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# STRESS FRACTURES CAUSED BY PHYSICAL EXERCISE

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A series of 142 stress fractures caused by sporting activities and physical exercise is presented. 121 fractures occurred in athletes and 21 in non-competitive sportsmen. Distance runners presented with 68 fractures, skiers 12, sprinters 10, orienteering runners 9, vaulters 3, and football-players 3 fractures. Athletes engaged in other events had fewer stress fractures. 76 fractures occurred in the tibia, 26 in the metatarsal bones, 20 in the fibula, 5 in the femoral neck, 4 in the femoral shaft, and 2 in the metacarpal bones, lower pubic arch and sesamoid bones of the first MTP-joint. There was one fracture of each of the following: the humeral shaft, the ulna, the vertebral arch of L 5, the tarsal navicular and the proximal phalanx of the fifth toe. The treatment was generally a pause in training for 4–6 weeks, on the average. Running caused most of the stress fractures; the rest followed jumping exercises. The athletes mostly developed stress fractures during a period of alteration from one training session to another or during the preparation period close to the competition season. Joggers usually developed stress fractures 2–4 months after the beginning of regular training.

*Key words:* fracture; stress fracture; athletic injuries; physical exercise

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Although the German army physician Breithaupt as early as 1855 described stress fracture in soldiers, stress fractures in athletes were not mentioned until several decades later (Pirker 1934, Baetzner 1936). With the growing interest in competitive sports and the development of sports medicine, more stress fractures have been found to occur in athletes (Burrows 1948, Devas & Sweetnam 1956, Devas 1969, Blazina et al. 1962, Arndt 1969, Brubacker & James 1974, Clement 1974, Apel & Metze 1975, Haluzicky & Szabad 1975, McBryde 1975). Stress fracture develops in a bone, without trauma, when it is rhythmically bending as a result of constant and long-lasting movement, muscular forces and mechanical stress. In both athletes and soldiers the same basic factors have been found to be the probable causes of stress fractures. These are, for example, the circumstances, methods and amount of training; skeletal framework, muscle fatigue and physical condition (Bernstein & Stone 1944, Weber 1967, Devas 1975). Gilbert & Johnson (1966) found fewer cases of stress fractures in army recruits who were in good physical condition and who had previously participated in sports. Although the physical condition as well as the strength of the skeleton of athletes is, in general, better than in soldiers (Nilsson & Westlin 1971), stress fractures occur nevertheless. Thorough studies of stress fractures in athletes are not available.

The aim of this study was to describe the stress fractures found in Finnish athletes and non-competitive sportsmen. Special attention was paid to the connection between the intensity and amount of training and the appearance of stress fractures.

## PATIENTS AND METHODS

During the years 1968–1976, 142 stress fractures in athletes and non-competitive sportsmen were recorded.

The median age of the patients was 22 years (range 10–51 years; Figure 1). Seventy-seven per cent of them were between 16 and 29 years. There were 25 women (17.6 per cent) and 117 men (82.4 per cent).

Seventy fractures occurred on the right and 72 on the left side.

The series consists of 68 middle- and long-distance runners, 12 skiers, 10 sprinters and hurdlers and 9 orienteering runners (Table 1). Non-competitive sportsmen sustained 21 fractures; they were all joggers.

Most fractures occurred in April (20 per cent). Runners usually developed fractures in spring and autumn, joggers in autumn, and skiers during the snowless season. Most women's fractures appeared in autumn.

The number of patients with stress fractures amounted to about 1 per cent of the total number of athletes attending the clinic.

### *Condition of training*

In only 13 cases was the stress fracture a consequence of training other than running. In 52 long-distance runners (76 per cent) the amount of training preceding the appearance of the stress fracture was noted. On the average they had been running approximately 110 km/week. Fifteen runners ran less than 100 km/week and eight more than 150 km/week. One athlete ran 200 km/week. The skiers and orienteering runners did approximately the same amount of training. The joggers trained over a distance of about 30–40 km/week. Most of them had been practising regular physical

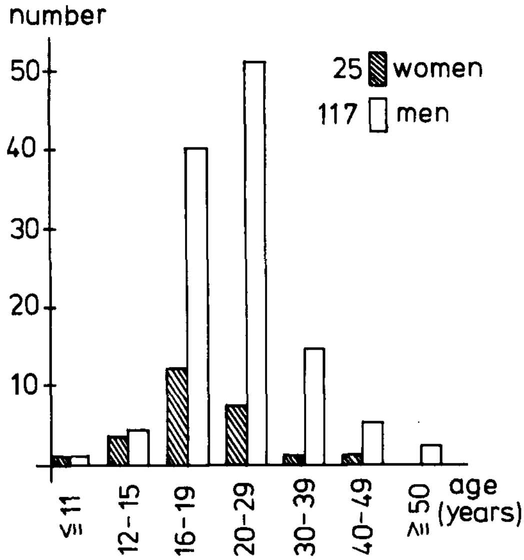



*Figure 1. Age and sex distribution of patients with 142 stress fractures.*

*Table 1. Relation between sporting activity and stress fracture site*

| Sports \ Bone | Tibia | Metatarsal bones | Fibula | Femoral neck | Femoral shaft | Pubic arch | Metacarpal bones | Sesamoid bones | Humeral shaft | Ulna | Tarsal navicular | Toe phalanx | Vertebral arch | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Track and field | 50 | 19 | 10 | 4 | 1 | | | | 1 | | | | | 85 |
| Jogging | 7 | 5 | 5 | | 1 | 2 | | | | | | 1 | | 21 |
| Skiing | 6 | 1 | 1 | 1 | 2 | | | 1 | | | | | | 12 |
| Orienteering | 7 | | 2 | | | | | | | | | | | 9 |
| Ball games | 4 | 1 | 1 | | | | | | | 1 | 1 | | | 8 |
| Power events | | | | | | | 2 | | | | | | 1 | 3 |
| Gymnastics | 2 | | | | | | | | | | | | | 2 |
| Cycling | | | 1 | | | | | 1 | | | | | | 2 |
| Total | 76 | 26 | 20 | 5 | 4 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 142 |

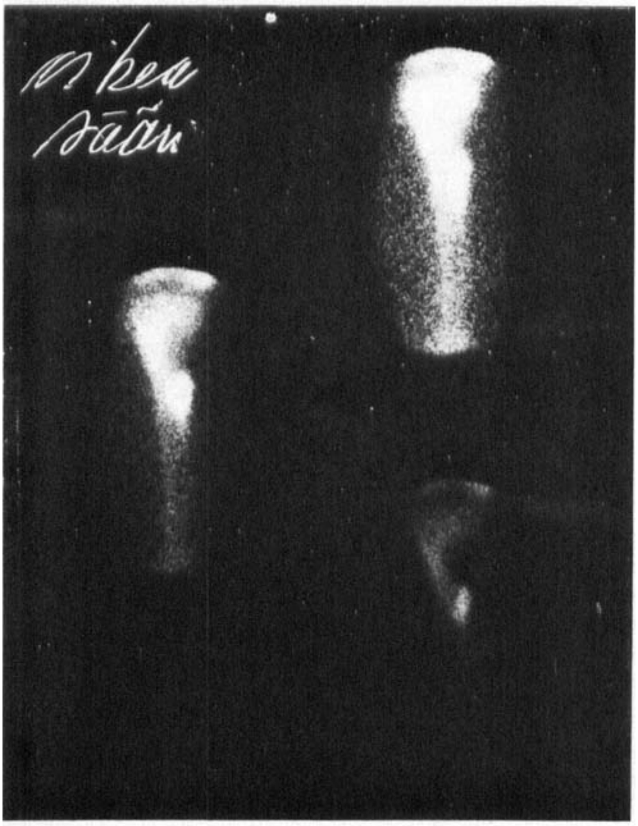


*Figure 2. Gamma camera scintigram of a stress fracture in the upper tibia of a distance runner. The fracture was not visible in radiograms.*

exercise for only a few months before the onset of the symptoms of the stress fracture.

### *Symptoms and diagnosis*

The main symptom of the stress fracture was pain, which at an early stage appeared only after training, then during it, and later, even when walking. The pain was at first diffuse in character, later localized. A characteristic symptom was pain caused by a pace- or stride shock. A palpable callus was often preceded by local swelling and tenderness.

In most cases repeated radiograms were necessary to confirm the diagnosis. Initially a delicate fissure line might be seen, but usually the fracture became detectable only after callus formation. Tomography proved useful in the early stage. Radioisotope-scanning ($Sr^{85}$, $Tc^{99}$) was positive before the radiological changes (Figure 2), which took 2–6 weeks to show up. Isotope activity was increased for 1 year following healing of the fracture.

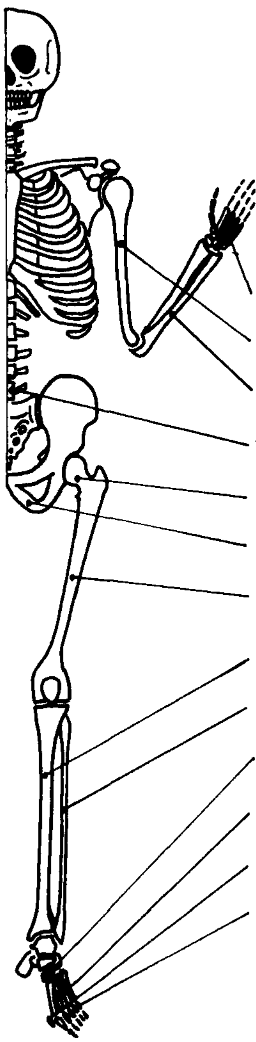
### *Location*

Ninety-five per cent of the stress fractures were found in the lower extremities and 5 per cent elsewhere in the skeleton (Figure 3). The relation between the site of fractures and the sports event is shown in Table 1.

Seventy-six fractures occurred in the tibia (53.5 per cent). Most of them were located in the proximal and distal thirds of the shaft, whilst only two fractures appeared in the middle third. The fracture line was visible in about 40 per cent of the cases. Callus developed postero-medially in fractures of the upper and lower third (Figure 4), and anteriorly in the middle third fractures. The uppermost fractures did not become visible (as an increased internal density in the radiograms) until 2 months after the onset of symptoms. Usually the fracture extended through one cortex only and in a few cases through the whole bone.

Ten out of 26 stress fractures in the metatarsal bones were in both the second and the third bone, four were in the fourth and two in the fifth bone. Most of these fractures were located in the shaft

*Figure 3. Topographical location of stress fractures.*



| BONE | WOMEN | MEN | TOTAL | PER CENT |
|---|---|---|---|---|
| METACARPALS | - | 2 | 2 | 1.4 |
| HUMERUS | - | 1 | 1 | 0.7 |
| ULNA | - | 1 | 1 | 0.7 |
| VERTEBRAL ARCH | - | 1 | 1 | 0.7 |
| FEMORAL NECK | 3 | 2 | 5 | 3.5 |
| PUBIC ARCH | 1 | 1 | 2 | 1.4 |
| FEMORAL SHAFT | - | 4 | 4 | 2.8 |
| TIBIA | 8 | 68 | 76 | 53.5 |
| FIBULA | 2 | 18 | 20 | 14.1 |
| TARSAL NAVICULAR | 1 | - | 1 | 0.7 |
| METATARSALS | 10 | 16 | 26 | 18.3 |
| SESAMOID BONE | - | 2 | 2 | 1.4 |
| DIGITAL BONE | - | 1 | 1 | 0.7 |
| | 25 | 117 | 142 | 100 % |

and the neck. A fusiform callus was characteristic of these fractures in radiograms.

In the fibula 16 of the 20 stress fractures were located just proximal to the tibio-fibular syndesmosis. All these fractures were caused by running. Other fibular fractures followed jumping exercises.

Three distance-runners, one skier and one high-jumper presented with a stress fracture of the femoral neck. Three of them were women. The fractures were located infero-medially (Figure 6). X-ray changes developed 2–4 months after the onset of symptoms.

In two athletes sesamoid stress fractures occurred in the medial bone of the first MTP-joint. These fractures were easiest to observe in tangential projections. Symptoms disappeared without treatment in about 6 months.

Spondylolysis of the fifth lumbar vertebral arch appeared in a previously symptom-free judoka. Initial radiograms were normal. The diagnosis was confirmed with oblique projections and tomography 6 months later. The scintigram ($Tc^{99}$) was also positive. During rest, symptoms disappeared. After 8 months the patient gradually returned to full training and soon afterwards won the third prize in the Finnish Judo Championships.

## *Special features*

Six partial stress fractures transformed into complete fractures during training or competition.

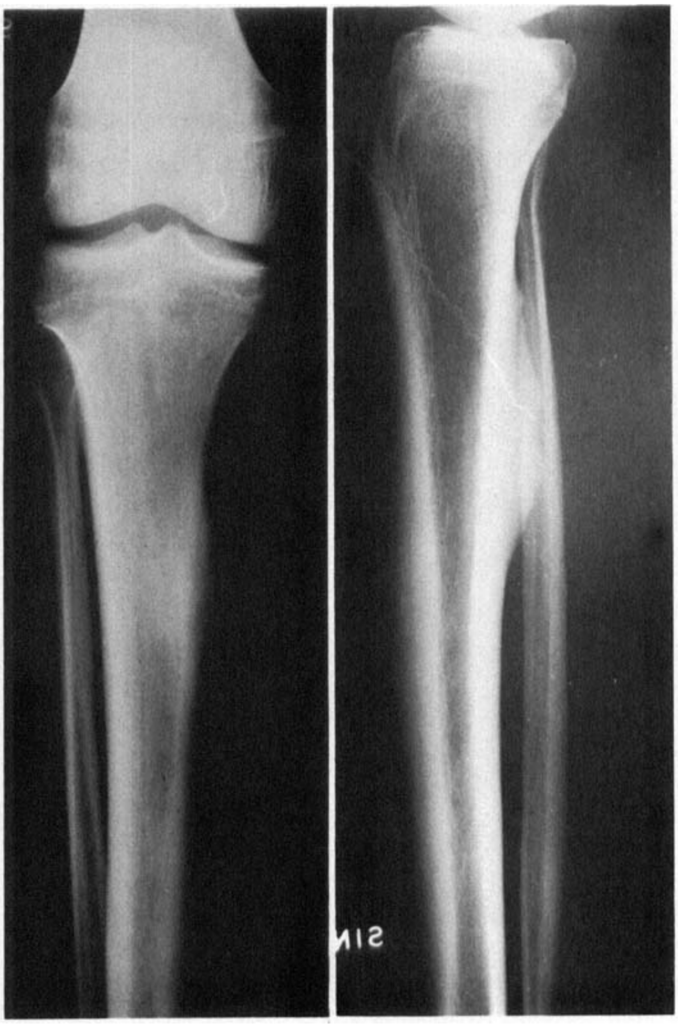



*Figure 4. Stress fracture of the upper tibia in a distance runner. A large callus is located posteriorly.*

Two of them were in the femoral shaft, two in the third metatarsal bone, one in the tibia, and one in the humerus.

Four female and eight male athletes presented with more than one fracture. Seven of them had two consecutive stress fractures in different bones with an interval of approximately 11 months. Four men had two simultaneous fractures in different bones. Three consecutive stress fractures occurred in the tibias of one long-distance runner. He was the only patient with a renewed stress fracture in the same bone.

### *Treatment*

Generally the treatment was limited to a pause in training, lasting for 4–6 weeks. Normal activity was allowed. A longer pause was needed in stress fractures of the upper tibia, femoral neck and shaft, pelvis, ulna and vertebral arch. In fractures of the femoral neck the pause lasted about half a year and in the fracture of the vertebral arch 8 months.

A plaster cast was used in five cases. Four of these were complete fractures. Eight patients needed crutches.

Two patients were treated by open surgery because of complete femoral shaft fractures.

Sick leave was required in 14 cases (9.8 per cent).

## DISCUSSION

Stress fractures are caused by a certain disproportion between the load and the strength

*Figure 5. Stress fracture of the lower tibia in a sprinter. A. Radiogram 3 weeks after the onset of symptoms. Oblique fracture just visible with thickening of both the anterior and posterior cortices.*

of the musculo-skeletal tissues. The bones do not have enough time to adapt to increasing and long-lasting mechanical stress. In the series presented above the amount of training of the endurance runners was 110 km/week, which is not particularly high, as modern endurance runners often run 250 km/week. The fitness joggers did 30–40 km/week which is also quite a moderate amount of training. A common aetiological feature was a change in either the quality or the quantity of training. This was most conspicuous in joggers, who usually sustained stress fractures 2–3 months after the beginning of a regular training programme, just as soldiers get stress fractures in the months immediately following recruiting (Gilbert & Johnson 1966, Wilson & Katz 1969). Similarly the seasonal variations are related to the changes in the training programmes. Among the 12 patients who sustained more than one fracture, individual unknown factors may be of significance. Running technique and psychological predisposition may be important.

In the differential diagnosis both the definite bone diseases, tumours etc, and other overuse injuries of athletes must be considered (Devas 1975).

There were only nine children in the series. They all exercised significantly more than


*B. Radiogram after 6 weeks. Oblique stress fracture clearly demonstrable.*

children on the average. This rare occurrence of stress fractures in children was also noted by Griffiths (1952), Berkebile (1964) and Zweymüller & Frank (1974).

The frequency and location of stress fractures differ in various materials of army recruits and athletes (Blazina et al. 1962, Darby 1967, Devas 1975). In the present series more than half of all fractures were located in the tibia. The same observation was made in previous Finnish series of soldiers' stress fractures (Söderlund 1952, Salmela 1969). This high relative proportion of fractures in the tibia has never been reported elsewhere in the world. On the other hand, fracture of the distal fibula is rare, although it is considered common in athletes (Burrows 1948, Devas & Sweetnam 1956, McBryde 1975). No calcaneal stress fractures were found. The general use of good sports shoes may explain this.

Generally the only treatment needed is rest from sporting activities. After 4–6 weeks break the athletes could gradually increase their training. The risk of a stress fracture becoming complete is particularly great in fractures of the femoral shaft and neck (Provost & Morris 1969, Bargren et al. 1971).

*Figure 6. Three-month-old stress fracture of the femoral neck in a female skier.*

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