for the Army Training Regi-

ment was reduced to 27 inches (68.6 cm) for all marching other than that on the drill square. Since then no further cases have been reported.

The increase in loading around the inferior pubic ramus by an unnatural gait due to overstriding may be the mechanism of stress fracture in women (Pavlov et al 1982). The adductor and external rotator muscles are attached to the pubic arch in two groups on either side of the ischiopubic line. In women the bones of the pelvis are more slender, the pubic symphysis is shallower, the margins of the ischiopubic rami are less everted and the obturator foramen is more triangular than oval (McMinn 1990).

The delay between the first symptoms and the diagnosis has been noted previously (Oxburn and Nichols 1981; Pavlov et al 1982; Jones et al 1993). Scully and Besterman (1982) describe how bone damaged by stress is weakened during remodelling. By the third week of training stress-induced damage is sufficient to make the bone susceptible to fracture. Training should therefore provide cyclical exposure to stress, with rest days, rather than a progressive and continuous increase. Pester and Smith (1992) showed a reduction of 7.32% in the rate of stress fractures in female recruits in one year, produced by training modifications so that sessions of high-impact activities were limited, spaced at reasonable intervals, and omitted during the third week.

At first our recruits had simple groin strains. The diagnosis of stress fracture was made only when the symptoms failed to settle and radiographs showed some changes. Another factor in the delay was the pressure to continue training: recruits who missed more than five days because of injury were denied the long weekend leave or made to repeat the whole course. A relatively minor change in training appears to have solved the problem.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Reference


