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# Stress Fractures: A Review of 180 Cases

Peter Brukner, M.B.B.S., Christopher Bradshaw, M.B.B.S., Karim M. Khan, M.B.B.S., B.Med.Sci., Susan White, M.B.B.S., and Kay Crossley, B.Sci. (Physiotherapy)

*Olympic Park Sports Medicine Centre, Melbourne, Australia*

**Abstract:**

**Objective:** To review the cases of stress fracture seen over a 2-year period at a sports medicine clinic.

**Design:** One hundred and eighty cases diagnosed as stress fractures on the basis of clinical picture and radiological evidence were reviewed. The following features of each stress fracture were noted: age, sex, site, sport/activity.

**Setting:** A sports medicine centre in Melbourne, Australia.

**Patients:** The average age was 21.8 years. Seventy eight of these stress fractures were seen in women, 102 in men.

**Results:** The most common sites of stress fractures were the metatarsal bones (n = 42), tibia (n = 36), fibula (n = 30), tarsal navicular (n = 26) and pars interarticularis (n = 17). The most common sport was track (n = 54). Other common sports activities were jogging/distance running (n = 35), dance (n = 32) and Australian football (n = 14). The distribution of sites of stress fractures varied from sport to sport. Among the track athletes (n = 54), navicular (n = 19), tibia (n = 14) and metatarsal (n = 9) were the most common stress fracture sites. The distance runners (n = 35) predominantly sustained tibia (n = 15), and fibula (n = 8) stress fractures, while metatarsal stress fractures (n = 18) were the most common among dancers. The distribution of sports varied with the site of the stress fracture. In the metatarsal stress fractures (n = 42), dance was the most common activity. Distance running (n = 15) and track (n = 14) were the most common sports in the group to have sustained tibia stress fractures (n = 36). Track athletes (n = 14) were particularly prevalent in the navicular stress fracture group (n = 26).

**Conclusion:** The distribution of sites of stress fractures in this study shows some differences from previously published studies.

**Key Words:** Stress fractures—Overuse injuries—Sports injuries.

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A stress fracture can be defined as a partial or complete fracture of bone that results from the repeated application of a stress lower than that required to fracture the bone in a single loading situation (13). A number of series of stress fractures among athletes have been described in the literature (1–3,5,6,8–10,14–16,18,19).

These studies generally show that the tibia is the most common site of stress fracture. Other common sites are the fibula, the metatarsal bone, and, in some studies, the navicular bones. Running activities especially track running and distance running are the most common sporting activities among those who sustain stress fractures.

## METHODS

A review was undertaken of 180 consecutive stress fractures seen at a sports medicine centre in Melbourne, Australia over a 2-year period. A stress fracture was defined clinically as an area of marked focal, bony tenderness in association with either a focal area of markedly increased uptake on the delayed phase of a technetium $^{99m}$-labeled bone scan or evidence of a fracture on plain radiograph or computerised tomography (CT).

The following features of each stress fracture were noted: age, sex, site, and sport/activity.

## RESULTS

The average age of the 180 patients was 21.8 years. The average age of those with metatarsal stress fractures was 21, tibia was 23, fibula 21, tarsal navicular 20, and pars interarticularis 20 years.

Seventy-eight of the stress fractures were seen in females, 102 in males. The only common fracture site at which there was a marked difference in the male/female ratio was the metatarsals. Of the 43 metatarsal stress fractures, 16 were in males and 27 in females.

The distribution of sites of the 180 stress fractures

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Address correspondence and reprint requests to Dr. Peter Brukner, Olympic Park Sports Medicine Centre, Swan St., Melbourne, 3004, Australia.

TABLE 1. *Distribution of sites of*

| Sport | Metatarsal | Tibia | Fibula | Tarsal navicular | Pars interarticularis | Talus | Femur (shaft) | Ribs | Pubic bones |
|---|---|---|---|---|---|---|---|---|---|
| Track | 9 | 14 | 5 | 19 | 1 | 1 | 1 | 0 | 1 |
| Jog/distance run | 5 | 15 | 8 | 1 | 0 | 1 | 2 | 0 | 1 |
| Dance | 18 | 1 | 7 | 0 | 3 | 1 | 0 | 0 | 1 |
| Aust. football | 2 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 0 |
| Racquet sports | 1 | 1 | 2 | 1 | 3 | 0 | 0 | 0 | 0 |
| Field events | 0 | 0 | 2 | 0 | 4 | 0 | 1 | 0 | 0 |
| Row/canoe | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 3 | 0 |
| Triathlon | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| Basketball/netball | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Cricket | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Aerobics | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Golf | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Field hockey | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Weightlifting | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Rugby | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Martial arts | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Work-related | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Total | 42 | 36 | 30 | 26 | 17 | 6 | 5 | 4 | 3 |

is shown in Table 1. The most common sites of stress fractures were the metatarsal bones (n = 42), tibia (n = 36), fibula (n = 30), tarsal navicular (n = 26), and the pars interarticularis (n = 17).

The distribution of primary sport or activity played by the patients with stress fractures is also seen in Table 1. The most common sport was track (n = 54). Other common sports activities were jogging/distance running (n = 35), dance (n = 32), and Australian football (n = 14).

The distribution of sites of the stress fractures varied from sport to sport. The percentage distribution of sites of the four sports with the largest number of stress fractures is shown in Table 2. Among the track athletes (n = 54), the most common sites were tarsal navicular (35.2%), tibia (25.9%), metatarsals (16.7%), and fibula (9.3%). Among the distance runners (n = 35), the most common site was the tibia (21.9%), followed by the fibula (22.9%) and metatarsal (14.3%). The most common site in dancers (n = 32) was the metatarsals (56.3%). Other common sites were the fibula (21.9%) and the pars interarticularis (9.4%). Australian footballers (n = 14) had a more varied distribution of sites, including tibia (21.4%), fibula (21.4%), metatarsals (14.3%), and navicular (14.3%).

The percentage distribution of sports was calculated for the five most common sites of stress fractures: the metatarsals, tibia, fibula, tarsal navicular, and pars interarticularis. The distribution is shown in Table 3. Dancers (42.9%) were the most common group who sustained metatarsal stress fractures. Track (38.9%) and distance runners (41.7%) sustained the most tibia stress fractures, whereas distance runners (30.8%) and dancers (26.9%) were prominent among the fibula stress fractures. Track

TABLE 2. *Percentage distribution of sites of stress fractures from the sports with the highest incidence*

| Site | Track (n = 54) | Distance (n = 35) | Dance (n = 32) | Australian football (n = 14) |
|---|---|---|---|---|
| Metatarsal | 16.7 | 14.3 | 56.3 | 14.3 |
| Tibia | 25.9 | 42.9 | 3.8 | 21.4 |
| Fibula | 9.3 | 22.9 | 21.9 | 21.4 |
| Tarsal navicular | 35.2 | 2.9 | 0 | 14.3 |
| Pars interarticularis | 1.9 | 0 | 9.4 | 0 |
| Femur (shaft) | 1.9 | 5.7 | 0 | 0 |
| Talus | 1.9 | 0 | 3.1 | 7.1 |
| Pubic bones | 1.9 | 5.7 | 3.1 | 0 |
| Calcaneus | 1.9 | 5.7 | 0 | 7.1 |
| Sesamoid | 1.9 | 0 | 3.1 | 0 |
| Patella | 0 | 2.9 | 0 | 0 |
| Toe phalanx | 1.9 | 0 | 0 | 0 |
| Medial malleolus | 0 | 0 | 0 | 7.1 |
| Femur (neck) | 0 | 0 | 0 | 7.1 |

*stress fractures and sports played*

| Calcaneus | Sesamoid | Patella | Toe phalanx | Medial malleolus | Femur (neck) | Cuneiform | Ulna | Total |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 54 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 35 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 32 |
| 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 14 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 180 |

athletes (73.1%) were by far the most common among the navicular stress fracture, and the pars fractures were evenly distributed.

## DISCUSSION

In this study, more stress fractures were reported in males (56.7%) than in females (43.3%). Women are thought to be at increased risk for stress fractures due to the relatively frequent occurrence of hypoestrogenic status associated with intense activity leading to reduced bone density (4). However, no inference to the relative frequency of stress fractures in males and females can be drawn because of the nature of the study.

The distribution of stress fractures showed that the metatarsal bones (23.3%) were the most common site, followed by the tibia (20.0%), the fibula (16.6%), and the tarsal navicular (14.4%). In most other reported series of stress fractures (1–3,5,6,8–10,14–16,18,19), the tibia is the most common site. A summary of the distribution of stress fracture sites from previously reported studies is shown in Table 4.

The main problem with comparison of these studies is the variation of sporting activities in the different series. The high incidence of metatarsal stress fractures in our study may be partially explained by the large number of dancers seen at our clinic. If the 32 stress fractures that occurred in dancers are removed, then the tibia becomes the most common site (23.6%), followed by tarsal navicular (17.6%), metatarsals (16.2%), and fibula (15.5%).

The incidence of tarsal navicular stress fractures (14.4%) is higher than in most other studies, although Matheson et al. (14) had a high incidence of tarsal stress fractures (25.3%) and Benazzo et al. (2)

TABLE 3. *Percentage distribution of sports among the most common stress fracture sites*

| Sport | Metatarsal (n = 42) | Tibia (n = 36) | Fibula (n = 30) | Tarsal navicular (n = 26) | Pars interarticularis (n = 17) |
|---|---|---|---|---|---|
| Track | 21.4 | 38.9 | 16.7 | 73.1 | 5.8 |
| Jog/distance run | 11.9 | 41.7 | 26.7 | 3.8 | 0 |
| Dance | 42.9 | 2.8 | 23.3 | 0 | 17.6 |
| Australian football | 4.8 | 8.3 | 10.0 | 7.7 | 0 |
| Racquet sports | 2.4 | 2.8 | 6.7 | 3.8 | 17.6 |
| Field events | 0 | 0 | 6.7 | 0 | 23.5 |
| Row/canoeing | 2.4 | 0 | 3.3 | 3.8 | 0 |
| Triathlon | 2.4 | 0 | 3.3 | 3.8 | 0 |
| Basketball | 2.4 | 0 | 0 | 3.8 | 11.8 |
| Cricket | 0 | 0 | 0 | 0 | 17.6 |
| Aerobics | 7.2 | 0 | 3.3 | 0 | 0 |
| Field hockey | 0 | 0 | 0 | 0 | 5.9 |
| Rugby | 0 | 2.8 | 0 | 0 | 0 |
| Martial arts | 2.4 | 0 | 0 | 0 | 0 |
| Work-related | 0 | 0 | 0 | 0 | 5.9 |

TABLE 4. *Percentage distribution of sites of stress fractures from previously published series compared to present study*

| Study (reference) | No. of stress fractures | Tibia | Metatarsals | Fibula | Navicular |
|---|---|---|---|---|---|
| Brubaker and James, 1974 (3) | 17 | 41.2 | 29.4 | 17.6 | 5.9 |
| Orava, 1980 (15) | 200 | 53.5 | 18.0 | 12.5 | 1.5 |
| Pagliano and Jackson, 1980 (16) | 99 | 20.2 | 37.4 | 15.2 | N/A |
| Taunton et al., 1981 (19) | 62 | 55.0 | 16.1 | 11.3 | 3.2 |
| Sullivan et al., 1984 (18) | 57 | 43.8 | 14.0 | 21.0 | 0 |
| Hulkko and Orava, 1987 (10) | 369 | 49.5 | 19.8 | 12.0 | 2.5 |
| Matheson et al., 1987 (14) | 320 | 49.1 | 8.8 | 6.6 | 25.3[a] |
| Barrow and Saha, 1986 (1) | 140 | 63.0 | 21.0 | 9.0 | 0.7 |
| Courtenay and Bowers, 1990 (6) | 108 | 38.0 | 19.8 | 12.0 | 5.4 |
| Ha et al., 1991 (9) | 169 | 31.5 | 7.1 | 10.7 | 4.5 |
| Cameron et al., 1992 (5) | 253 | 37.5 | 22.5 | 11.8 | 10.0 |
| Benazzo et al., 1992 (2) | 49 | 26.5 | 14.3 | 12.2 | 28.6 |
| Goldberg and Pecora, 1994 (8) | 58 | 18.9 | 25.9 | 12.1 | 3.5[a] |
| Brukner et al. (this study) | 180 | 20.0 | 23.3 | 16.6 | 14.4 |

[a] All tarsal fractures.

reported an incidence of navicular stress fractures of 28.6% in their series of track and field athletes. Track and field athletes have previously been noted to be at high risk for the development of navicular stress fractures (11).

The distribution of sports showed track to be the most common (30.0%) followed by jog/distance running (19.4%), dance (17.8%), and Australian football (7.8%). The distribution of sports is greatly influenced by the distribution of patients attending the clinic.

The pattern of distribution of stress fracture sites for the four most common associated sports and activities (Table 2) shows some marked differences among the sports. In the track athletes who sustained stress fractures (n = 54), the most common site was the tarsal navicular (35.2%), followed by the tibia (25.9%), metatarsal (16.7%), and fibula (9.3%). This distribution is similar to a study of 49 track athletes (2) in which navicular (28.6%), tibia (26.5%), metatarsal (14.3%), and fibula (12.2%) were the most frequent sites.

Tarsal navicular fractures were virtually nonexistent (2.9%) in the distance runners (n = 35), who sustained a stress fracture. Almost half the fractures among the distance runners were in the tibia (42.9%).

In the dance group (n = 32), metatarsal stress fractures accounted for more than half the total (56.3%). Fibula (21.9%) was the next most common site, followed by the pars interarticularis (9.4%). In another study of 27 stress fractures in ballet dancers (12), metatarsals were also the most common (63.0%), followed by tibia (22.2%) and pars interarticularis (7.4%).

Australian football is a popular form of football in this country and makes considerable demands on the participants. In recent years, the amount of running has increased dramatically and resulted in an increase in overuse injuries. The stress fractures in this group (n = 14) were distributed between tibia (21.4%), fibula (21.6%), metatarsals (14.3%), and tarsal navicular (14.3%). In another study of injuries in elite Australian footballers (17), a similar number of stress fractures (n = 14) was reported. In this series, 50% of the stress fractures were in the metatarsals, 21.4% in the tibia, and 14.3% in the pars interarticularis.

The distribution of sports involved with the five most frequent sites of stress fractures (Table 3) shows the expected high percentage (42.9%) of dancers sustaining metatarsal stress fractures, although perhaps one would have expected more metatarsal stress fractures among distance runners (11.9%) than the track athletes (21.4%). Stress fractures of the tibia occurred largely in distance runners (41.7%) and track athletes (38.9%). The fibula stress fractures were distributed more evenly with distance runners (26.7%), dancers (23.3%), and track athletes (16.7%) comprising two-thirds of the total.

The distribution of tarsal navicular stress fractures (n = 26) confirmed the association of this fracture with track athletes (73.1%). The 17 stress fractures of the pars interarticularis were distributed among eight different sports with field events (23.5%), dance (17.6%), racquet sports (17.6%), and cricket (17.6%) the most common. The cricket fractures were all in fast bowlers, an association that has been previously recognised (7).

## CONCLUSION

Analysis of this series of 180 stress fractures seen at a sports medicine clinic over a 2-year period showed a somewhat different distribution of fractures compared to other series. Particular sports are associated with specific sites of stress fracture occurrence.

## REFERENCES


1. Barrow GW, Saha S. Menstrual irregularity and stress fractures in collegiate female distance runners. *Am J Sports Med* 1988;16:209–16.
2. Benazzo F, Barnabei G, Ferrario A, Castelli C, Fischetto G. Stress fractures in track and field athletes. *J Sports Traumatol* 1992;14:51–65.
3. Brubaker CE, James SL. Injuries to runners. *J Sports Med* 1974;2:189–98.
4. Brukner P, Khan K. *Clinical sports medicine*. Sydney: McGraw-Hill, 1993.
5. Cameron KR, Telford RD, Wark JD. Stress fractures in Australian competitive runners. [Abstract]. In: *Proceedings Australian Sports Medicine Federation Annual Conference, 1992*.
6. Courtenay BG, Bowers DM. Stress fractures: clinical features and investigation. *Med J Aust* 1990;153:155–6.
7. Elliot BC, Hardcastle PH, Burnett AF, Foster DH. The influence of fast bowling and physical factors on radiologic features in high performance young fast bowlers. *Sports Med Train Rehabil* 1992;3:113–30.
8. Goldberg B, Pecora C. Stress fractures. A risk of increased training in freshman. *Phys Sportsmed* 1994;22:68–78.
9. Ha KI, Hahn SH, Chung M, Yang BK, Yi SR. A clinical study of stress fractures in sports activities. *Orthopedics* 1991;14:1089–95.
10. Hulkko A, Orava S. Stress fractures in athletes. *Int J Sports Med* 1987;8:221–6.
11. Khan KM, Brukner PD, Kearney C, Fuller PJ, Bradshaw CJ, Kiss ZS. Tarsal navicular stress fractures in athletes. *Sports Med* 1994;17:65–76.
12. Kadel NJ, Teitz CC, Kronmal RA. Stress fractures in ballet dancers. *Am J Sports Med* 1992;20:445–9.
13. Martin AD, McCulloch RG. *J Sports Sci* 1987;39:155–63.
14. Matheson GO, Clement DB, McKenzie DC, Taunton JE, Lloyd-Smith DR, MacIntyre JG. Stress fractures in athletes. A study of 320 cases. *Am J Sports Med* 1987;15:46–58.
15. Orava S. Stress fractures. *Br J Sports Med* 1980;14:40–4.
16. Pagliano J, Jackson D. The ultimate study of running injuries. *Runners World* 1980;Nov:42–50.
17. Seward H, Orchard J, Hazard H, Collinson D. Football injuries in Australia at the elite level. *Med J Aust* 1993;159: 298–301.
18. Sullivan D, Warren RF, Pavlov H, Kelman G. Stress fractures in 51 runners. *Clin Orthop* 1984;187:188–92.
19. Taunton JF, Clement DB, Webber D. Lower extremity stress fractures in athletes. *Phys Sportsmed* 1981;9:77–86.