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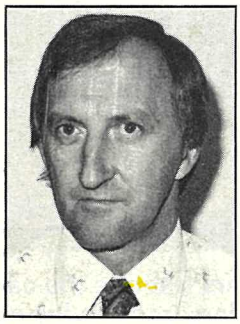
Stress fractures of the lower limbs in runners

K D Fitch

Stress fractures are a common sports injury and running can cause fractures in most bones from the metatarsals to the pubic rami. Pain after an increase in or modification to a running programme is the initial symptom; there will be point tenderness over bone. Rest from running for six to 10 weeks is necessary but alternative exercise must be prescribed for those 'addicted' to running.

The first description (in 1855) of a stress fracture is accredited to Breihaupt, a Prussian army doctor, who reported painful swollen feet in soldiers after long marches.[1] Stechow described metatarsal fractures in soldiers in 1897[2] and the term 'march fractures' has endured. Four decades elapsed before stress fractures were noted in athletes (again in the German literature).[3] Devas, a London orthopaedic surgeon, has been the most prolific author on the subject and his excellent monograph is recommended.[4]



Prepared by request

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The exponential increase in the number of joggers, 'fun' and marathon runners over the past decade has been associated with an 'epidemic' of stress fractures in the bones of the lower limbs. Stress fractures are not confined to runners or the legs and occur in the lumbar pars interarticularis of gymnasts[5] and fast bowlers; the ribs of weight lifters;[4] the humerus of throwers and arm wrestlers;[6] and the hook of the hamate in golfers and tennis players.[7]

Recreational athletes attend their family physician with symptoms of stress fractures but they frequently remain undiagnosed.

Causes

Causes of stress fractures in runners are listed in *Table 1*.

In many instances there is a combination of factors but the most common is a sudden increase in the training distance. Long distance runs are essential in the preparation for a marathon (42 km) and the more experienced the runner the more likely is a training error the cause of the fracture.

Pathophysiology

The underlying factor in the accelerated remodelling of bone (the consequence of stress overload)[4, 8] is muscular forces acting on bone. Osteoclastic activity commences the remodelling process and results in resorption, rarefaction and, if the stress is continued, microfractures. With rest or reduced activity osteoblasts lay down a new and stronger bone matrix better able to withstand stress; continued running will convert a microfracture to a macrofracture. Healing involves endosteal and periosteal callus formation to buttress the cortex and focal sclerosis and these are its radiological features.[4]

Clinical features

The onset of a stress fracture can be sudden or insidious; dramatic development while running is uncommon and often preceded by minor symptoms. Usually the fracture begins gradually and is associated with a history of a sudden increase in the amount, frequency or intensity of training. The first symptom is pain after a run which is relieved rapidly by rest. Perseverance with running will increase the severity of pain and its resolution will require a longer period of rest. The second stage is pain as the run begins, often ceasing after a short distance but returning before the run is finished; night pain now might prevent sleep. Finally the pain becomes constant and prevents running.

Examination reveals point tenderness over bone at a typical stress fracture site. There might be slight swelling but a full and pain free range

Table 1
Causative factors in runners' stress fractures

Training errors	Sudden increase in the amount, frequency or intensity of training
Biomechanical factors	Pronated or cavus feet; fore or rear foot varus; tibial varum; discrepancy in leg length
Surfaces and terrain	Change of running surface (eg grass to road); running down or across the face of hills
Running mechanics	Gait is faulty or becomes so when fatigued
Footwear	Shoes damaged or inappropriate for the feet or running surface
Temporary cessation of training	Training resumed after inactivity, especially if previous levels attempted immediately

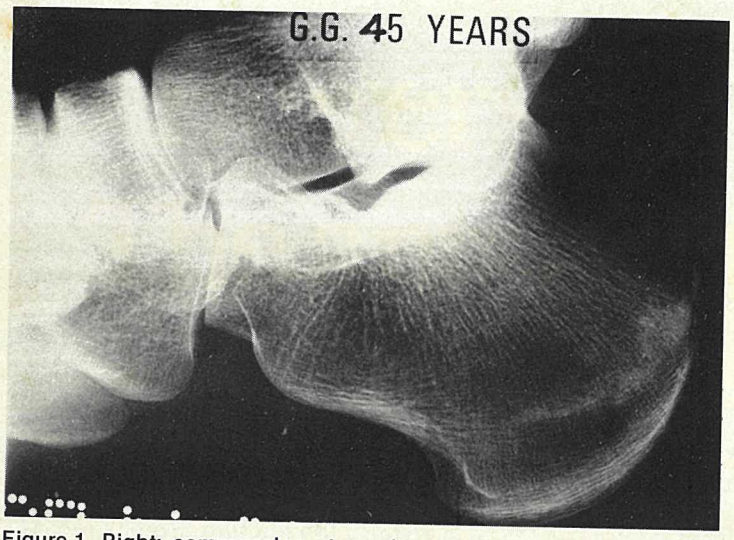

Figure 1. Right: compression stress fracture in calcaneus of 45-year-old male after three weeks of recreational jogging on footpath.

Figure 3. Bilateral stress fractures of the shafts of the second metatarsal in a 16-year-old boy.

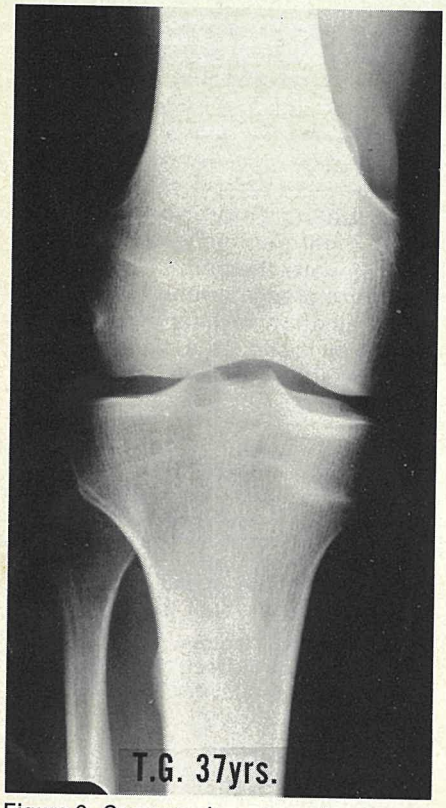

Figure 2. Compression stress fracture of the medial tibial plateau in a 37-year-old jogger.

of passive movements of the proximal and distal joints is customary (except with fractures close to the hip joint). In the majority, resisted contraction of the muscles spanning the injured region of bone is painless.

Type and site

Devas classified stress fractures radiologically as: distraction (oblique, longitudinal, transverse); and compression.[4]

The tibia is a classical site of oblique distraction fractures. Distinction between fracture lines and nutrient arteries can be difficult but fracture lines tend to be 'down and out', that is extend distally from the inner rim to the outer cortex.[4] A transverse fracture has the potential to extend into a complete fracture which can cause displacement (for example neck of femur).

Compression fractures in which no fracture line is visible are typified in the calcaneus (*Figure 1*) and the medial tibial plateau (*Figure 2*). The clinical features are diagnostic; X-ray after four or five weeks will show an area of sclerosis.

Bilateral fractures are not uncommon in the tibiae, fibulae, metatarsals, femora and calcanei (*Figure 3*). Multiple fractures in the same bone (especially the tibia) are encountered occasionally and confirm that the healed region of a fully united fracture is able to withstand stress better than the rest of the bone.

Sites of stress fractures are predictable, as exemplified in the metatarsals where fractures of the shafts and neck region of the second and third are most common (*Figure 3*). The first and fifth metatarsals are overloaded less often than the fourth. In the tarsus, the calcaneus and navicular are the bones affected. Joggers fracture the calcaneus; sprinters, hurdlers and high jumpers fracture the navicular. Navicular fractures are difficult to diagnose radiologically and often result in non union and the need

Stress fractures of the fibula occur five to eight centimetres proximal to the tip of the malleolus (*Figure 4*). Fractures are seen at most levels of the tibia but usually the upper third in adolescents (*Figure 5*) and the middle and lower thirds and medial plateau in adults (*Figure 2*).

- **Joggers fracture the calcaneus; sprinters fracture the navicular.**

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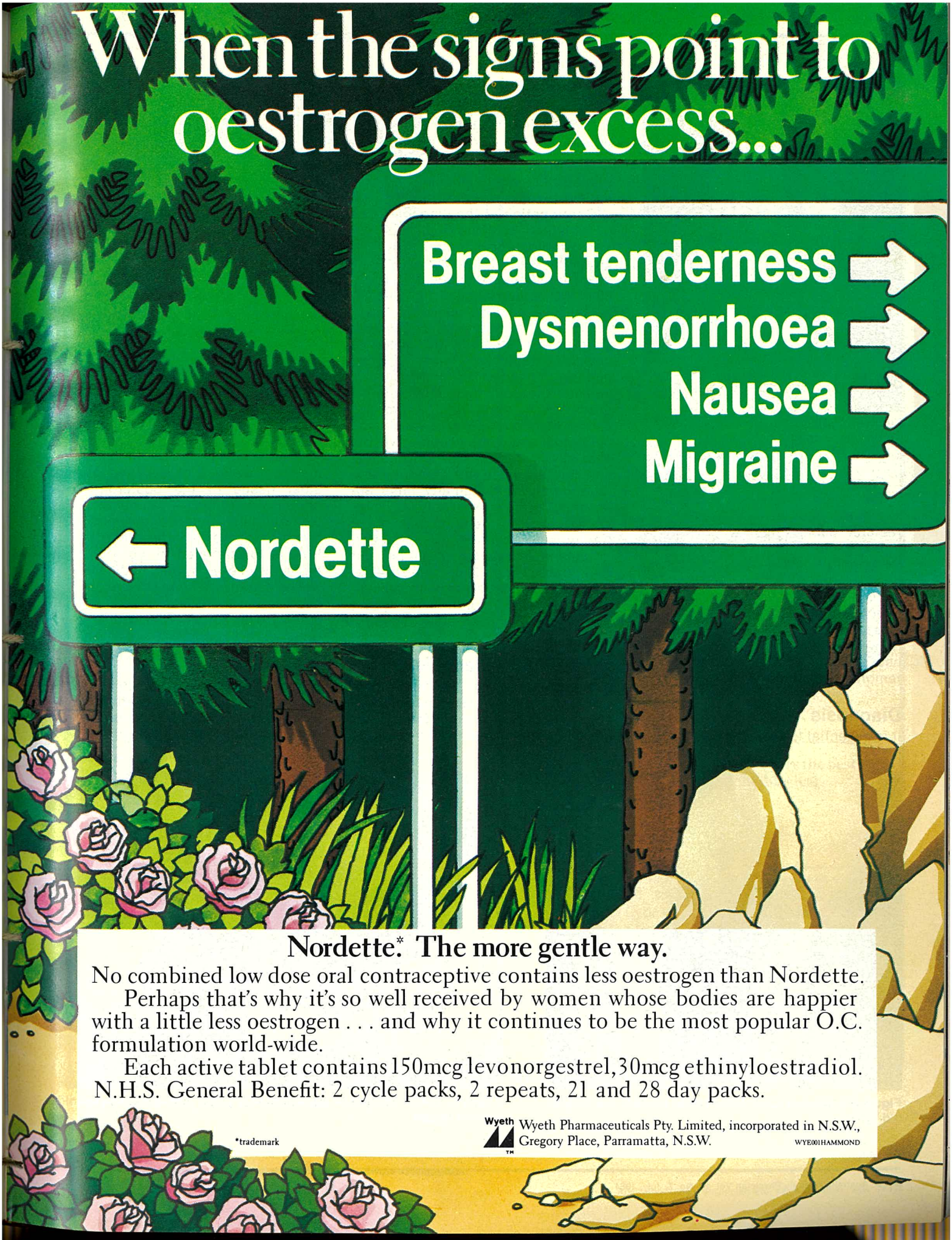

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Figure 4. Typical site and appearance of a fibula stress fracture.

Femoral stress fracture can develop in the region of insertion of adductor magnus, longus and brevis and in the femoral neck. Failure to diagnose stress fracture of the neck of femur (or the patient's persistence with running despite contrary advice) can result in a complete fracture with displacement which requires internal fixation.[9] Stress fracture of the inferior pubic ramus[10] (*Figure 6*), which is slow to heal, is a differential diagnosis of a femoral neck fracture.

Diagnosis

It is essential to consider stress fracture as a diagnostic possibility in any patient presenting with bone pain.

- **Stress fracture should be considered in the differential diagnosis of bone pain.**

Confirmation of the diagnosis can be obtained by bone scan, conventional radiography, tomography and computerised axial tomography (CAT scan). A radionuclide bone scan using 99 m technetium labelled diphosphonate will be positive almost immediately;[11] it is valuable when the clinical diagnosis is in doubt (for example navicular fractures; *Figure 7*) or evidence is needed to convince the patient to cease running. Conventional radiography rarely will be positive sooner than four weeks, by which time periosteal new bone becomes visible over stress fractures of long bones. The fracture lines are demonstrable infrequently; good quality films are essential, often several oblique views. Tomography is helpful with some fractures (for example the pars interarticularis and tarsal navicular) but CAT scans (*Figure 8*) provide superior diagnostic information with less irradiation; they are particularly useful in the assessment of slow healing.

Differential diagnosis

A history of stress overload, pain which is typical in site and relationship to activity and point tenderness are characteristic of stress fracture.

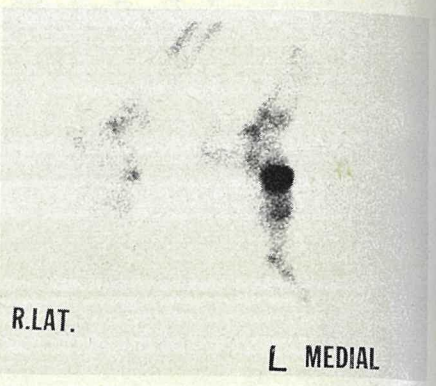

Figure 7. Bone scan of an early tarsal navicular stress fracture.

Differential diagnoses include osteogenic sarcoma, osteid osteoma, osteomyelitis, osteomalacia and 'shin splints'.

'Shin splints' — a condition resulting from overuse of the tendoperiosteal tissue of the posteromedial border of the tibia — can be difficult to distinguish. Associated pain and tenderness over a large area of the tibia is exacerbated by activity and promptly relieved by rest. Radiography will be negative; a bone scan might be positive but there is increased radioactivity over 30 to 50 per cent of the tibial shaft linearly.

The two major reasons for failure to diagnose a stress fracture are neglect of it as a diagnostic possibility and acceptance of negative radiography which has been taken prematurely or examines the region inadequately.

Figure 5. Classical upper tibial stress fracture in a 13-year-old athlete.

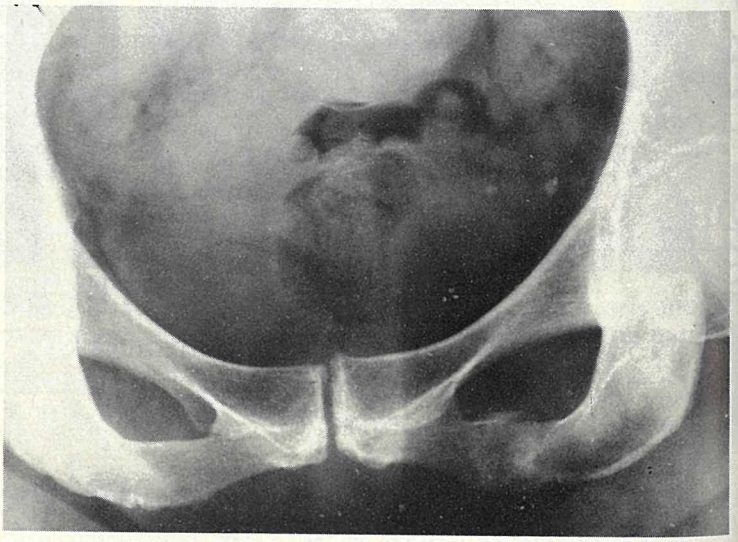

Figure 6. Stress fracture of the left inferior pubic ramus in a 48-year-old woman jogger.

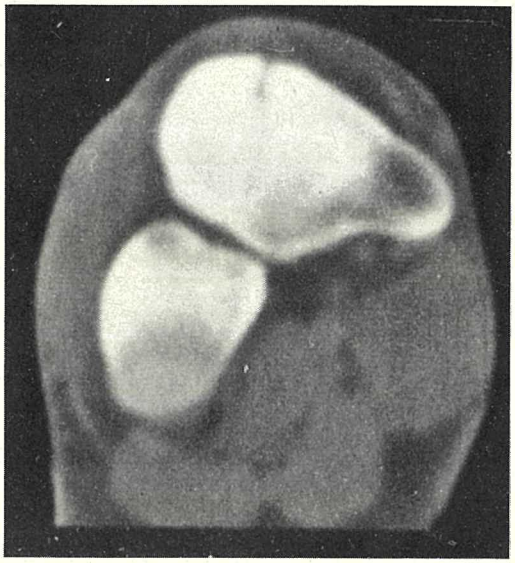

Figure 8. CAT scan of a stress fracture of the tarsal navicular bone.

Management

Removal of the cause (running) usually will result in healing within 10 weeks. Often these patients are most impatient to return to their sport and should commence other weight supported exercises such as cycling or swimming. 'Aqua-running' ('running' chest deep in a swimming pool using a floatation vest) to maintain cardiorespiratory fitness[12] may be recommended.

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