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STRESS FRACTURES

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Although the German military surgeon Breithaupt, as early as 1855 described stress fractures in soldiers, such injuries were not mentioned in athletes until several decades later. With growing interest in competitive sport, the higher intensity of training and the growth of sports medicine, stress fractures are found in increasing numbers. The first radiographs of stress fractures of the metatarsal bones were published in 1897 by Stechow on 36 soldiers suffering from "march fracture".

Stress fractures develop in a bone without acute trauma, due to rhythmic bending repeated many times, muscle force and mechanical strain. Repeated and usually submaximal strain results in fatigue of the bone structure. Usually the fracture is limited to one side of the cortex only, but if untreated it may become complete. The musculo-skeletal system of competitive athletes is generally more adapted to hard exercise than that of recruits and keep-fit participants, nevertheless, stress fractures can develop in fit athletes as well.

During the ten years between 1969 and 1978, 200 cases of stress fracture caused by sport and physical exercise were recorded in 185 patients. All were athletes training regularly, or non-competitive keep-fit participants, 159 males and 41 females. Ages ranged from 10-51 years, av. 22.7. In the athletes' group the median age was 20.8, and in the joggers' group 33.2 years. Servicemen were not included in this survey. 80% of the patients were below 29 years. 15% were joggers, and of the athletes 116 (58%) were from track and field events, middle and long distance runners, jumpers and throwers exclusively. Cross-country skiers, orienteers, ball games players and power event athletes formed the next groups according to injury frequency. Amongst the ball players there were five footballers, four Finnish baseball players, two from ice hockey, and one who played both basketball and volleyball.

The anatomical distribution of stress fractures is shown in figs 1 (tibia and fibula), 2 (metatarsals) and 3

Fig. 1 Sites of stress fractures in the tibia and fibula. Thick lines indicate x 5 fractures at this site.

(femur). The highest incidence was in the tibia, then, in order of frequency, the metatarsals, the fibula, the femoral shaft, sesamoid bones of the hallux, and the femoral neck. Metatarsal fractures were relatively commoner in women than in men. There were only eight fractures in the series caused by training other than running or jumping; a metacarpal fracture in a boxer, another in a karateka, a humeral shaft fracture in a shot-putter, of the olecranon in a javelin thrower, of the ulna in a basketball player, and of the fifth lumbar vertebral arch in a young judoka. Two skiers suffered metatarsal

Fig. 2 Callus formation at the site of a tibial stress fracture.

Fig. 3 Sites of stress fractures in the metatarsal bones.

stress fractures. Though difficult to estimate accurately, it would appear that stress fractures could appear in runners training over 110 km/week, though one patient usually ran more than 200 km before his fracture appeared.

TABLE I:
Track and Field Athletes with Stress Fractures
from a series of 200 cases of stress fractures

	Males	Females	Total
Long and Middle Distance Running	78	12	90
Sprinting/Hurdling	11	4	15
High Jump	1	3	4
3 – Jump	1	—	1
Shot Put	1	—	1
Javelin	2	1	3
Junior Track and Field	1	1	2
	95	21	116

In the diagnosis of stress fractures early radiographs, control examinations and radio-isotope (Sr 85 and Tc 99) scanning were used. Isotope uptake could be detected before there was any roentgenological evidence of a fracture in many cases.

16 stress crack fractures (8%) became complete fractures, of which seven failed to unite; one in the posterior process of the talus, and the remainder in the sesamoid bones of the hallux, and callus formation could be seen around the sesamoid bone in one patient after a year. In only four cases was open surgery necessary; three fractures of the femoral shaft at the lower end

Fig. 4 Healing stress fracture of the 4th metatarsal.

Fig. 5 Callus formation in a sesamoid bone below the head of the 1st metatarsal.

TABLE II:
Connection between Sports Events and Anatomical Location of Stress Fractures

	Tibia	Metatarsal Bones	Fibula	Femoral Neck	Femoral Shaft	Pubic Arch	Metacarpal Bones	Hallux Sesamoids	Humeral Shaft	Ulna	Olecranon	Tarsal Navicular	Talus	Digital Bone (Toe)	Vertebral Arch	TOTAL
Track & Field	67	22	14	4	3	1		1	1		1	1	1			116
Jogging	12	7	5		1	2		2						1		30
Skiing	8	3	1	1	2			2				1				18
Orienteering	10		2		1											13
Ball Events	6	3	2							1		1				13
Power Events		1					2								1	4
Gymnastics	2															2
Cycling			1					1								2
Dancing	2															2
TOTAL	107	36	25	5	7	3	2	6	1	1	1	3	1	1	1	200

Fig. 6 Sky-line view of fracture of a sesamoid bone below the 1st metatarsal

were treated by AO plate fixation, and an old transverse fracture of the tarsal navicular with pseudarthrosis received an autogenous graft, using a similar technique to that commonly used for ununited carpal scaphoid fractures. Some cases required immobilisation in plaster of Paris; complete fractures of the tibia, of the humeral shaft, and one complete metatarsal fracture.

Because radiological and clinical impressions were suggestive of neoplasm or of Paget's disease biopsies were taken in four cases, but all proved to be stress fractures of the tibia. In only 18 patients (9%) was it necessary for them to be unable to carry out their normal occupations, and the final outcome was excellent in all but five. Two hallux sesamoid fractures produced symptoms a year after original diagnosis; the talus fracture produced pain during javelin throwing, and the vertebral arch fractures and the tarsal navicular lesion are all likely to produce disability later.

Multiple stress fractures were found in ten men (three in one man) and in five women. Simultaneous fractures occurred in three cases, once in the same metatarsal bone. Refracture at the same site was never found though two fractures in the same bone were observed. Although common in recruits, no calcaneal fractures were seen among the athletes; possibly well fitting sports shoes gave better protection than army boots.

Complete fractures can be considered as

Fig. 7 Sites of stress fractures in the femur.

complications of stress fractures, but can usually be prevented by early and accurate diagnosis with careful radiological investigation, essential if an athlete has pain from an overuse injury in the region of a bone that lasts for over a month. Stress fractures usually produce symptoms before radiological changes are detected; these often take between two to eight weeks to develop. If the diagnosis has been confirmed, the break from training must be adequate, as early resumption of training before the fracture has had time to consolidate

Fig. 8 Small stress fracture just above the lesser trochanter of the femur.

Fig. 9 Radio-isotope scan showing fracture before any X-Ray evidence.

Fig. 10 AO plate fixation of a femoral stress fracture, which became complete, and needed open operation.

TABLE III

Duration of Rest (= Running Pause) in Different Kind of Stress Fractures from Athletic Activities.

Tibia (Shaft)	4-6 Weeks
Upper Tibia	8-10 Weeks
Fibula	3-4 Weeks
Metatarsal Bones	2-4 Weeks
Femoral Shaft	3-4 Months
Femoral Neck	3-4 Months
Others	Individual

increases the risk of a complete fracture and a long period of disability. Table III shows the recommended training breaks used in our clinic for fractures of large bones such as the femur. Follow-up X-Rays should be taken to check progress, as disappearance of symptoms is no guide to bone union. In the Deaconess Institute's sports clinic, the largest in Finland, stress fractures were seen in 1.1% of all athletes and joggers examined, and it is estimated that 1.2/thousand athletes in the area sustained such injuries.