EPIDEMIOLOGY AND SITE SPECIFICITY OF STRESS FRACTURES

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Stress fractures have been reported to occur in association with a variety of sports and physical activities. Clinical impression suggests that stress fractures are more common in weightbearing activities, particularly those involving a running or jumping component. It is difficult, however, to compare the incidence of stress fractures in different sports or to identify the sport or activity with the greatest risk because of a lack of sound epidemiologic data. This article reviews the descriptive epidemiology of stress fractures, particularly methodology issues, injury rates, injury characteristics, and injury morbidity. Most of the literature in this area pertains to female runners and to male military populations. There is no information about stress fracture rates in the general community.

METHODOLOGY ISSUES

Study Design

The two main measures of injury frequency are prevalence and incidence. Prevalence quantifies the proportion of individuals in a population who have a stress fracture at a specific instant. In contrast, inci-

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dence quantifies the number of new stress fractures that develop in a population of individuals at risk during a specific time interval[25]; incidence is the more widely used measure in the stress fracture literature. The ability to make valid inferences about stress fracture frequency from a study depends upon the study design employed. Generally, three types of study design have been used in stress fracture descriptive epidemiology.

1. The *prospective cohort design* consists of subjects assembled at baseline and then followed over a predetermined length of time, during which the occurrence of injury, and ideally, exposure is monitored and recorded through some form of surveillance.[12] This type of study has the strongest design as it permits comparison between injured (numerator) and noninjured (denominator) individuals so that a true assessment of incidence and risk of stress fracture can be made. Although there are a number of prospective cohort studies in athletes evaluating incidence rates for all injuries or for broad categories of injuries (e.g., sprains, strains), few specifically evaluate stress fractures. In contrast, the military literature contains numerous prospective cohort studies investigating stress fracture incidence rates.
2. The *retrospective cohort design* is similar to the prospective cohort design in that subjects are assembled at baseline; however, these cohorts have already been exposed to the risk of injury prior to the study and stress fractures have already been sustained by some of the subjects at some stage in the past. Stress fracture rates can be calculated because the design involves both the numerator and the denominator; however, stress fracture rates from this study design may be biased by selection factors affecting subject enrollment and, because data are collected retrospectively, by inaccurate or biased recall of stress fracture history. Those in which documented medical records serve as the source of stress fracture data are likely to have less error than those where subjects are questioned.
3. *Case series* consist of a single study group comprised of individuals with stress fractures, usually presenting to a hospital or treatment facility. The primary use of case series is to allow assessment of the relative frequency of stress fractures compared with other injuries, to describe various characteristics of the stress fracture and the injured athlete, and to provide a general indication of morbidity. There are several major limitations of case series, however. First, because they do not provide any information about the population from which the injuries arose, they cannot be used to calculate the absolute risk of stress fracture. Second, the composition of most case series will strongly reflect

various selection and referral mechanisms that may cause it to be a nonrepresentative sample of all injuries in the population.[51] The single case report, although often used to present details about an unusual stress fracture, does not provide any further information. Most of the athletic stress fracture literature comprises case series and case reports.

Study Interpretation

Apart from the study design, there are several other factors that can influence the interpretation of the results and the validity of the conclusions, including sampling methods, sample size, expression of incidence rates, length of stress fracture observation period, and stress fracture definition.

Selection factors affecting which cases enroll in a study may lead to bias in the results. For example, if nonrandom sampling is used to recruit subjects, those who choose to enroll may differ from those who do not. These differences may influence the risk of stress fracture and reduce the generalizability of the results. In addition, athlete stress fracture studies often comprise small numbers that may lead to nonrepresentative samples. In contrast, the military lends itself to data collection; therefore, military studies have tended to have much larger samples. Given differences in training, footwear, and initial fitness levels, results from these studies do not necessarily apply to athletic populations.

The way in which incidence is expressed in the stress fracture literature differs depending on the choice of numerator and denominator. In some studies, participant rates are reported whereby the total number of athletes (or recruits) with stress fractures is divided by the total number of participants; however, a potential flaw with this is that athletes may develop more than one stress fracture either concurrently or on another occasion. An alternative is to calculate case rates where the numerator instead consists of the total number of stress fractures that occur during the study period. In practice, participant and case rates are often presented as a percentage (i.e., the number of athletes with stress fractures or the number of stress fractures per 100 athletes). In some studies the results are broken down and calculated according to participant characteristics, such as age, gender, and competitive level. This is useful because these characteristics may influence stress fracture rates.

The length of stress fracture observation differs between studies. In the military, most calculate stress fracture rates during 8- to 12-week training periods; however, studies in athletes use varying periods. The most common method has been to assess whether participants have ever sustained one or more stress fractures at any stage in the past. Strictly speaking, this does not provide an incidence or a prevalance rate.

Expression of stress fracture rates as participant or case rates may not allow meaningful comparison of the results of different studies, either within the same sport or between sports. Various exposure of participants to the risk of stress fracture can lead to inaccurate denominator data. For example, a player who is sidelined is not at the same risk of sustaining a stress fracture as one who plays the entire season. In more recent injury literature, methods have been introduced to quantify exposure, and examples include expressing rates in terms of practice matches, long jumps, or hours of running.[12] Unfortunately, few stress fracture studies have expressed incidence rates in terms of exposure.

A major problem in the literature is the nonstandardized definition of stress fracture. This obviously influences both stress fracture rates as well as site distributions, hence making comparison between studies difficult. For example, some studies rely on radiographic confirmation whereas others use bone scan. Given the relative insensitivity of radiographs for stress fracture diagnosis, it is likely that these will underestimate the true incidence of stress fractures. Conversely, as bone scans are less specific for stress fractures, reliance on these alone may overestimate the true incidence of stress fractures.

STRESS FRACTURE INJURY RATES

Stress Fracture Rates in Athletes

Only two studies allow a direct comparison of annual stress fracture rates in different sporting populations[23, 29]; a summary of their methodology is provided in Table 1. Johnson et al[29] conducted a 2-year prospective study to investigate sports-related injuries in collegiate male and female athletes. In total, 34 stress fractures were diagnosed over the study period. Of these stress fractures, track and field accounted for 64% in women and 50% in men. The stress fracture incidence rate (expressed as a case rate) in males was highest for track and field (9.7%), followed by lacrosse (4.3%), crew (2.4%), and football (1.1%). For females, the stress fracture incidence rate was highest for track and field athletes (31.1%), followed by crew (8.2%), basketball (3.6%), lacrosse (3.1%), and soccer (2.6%). Neither gender sustained a stress fracture in fencing, hockey, golf, softball, swimming, or tennis.

Similar findings were reported by Goldberg and Pecora[23] who reviewed medical records of stress fractures occurring in collegiate athletes over a 3-year period. Approximate participant numbers were available

Table 1. STRESS FRACTURE RATES IN ATHLETES EXPRESSED AS PARTICIPANT RATES UNLESS OTHERWISE STATED

Reference	Study Design	Population	Subject Sex and Number	Method of Data Collection	Response Rate of Questionnaire	Observation Period	Diagnosis of Stress Fracture	Stress Fracture Rate
Running								
Barrow & Saha, 1988[1]	R	Collegiate distance runners	240-F	Self-admin question	24%	Hx	Radiograph or BS	37.0%
Brunet et al, 1990[11]	R	Recreational/competitive runners	375-F 1130-M	Self-admin question	NS	Hx	NS	13.2%-F 8.3%-M
Cameron et al, 1992[13]	R	State/national-level runners	263-F 287-M	Self-admin question	67%	Hx	NS	26.6%-F 28.0%-M
Bennell et al, 1995[5]	R	Track & field athletes	53-F	Self-admin question	100%	Hx	Radiograph, BS, or CT	51.5% 84.9%*
Bennell et al, 1996[6]	P	Track & field athletes	46-F 49-M	Monitoring	NA	1 yr	BS, + CT	21.7%-F 20.4%-M 30.4%-F* 24.5%-M*
Ballet dancing								
Warren et al, 1986[52]	R	Professional ballet dancers	40-F	Self-admin question	100%	Hx	Radiograph or BS	45.0% 67.5%*
Frusztajer et al, 1990[20]	R	Ballet dancers	45-F	Interview + question	100%	1 yr	NS	22.0%
Kadel et al, 1992[32]	R	Professional ballet dancers	54-F	Self-admin question	100%	Hx	Radiograph or BS	31.5% 50.0%*
Collegiate sport								
Johnson et al, 1994[29]	P	Collegiate athletes	321-F 593-M	Monitoring	NA	2 yrs	Radiograph or BS	6.9%-F*† 2.0%-M*†
Goldberg and Pecora, 1994[23]	R	Collegiate athletes	≈1200-F ≈1800-M	Review of med records	NA	3 yrs	Radiograph or BS	2.7%-F*† 1.4%-M*†
Figure skating								
Pecina et al, 1990[43]	R	Elite ice skaters	42 M/F	Self-admin question	100%	Hx	NS	21.0%
Gymnastics								
Dixon and Fricker, 1993[19]	R	Elite gymnasts	74-F 42-M	Review of med records	NA	10 yrs	Radiograph or BS	27.0%-F* 14.3%-M*

*Stress fracture rates expressed as case rates: number of stress fractures per 100 athletes.
†Annual incidence.
M = males; F = females; NS = not stated; NA = not applicable; P = prospective cohort; R = retrospective cohort; BS = bone scan; CT = computed tomography; Hx = history.

to allow calculation of estimated incidence case rates in each sport. The greatest incidence occurred in softball (19%), followed by track and field (11%), basketball (9%), lacrosse (8%), baseball (8%), tennis (8%) and gymnastics (8%); however, participant numbers were small in some of these sports, which may have led to a bias in incidence rates.

These studies suggest that track athletes are at highest risk for stress fracture; however, because neither study expressed incidence in terms of exposure, it may not be strictly valid to compare the risk of stress fracture in such diverse sports. Other studies have measured stress fracture rates in a specific sporting population, mostly runners and ballet dancers.* Variation in reported rates reflect differences in methodology, particularly cohort demographics and method of data collection; these are summarized in Table 1. Retrospective studies have found that 13% to 52% of female runners have had a history of stress fracture. The lowest rate was found in one study that included recreational as well as competitive runners. Ballet dancers are another population where stress fracture rates are high, with 22% to 45% of dancers reporting a history of stress fracture. All of these studies, however, used a questionnaire, and thus rely on subject recall of stress fracture history.

To the authors' knowledge, there is only one athlete study that has expressed stress fracture incidence rates in terms of exposure.[6] This 12-month prospective study followed a cohort of 95 track and field athletes. Results showed an overall rate of 0.70 stress fractures per 1000 training hours. Further research is needed to quantify incidence rates in this manner and allow comparison between studies.

Stress Fracture Rates in the Military

The incidence of stress fractures in male recruits undergoing basic training for periods of 8 to 14 weeks is remarkably similar, and generally ranges from 0.9% to 4.7%[8, 21, 30, 31, 44–47, 49]; however, in two particular studies involving the Israeli army, the reported incidence was 31%[40] and 24%.[38] The authors attributed this higher incidence to several factors, including meticulous follow-up, a high index of suspicion, and the use of the radioisotope bone scan for diagnosis. In addition, asymptomatic areas of uptake on bone scan were also classified as lesions that would inflate the reported rates. Stress fracture rates in female military recruits during basic training are generally higher than those in males, ranging from 1.1% to 13.9%.[8, 30, 31, 44–46]

*References 1, 5, 6, 11, 13, 19, 20, 23, 29, 32, 43, 52.

Stress Fracture Recurrence Rates

Clinically, it seems that recurrence of stress fractures at new sites is common. In a retrospective study of female track and field athletes, half of those who reported a history of stress fracture had a stress fracture on more than one occasion[5]; however, few studies have reported recurrence rates in either athletes or the military. When male and female track and field athletes were followed prospectively for 1 year, 60% of those who sustained a stress fracture had a previous stress fracture history.[6] The athlete recurrence rate in this study was particularly high, at 12.6%. A large number of male military recruits were followed for a minimum of 1 year after basic training.[39] The recurrence rate of stress fractures at a different site in those who had sustained a stress fracture during basic training was 10.6%. In the control group of 60 recruits who did not develop a stress fracture during basic training, the incidence of stress fracture after basic training was only 1.7%. This finding could indicate the persistence of risk factors in susceptible individuals.

Comparison of Stress Fracture Rates in Different Age Groups

It is unclear whether age, as an independent factor, influences the risk of stress fracture. Results in the military are conflicting, and there are no studies in athletes investigating the incidence of stress fractures in individuals of different ages engaged in identical training. In a retrospective cohort study of 20,422 military recruits, review of clinical records found a positive association between increasing age (in the range 17–34 years old) and the incidence of stress fractures in both men and women.[8] Similar results, even after adjusting for pretraining physical activity, were reported by Gardner et al[21] in a large prospective study. These suggest that increasing age, within the range studied, may be associated with a higher incidence of stress fractures. It is surmised that this may be because bone of older individuals is less resistant to fatigue failure.[15, 33]

A recent prospective study by Milgrom et al[38] in the Israeli army contradicts the hypothesis that stress fracture incidence increases with age in military recruits. For each year of increase in age from 17 to 26 years, the risk for stress fracture at all sites decreased by 28%. The authors suggested that the decreasing risk with age may be related to increased structural maturity, increased bone density, larger cross-sectional moment of inertia, or changes in bone quality in the older recruits. It is also possible that injury-prone older individuals may be less likely to apply for military training; however, the number of recruits over the age of 19 was very small in this study.

A case series of 1407 patients presenting to a sports medicine center found that stress fractures/periostitis comprised a greater percentage of injuries in the younger group (mean age, 30 years old) compared with that in the older group (mean age of 57 years)[36]; however, because of the study design, it is not known whether this reflects selection of stress-fracture-resistant individuals in the older group, modification of training regimens to lower musculoskeletal stress, or an independent age effect on stress fracture development.

Comparison of Stress Fracture Rates in Whites and Blacks

Prospective and retrospective military studies suggest that both male and female whites are at greater risk for stress fractures than blacks (Table 2).[8, 21, 38] In the only athlete study comparing stress fracture rates between races (a retrospective design was employed), the questionnaire response rate was only 24%, and the number of blacks was small[1]; however, a higher prevalence of stress fracture history was found in whites (two times that in blacks). It has been surmised that lower stress fracture risk in blacks may be related to their higher bone density[17, 37] or to different biomechanical features that may protect against stress fracture development.[22]

Comparison of Stress Fracture Rates in Men and Women

It is often suggested that women sustain a disproportionately higher number of stress fractures than men. The relative risk of stress fracture for women compared with men from studies where stress fracture rates can be directly compared is shown in Figure 1. In the military, reported incidence rates over an 8-week training period vary from 1.1% to 13.9% in women, and from 0.9% to 3.2% in men. These studies consistently show that female recruits have a greater risk of stress fracture than male recruits, with relative risks ranging from 1.2 to 10.[8, 30, 31, 44–46] This increased risk persists even when training loads are gradually increased to moderate levels and when incidence rates are separated by age and race. The most likely explanation for these findings in the military is lower initial physical fitness in the female recruits. Other possible reasons include differences in bone density and geometry, gait, biomechani-

Table 2. STUDIES INVESTIGATING THE RATES AND RELATIVE RISK OF STRESS FRACTURES COMPARING WHITES AND BLACKS*†

Reference	Population	Study Design	Number of Whites	Number of Blacks	Stress Fracture Rates of Whites	Stress Fracture Rates of Blacks	Relative Risk of Whites vs Blacks
Men							
Brudvig et al, 1983[8]	Military	R	NS	NS	1.1	0.2	4.7‡
Gardner et al, 1988[21]†	Military	P	2050	975	1.6§	0.7§	2.3‡
Milgrom et al, 1994[38]	Military	P	765	18	24.8	0.0	24.8‡
Women							
Brudvig et al, 1983[8]	Military	R	NS	NS	11.8	1.4	8.5‡
Barrow and Saha, 1988[1]	Athletes	R	220	12	39.0	17.0	2.3

*All rates are expressed as participant rates unless stated.
†Blacks include all racial and ethnic groups apart from whites.
‡Statistically significant difference between races.
§Stress fracture rates expressed as case rates: number of stress fractures per 100 recruits.
NS = not states; P = prospective cohort; R = retrospective cohort.

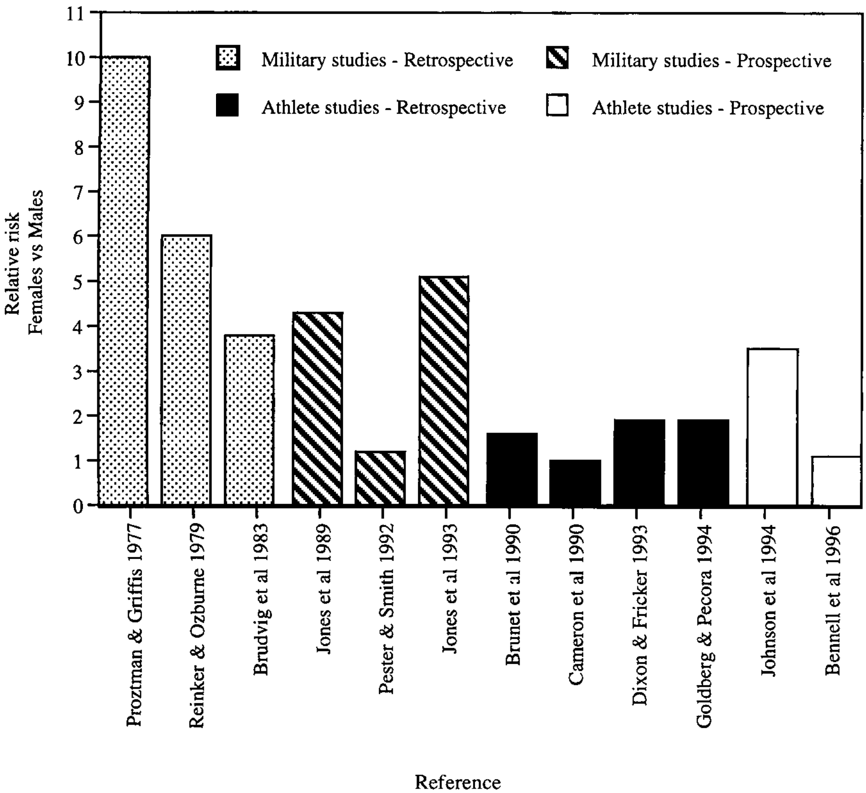

Figure 1. Relative risk of stress fracture for women compared with the risk for men from studies in which stress fracture rates can be directly compared.

cal features, body composition, and endocrine factors, particularly estrogen status.

In contrast, a gender difference in stress fracture rates is not as evident in athletic populations.[6, 11, 13, 19, 23, 29] Studies either show no difference between male and female athletes or a slightly increased risk for women, up to 3.5 times that of men (Fig. 1). A possible confounding variable is that, unlike the military, where the amount and intensity of basic training is rigidly controlled, it is difficult to assume equivalence of training between the genders in most of these studies; however, Bennell et al[6] found no significant difference between gender incidence rates, even when expressed in terms of exposure. Women sustained 0.86 stress fractures per 1000 training hours compared with 0.54 in men. It is feasible that the gender difference in stress fracture risk is lessened in athletes as they are more conditioned to exercise than recruits and their fitness levels may be closer.

Relative Frequency of Stress Fractures as a Proportion of Total Injuries

Numerous case series have reported that stress fractures comprise between 0.7% to 15.6% of all injuries sustained by athletic populations.[7, 19, 28, 41, 42, 53] In those investigating runners only, the relative frequency is much higher, ranging from 6.0% to 15.6%. In track and field athletes, stress fractures appear to comprise a large proportion of overuse injuries; 34.2% in women and 24.4% in men was reported by one study,[4] and 42.0% in men and women combined by another.[7] In elite gymnasts, stress fractures comprised 18.3% of overuse injuries in women and 9.2% in men.[19] It seems that the relative frequency of stress fractures is greater in female than in male athletes. The variation in results probably reflects differences in the composition of each case series.

STRESS FRACTURE CHARACTERISTICS

Athletes

Stress fractures are most common in bones of the lower extremity, but also occur in non-weightbearing bones, including the ribs, upper limbs, and pelvis. Numerous studies have reported the anatomical distribution of series of stress fracturess (Table 3).* Although there is great variation in the percentage of stress fractures reported at each bony site, the most common sites appear to be the tibia, metatarsals, and fibula. A number of factors may influence the reported distributions of stress fractures, including type and level of activity, gender, age, and in particular, method of diagnosis. For example, tarsal navicular stress fractures are rarely evident on radiographs. Thus, these will be underreported in comparison with stress fractures at other sites if diagnosis is confined to radiographs.

Stress fractures develop at skeletal sites that are subjected to repetitive mechanical loading during a particular activity. The site specificity of stress fractures was illustrated in a recent prospective study in 95 track and field athletes.[6] Although stress fracture incidence rates were similar in power and endurance athletes, the site distribution differed. Power athletes sustained significantly more foot fractures whereas endurance athletes sustained more long bone and pelvic fractures. The percentage of distribution of sports among the five most common sites in a series of 180 stress fractures, is shown in Table 4.[9] Dancers were the most common group who sustained metatarsal stress fractures; track

*References 1, 3, 6, 7, 10, 13, 16, 18, 23, 24, 26, 29, 32, 35, 41, 42, 48, 50.

Table 3. ANATOMIC DISTRIBUTION OF STRESS FRACTURES IN ATHLETES EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF STRESS FRACTURES IN EACH SERIES

Reference	Sport	No. of SF in Series	Diagnosis of SF	Tibia (%)	Fibula (%)	Metatarsal (%)	Navicular (%)	Femur (%)	Pelvis (%)
Brubaker and James, 1974[7]	Runners	17	NS	41.2	17.6	29.4	5.9	0	0
Orava, 1980[41]	Variety	200	Radiograph +/− BS	53.5	12.5	18.0	2.0	6.0	1.5
Pagliano and Jackson, 1980[42]	Runners	99	Self report	20.2	15.2	37.4	NS	NS	NS
Taunton et al, 1981[50]	Runners	62	Radiograph or BS	55.0	11.3	16.1	3.2	6.5	0
Clement et al, 1981[16]	Runners	87	NS	57.5	9.2	20.7	3.4	4.6	0
Sullivan et al, 1984[48]	Runners	57	Radiograph or BS	43.9	21.0	14.0	0	3.5	10.5
Barrow and Saha, 1986[1]	Runners	140	Self report	63.0	9.0	21.0	0.7	4.0	1.4
Hulkko and Orava, 1987[26]	Variety	368	Radiograph +/− BS	49.5	12.0	19.8	2.5	6.3	1.9
Matheson et al, 1987[35]	Variety	320	Bone scan	49.1	6.6	8.8	NS	7.2	1.6
Courtenay and Bowers, 1990[18]	Variety	108	Radiograph or BS	38.0	29.6	18.5	4.6	2.8	0.9
Ha et al, 1991[24]	Variety	169	Radiograph or BS	31.5	10.7	7.1	4.7	12.5	4.1
Cameron et al, 1992[13]	Runners	253	Self report	37.5	12.0	22.5	10.0	NS	NS
Benazzo et al, 1992[3]	Track and field	49	Radiograph, CT or BS	26.5	12.2	14.3	28.6	0	0
Kadel et al, 1992[32]	Ballet	27	Self report	22.0	0	63.0	NS	4.0	0
Goldberg and Pecora, 1994[23]	Variety	58	Radiograph or BS	18.9	12.1	25.9	NS	10.0	3.4
Johnson et al, 1994[29]	Variety	34	Radiograph +/− BS	38.2	0	20.6	11.8	23.5	0
Bennell et al, 1996[6]	Track and field	26	BS and CT	45.0	12.0	8.0	15.0	8.0	4.0
Brukner et al, 1996[9]	Variety	180	Radiograph, CT or BS	20.0	16.7	23.3	20.0	3.3	1.1

BS = bone scan; CT = computed tomography; NS = not stated; SF = stress fracture.

Table 4. PERCENTAGE DISTRIBUTION OF SPORTS AMONG THE MOST COMMON STRESS FRACTURE SITES

(*From* Brukner P, Bradshaw C, Khan KM, et al: Stress fractures: A review of 180 cases. Clin J Sports Med 6:85, 1996; with permission.)

and distance runners sustained the most tibial stress fractures whereas distance runners and dancers were prominent among fibula stress fractures. Track athletes were by far the most common among the navicular stress fractures. Pars fractures were seen in athletes in field events, racquet sports, cricket, dancing, and basketball. It is therefore apparent that different sports show typical patterns of stress fractures, and these are summarized in Table 5.[9] Other sports associated with certain stress fractures are rowing or golf (rib stress fractures), pitching (humeral fractures), and gymnastics (pars fractures).

Conditioned athletes may sustain different stress fractures to those unaccustomed to activity. In a series of 368 fractures, competitive athletes had stress fractures in the tibia significantly more often whereas recreational athletes had significantly more metatarsal and pelvic bone fractures.[26, 41] It has also been reported that females sustain more metatarsal,[26, 41] pelvic,[26] and navicular stress fractures[29] than males. Age differences may play a part, as Matheson et al[35] found significantly more femoral and tarsal stress fractures in older athletes and more tibial and fibular stress fractures in younger athletes; however, an interaction between age and site of stress fracture was not confirmed in another large series.[26]

Military Recruits

The location of stress fractures in military personnel has appeared to change over the years, probably as a result of changes in training, a

Table 5. SPORTS AND ACTIVITIES COMMONLY ASSOCIATED WITH DIFFERENT STRESS FRACTURE SITES

(*From* Brukner PD, Khan KM: Clinical Sports Medicine. Sydney, McGraw-Hill Book Company, 1993, p 17; with permission.)

greater emphasis on running instead of marching, in footwear (with athletic shoes often replacing combat boots), and in initial fitness levels with fitter recruits. Original reports primarily described injuries of the foot, with most diagnosed stress fractures occurring in the metatarsals[14, 27]; however, in the last two decades greater number of stress fractures have been found in the leg, particularly the tibia, and thus more closely approximating that which is observed in athletic populations. In a recent prospective study of 626 male US Marine Corp recruits, 27 stress fractures were sustained.[2] The most common site was the tibia (41%), followed by the metatarsals (26%), the femur (19%), and the tarsals (15%). The site distribution of stress fractures in military populations has been well reviewed by Jones et al.[31]

STRESS FRACTURE MORBIDITY

One way to assess stress fracture morbidity is the degree of disability. In their series of stress fractures in athletes, Hulkko and Orava[26] reported that 77% had symptoms only during training whereas 13% had symptoms in everyday life; sick leave was required in 10% of cases. Most other studies express stress fracture morbidity as the time taken until recovery, with recovery generally defined as return to sport or activity. Mean recovery times reported in case series have varied probably because of differences in the distribution of stress fracture sites. Benazzo et al[3] found a mean time of 4.4 months, and showed that this was directly related to the time between symptom onset and establishment of a diagnosis. Matheson et al[35] reported a mean recovery time of 12.8 weeks, with a range from 2 to 96 weeks. They found that tarsal stress fractures took the longest and femoral fractures the least; however, no correlation was evident between time to diagnosis and time to recovery.

Table 6 shows the percentage of stress fractures healed at different times according to site in a series of 368 stress fractures in athletes.[26] It is apparent that at some sites, such as the femoral neck, sesamoids, and middle third of tibia, recovery generally took more than 2 months; however, at other sites, such as the fibula and metatarsals, recovery took less than 2 months. Most stress fractures usually recover uneventfully. In a follow-up (of unspecified duration) of 51 runners with stress fractures, 82% were running symptom free, 16% had recurrent pain at the fracture site while running, and 2% ceased running due to recurrent pain.[48] Recruits who had suffered a stress fracture during a prospective study (n=66) were followed for a minimum of 1 year after basic training.[39] There was uneventful recovery in 47%, protracted recovery in 13.6%, recurrent stress fractures in new sites in 19.6%, intermittent

Table 6. PERCENTAGE OF STRESS FRACTURES HEALED AT DIFFERENT TIMES IN A CASE SERIES OF 368 STRESS FRACTURES IN ATHLETES

(*Adapted from* Hulkko A, Orava S: Stress fractures in athletes. Int J Sports Med 8:221, 1987; with permission.)

nonstress fracture bone pain (16.7%), and chronic stress fracture in 3%. Certain sites are prone to delayed or nonunion, and are more likely to prevent an individual from returning to previous activity levels. These sites include the anterior cortex and the tarsal navicular. For example, Khan et al[34] found that in navicular stress fractures, 86% of patients who had initial nonweightbearing cast immobilization treatment returned to sports compared with only 26% who continued weightbearing. Of those who were treated surgically, 73% were able to return to sport.

SUMMARY

Clinically, stress fractures appear to be a common overuse injury among athletes and in military recruits undertaking basic training; however, there is a lack of sound epidemiologic studies describing stress fracture occurrence in athletes. Few have directly compared stress fracture rates between sports to establish which poses the greatest risk for this injury. Furthermore, incidence rates, expressed in terms of exposure, have rarely been reported for stress fractures in athletes. Nevertheless, available data suggest that runners and ballet dancers are at relatively high risk for stress fractures. Although a gender difference in rates is clearly evident in military populations, this is less apparent in athletes. Other participant characteristics, such as age and race, may also influence stress fracture risk. The most common site of stress fracture in athletes is the tibia, although the site reflects the nature of the load applied to the skeleton. Stress fracture morbidity, expressed as the time until return to sport or activity, varies depending on the site. Generally, a period of 6 to 8 weeks is needed for healing; however, stress fractures at certain sites, such as the navicular and anterior tibial cortex, are often associated with protracted recovery and, in some cases, termination of sporting pursuits.

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