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Stress Fractures in Female Athletes

Diagnosis, Management and Rehabilitation

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Contents

Summary

Stress fractures are a common overuse injury among athletes. The incidence of stress fractures among females is higher in the military, but this difference is not as evident in the athletic population. The history of the patient with stress fracture is typically one of insidious onset of activity-related pain. If the patient continues to exercise, the pain may well become more severe or occur at an earlier stage of exercise. As well as obtaining a history of the patient's pain and its relation to exercise, it is important to determine the presence of predisposing factors. On physical examination, the most obvious feature is localised bony tenderness. Occasionally, redness, swelling or periosteal thickening may be present at the site of the stress fracture. The diagnosis of stress fracture is primarily a clinical one; however, if the diagnosis is uncertain, various imaging techniques can be used to confirm the diagnosis. In the majority of stress fractures, there is no obvious abnormality on plain radiograph. Although the triple phase bone radiograph is extremely sensitive, the fracture itself is not visualised and it may be difficult to precisely locate the site, especially in the foot. The radionuclide scan will detect evolving stress fractures at the stage of accelerated remodelling, so the findings must be closely correlated with the clinical picture. The characteristic bone scan appearance of a stress fracture is of a sharply marginated area of increased uptake, usually involving one cortex of the bone. Computerised tomography scanning is a helpful addition if the fracture needs to be visualised, or to distinguish between a stress reaction and stress fracture. Magnetic resonance imaging (MRI) is being used increasingly as the investigation of choice for stress fractures. The typical findings on MRI are of periosteal and marrow oedema, as well as fracture line. The basis of treatment of a stress fracture involves rest from the aggravating activity. Most stress fractures will heal in a straightforward manner, and return to sport occurs within 6 to 8 weeks. The rate of resumption of activity should be influenced by symptoms and physical findings. When free of pain, the aggravating activity can be resumed and slowly increased. It is important that the athlete with a stress fracture maintain fitness during this period of rehabilitation. The most commonly used methods are cycling, swimming, upper body weights and water running. There are a number of specific stress fractures that require additional treatment because of a tendency to develop delayed union or nonunion. These include stress fractures of the neck of the femur, anterior cortex of the tibia, navicular and second and fifth metatarsals. An essential component of the management of stress fractures, as with any overuse injury, involves identification of the factors that have contributed to the injury and, where possible, correction or modification of some of these factors to reduce the risk of the injury recurring. Stress fractures are more common in female athletes with menstrual disturbances. This may be due to the effect on bone density. The role of hormonal replacement in the management of these athletes is unclear at this stage.

A stress fracture is 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.[1]

While stress fractures appear to be a common overuse injury in athletes, the exact incidence in different sporting populations is not well documented due to a lack of sound epidemiological data.

It is often suggested that women sustain a disproportionately high number of stress fractures compared with men. This is consistently shown in military populations where the risk of stress fracture in female recruits ranges from 1.2 to 10 times that of men.[2-6] This increased risk persists even when training loads are gradually increased to moderate levels. Possible reasons for these findings include:

- lower bone density
- differences in gait
- more slender bones with lower moments of inertia
- unfavourable biomechanical conditions including a wide pelvis, coxa vara and genu valgum
- greater percentage of body fat loading the musculoskeletal system
- endocrine factors
- lower initial physical fitness.

However, a gender difference is not necessarily evident in athletic populations.[7-11] Studies allowing a direct comparison of stress fracture incidence in male and female athletes show either no difference or only a slightly increased risk for women[7-12] (table I). It is possible that during sporting participation, women can modify their activity levels to compensate. Nevertheless, it appears that stress fractures comprise a greater proportion of total injuries sustained in women than in men.[13,14]

1. Diagnosis

In the assessment of a patient presenting with a possible diagnosis of stress fracture, there are 3 questions that need to be answered:

- Is the pain bony in origin?
- If so, which bone is involved?
- At what stage in the continuum of bone stress is this injury?

Table I. Studies where the stress fracture rate in male and female athletes can be directly compared

Variable	Bennell et al.[11]	Brunet et al.[7]	Cameron et al.[8]	Johnson et al.[10]	Goldberg & Pecora[9]	Zernicke et al.[12]
Type of study	P	R	R	P	R	NS
Sport population	Track and field[a]	Runners[b]	Runners	Various[c]	Various[c]	Runners
Age (years)						
women	17-26	33	NS	≈18-22	≈18-22	≈18-22
men	17-26	39	NS	≈18-22	≈18-22	≈18-22
No. of participants						
women	53	375	263	321	≈1200	NS
men	58	1130	287	593	≈1800	NS
Observation period	12mo	History	History	2y	3y	12mo
Data collection point	Clinic	Q	Q	Clinic	Records	NS
Response rate (%)	NA	NS	67	NA	NA	NS
Stress fractures (%)						
women	21.7	13.2	26.6	6.9	≈2.7	20-25
men	20.4	8.3	28.0	2.0	≈1.4	10.0
Relative risk (women : men)	1.1	1.6	0.95	3.5	≈1.9[d]	2.2

a Competitive athlete.
b Mainly novices.
c Collegiate athletes.
d Population at risk was estimated, therefore providing an approximate incidence rate.
Abbreviations: NA = not applicable; NS = not stated; P = prospective; Q = questionnaire; R = retrospective.

To obtain an answer to these 3 questions a thorough history, precise examination and appropriate use of imaging techniques are used. In many cases the diagnosis of stress fracture will be relatively simple. In others, especially where the affected bone lies deeply (e.g. the femur) or the pattern of pain is nonspecific (e.g. the navicular), the diagnosis can present a challenge for the clinician.

2. History

The history of the patient with a stress fracture is typically one of insidious onset of activity-related pain. Initially, the pain will usually be described as a mild ache occurring after a specific amount of exercise. If the patient continues to exercise, the pain may well become more severe or occur at an earlier stage of exercise. The pain may increase to eventually limit the quality or quantity of the exercise performed or occasionally to force cessation of all activity. In the early stages, pain will usually cease soon after exercise. However, with continued exercise and increased severity of symptoms, the pain may persist after exercise. Night pain may occasionally occur.

As well as obtaining a history of the patient's pain and its relation to exercise, it is important to determine the presence of predisposing factors. Therefore, a training or activity history is essential. In particular, note should be taken of recent changes in activity level, such as increased quantity of training, increased intensity of training, changes in surface, equipment (especially shoes) and technique. It may be necessary to obtain information from the patient's coach or trainer. A full dietary history should be taken and particular attention should be paid to the possible presence of eating disorders. A menstrual history should be taken including age of menarche and subsequent menstrual status.

A history of previous similar injury or any other musculoskeletal injury should be obtained. It is essential to obtain a brief history of the patient's general health, medications and personal habits to ensure that there are no factors that may influence bone health. It is also important to obtain from the history an understanding of the patient's work and sporting commitments. In particular, it is important to know at what level and how serious the patient is about her sport and what significant sporting commitments are ahead in the short and medium term.

3. Physical Examination

On physical examination the most obvious feature is localised bony tenderness. Obviously, this is easier to determine in bones that are relatively superficial and may be absent in stress fractures of the shaft or neck of the femur. It is important to be precise in the palpation of the affected areas, particularly in regions such as the foot where there are a number of bones and joints in a relatively small area. Occasionally, redness and swelling may be present at the site of the stress fracture. There may also be palpable periosteal thickening, especially in a long-standing fracture. Percussion of long bones may result in the production of pain at a point distant from the percussion.

Joint range of motion is usually unaffected except in situations where the stress fracture is close to the joint surface, such as a stress fracture of the neck of the femur. Specific stress fractures may be associated with specific clinical tests. Examples of these are the hop test for stress fractures in the groin region, and hip extension while standing on the contralateral leg, which is used in the diagnosis of stress fractures of the pars interarticularis.

Some authors have suggested that the presence of pain when therapeutic ultrasound is applied over the pertinent area is of potential use in the detection of stress fractures.[15-17] Similarly, it is reported that application of a vibrating tuning fork to the affected bone and subsequent increase in pain is indicative of a stress fracture. We have not found these methods to be particularly helpful.

The physical examination must also take into account potentially predisposing factors, and, in all stress fractures involving the lower limb, a full biomechanical examination must be performed. Any evidence of leg length discrepancy, malalignment (especially excessive subtalar pronation), muscle imbalance, weakness or lack of flexibility should be noted.

4. Imaging

Imaging plays an important role in supplementing clinical examination to determine the answers to the 3 questions mentioned at the start of this article. In many cases a clinical diagnosis of stress fracture is sufficient. The classic history of exercise-associated bone pain and typical examination findings of localised bony tenderness have a high correlation with the diagnosis of stress fracture. However, if the diagnosis is uncertain, or in the case of the serious or elite athlete who wishes to continue training if at all possible and requires more specific knowledge of his or her condition, there are various imaging techniques available to the clinician.

4.1 Radiography

Radiography has poor sensitivity but high specificity in the diagnosis of stress fractures. The classic radiographic abnormalities seen in a stress fracture are new periosteal bone formation, a visible area of sclerosis, the presence of callus or a visible fracture line. If any of these radiographic signs are present, the diagnosis of stress fracture can be confirmed.

Unfortunately, in the majority of stress fractures there is no obvious radiographic abnormality. The abnormalities on radiography are unlikely to be seen unless symptoms have been present for at least 2 to 3 weeks. In certain cases, they may not become evident for up to 3 months, and some never become abnormal.

4.2 Isotopic Bone Scan (Scintigraphy)

If plain radiography demonstrates the presence of a stress fracture, there is seldom any need to perform further investigations. However, in cases where there is a high index of suspicion of stress fracture and a negative bone radiograph, the triple phase bone scan is the next line of investigation.

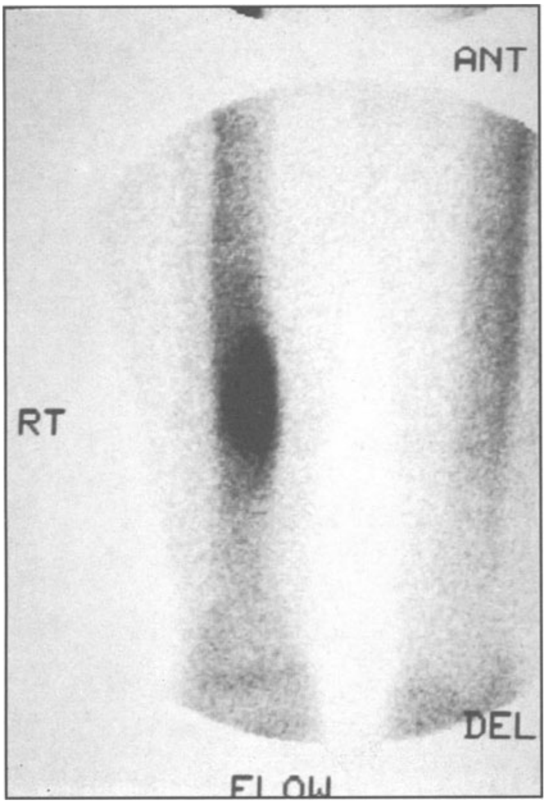

Fig. 1. Typical isotope bone scan appearance of stress fracture.

The bone scan is virtually 100% sensitive; at least twice as sensitive as x-ray[18] and consistently more sensitive than ultrasound,[19] thermography[20] and computerised tomography (CT).[21] In several studies, only 10 to 25% of bone scan–positive stress fractures had radiographic evidence of stress fracture.[22-26]

Changes on bone scan may be seen as early as 48 to 72 hours after the beginning of symptoms. The radionuclide scan may be positive as early as 7 hours after bone injury.[27]

The great disadvantage of bone scan is its lack of specificity; the fracture itself is not visualised and it may be difficult to precisely locate its site, especially in the foot. It also lacks specificity because other nontraumatic lesions such as tumour (especially osteoid osteoma), osteomyelitis, bony infarct and bony dysplasias can also produce localised increased uptake. It is therefore vitally important to correlate the bone scan appearance with the clinical features.

The radionuclide scan will detect evolving stress fractures at the stage of accelerated remodelling. At that stage, which may be asymptomatic, the uptake is usually of mild intensity, progressing to more intense and better defined uptake as microfractures develop.[27,28] This suggests that the pain associated with a stress fracture may not be present before the radionuclide scan becomes positive.

In stress fractures all 3 phases of the triple phase bone scan are positive.[29,30] Other bony abnormalities, such as periostitis (shin splints), are only positive on delayed images,[30,31] while certain other overuse soft tissue injuries would only be positive in the angiogram and blood pool phase, thus allowing us to differentiate between bony pathology and that involving soft tissue.

In the appropriate clinical setting, the scintigraphic diagnosis of a stress fracture is defined a focalised increase in uptake in the third phase of the bone scan. The characteristic bone scan appearance of a stress fracture is of a sharply marginated or fusiform area of increased uptake involving one cortex or occasionally extending the width of the bone[32] (fig. 1).

4.3 Computerised Tomography

CT may useful in differentiating those conditions with increased uptake on bone scan that may mimic stress fracture. These include osteoid osteoma, osteomyelitis with a Brodie's abscess and other malignancies.

CT scans are also particularly valuable in imaging fractures where this may be important in treatment. In particular, CT scanning of the navicular bone is extremely helpful[33,34] (fig. 2). It may also be valuable in detecting fracture lines as evidence of stress fracture in long bones (e.g. metatarsal and tibia) where plain radiography is normal and isotope bone scan shows increased uptake. CT scanning will enable the clinician to differentiate between a stress fracture (which will be visible on a CT scan) and a stress reaction. Particularly in elite athletes, this may considerably effect rehabilitation programmes and forthcoming competition programmes.

4.4 Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) does not image cortical bone as well as the CT scan, but has certain advantages in the imaging of stress fractures. Marrow haemorrhage and oedema (characteristically difficult findings with CT) are well visualised using MRI. Although CT scanning visualises bone detail, another advantage of MRI is in distinguishing stress fractures from a suspected bone tumour or infectious process.[35]

Specific MRI characteristics of stress fracture include: (i) new bone formation and fracture lines appearing as very low signal medullary bands that are contiguous with the cortex; (ii) surrounding marrow haemorrhage and oedema seen as low signal intensity on T1-weighted images and as high signal on T2-weighted and short T1 inversion recovery (STIR) images; and (iii) periosteal oedema and haemorrhage appearing as high signal intensity on T2-weighted and STIR images.[35] These changes are best seen if the MRI is performed within 3 weeks of the onset of symptoms.[36]

Fig. 2. Appearance of stress fracture of navicular with computerised tomography

5. Differential Diagnosis

The differential diagnosis of stress fracture can be divided into nonbony causes or bony causes. Nonbony causes in particular relate to muscle or tendon injury, either muscle strain, haematoma, delayed onset muscle soreness, tendon inflammation or degenerative change. Compartment syndrome, especially where it involves the anterior and deep posterior compartments of the lower leg, may mimic a stress fracture since these patients also present with exercise-related pain. Traction periostitis such as that previously termed shin splints or medial tibial stress syndrome may also mimic stress fractures, although the relationship of pain to exercise is different. The bone scan appearance of both compartment syndrome and periostitis differs from that of stress fracture.

Bony pathologies that can mimic stress fracture include tumour and infection. Osteoid osteoma is commonly mistaken for a stress fracture as it presents with pain and a discrete focal area of increased uptake on isotope bone scan. Two distinguishing features of osteoid osteoma are the presence of night pain and the relief of pain with the use of aspirin (acetylsalicylic acid).

6. Treatment

The basis of the treatment of stress fractures involves rest from the aggravating activity – a concept known as 'relative rest'. The length of time from a diagnosis of stress fracture to a full return to sport depends on a number of factors including the site of the fracture, the duration of the symptoms and the stage in the spectrum of bone strain. Most stress fractures with a relatively brief history of symptoms will heal in a straightforward manner and return to sport should occur within 6 to 8 weeks. However, there is a group of stress fractures that requires additional treatment to relative rest.

The primary aim of initial management of stress fracture is pain relief. This may involve the use of mild analgesics or nonsteroidal anti-inflammatory drugs (NSAIDs). In some cases where the activities of daily living are painful it may be necessary for the patient with a stress fracture to be non–weight bearing or partially weight bearing on crutches for a period of up to 7 to 10 days. In the majority of cases this is not necessary and mere avoidance of the aggravating activity will be sufficient.

The rate of resumption of activity should be modified according to symptoms and physical findings. At all times activity should be pain free and if any bony pain occurs then activity should be stopped for 1 to 2 days and then resumed at a lower level. The patient should be clinically reassessed at regular intervals; assessing in particular for bony tenderness.

When the activities of daily living are pain free, and there is no focal tenderness, resumption of the aggravating activity can occur on a graduated basis. For lower limb stress fractures where running is the aggravating activity, we recommend a programme that initially involves brisk walking increased by 5 to 10 minutes per day up to a length of 45 minutes. Once this is achieved without pain, we recommend introducing a period of 5 minutes' slow jogging within the 45-minute walk. Assuming that this increase in activity does not reproduce the patient's symptoms, the amount of jogging can be increased on a daily basis until the whole 45 minutes is completed at jogging pace. Once this is achieved, strides can introduced, initially half pace then gradually increasing to full pace striding. Once full pain-free sprinting is achieved, functional activities such as hopping, skipping and jumping, twisting and turning can be gradually introduced. It is important that this process is a graduated one and to err on the side of caution.

Progress should be clinically monitored by the presence or absence of symptoms and local signs. It is not necessary to monitor progress by radiography, scintigraphy, CT or MRI. Radiological healing often lags behind clinical healing.

6.1 Fitness Maintenance

It is important that the athlete with a stress fracture be able to maintain strength and cardiovascular fitness while undergoing the appropriate rehabilitation programme. It should be emphasised to the athlete that the rehabilitation programme is not designed to maintain or improve her fitness, but rather to allow the damaged bone time to heal and gradually develop or regain full strength. Fitness should be maintained in other ways.

The most common methods are cycling, swimming, water running and using upper body weights. These work-outs should as much as possible mimic the athlete's normal training programme in both duration and intensity. Water running is particularly attractive to runners for this reason. It involves the use of a vest as a flotation device.

Stretching should be performed to maintain flexibility during the rehabilitation process. Muscle strengthening is also an important component of the rehabilitation phase.

As well as maintaining these parameters of physiological fitness, it is possible in most cases for the athlete to maintain specific sports skills. In ball sports these can involve activities while either seated or standing still. This active rest approach also greatly assists the athlete psychologically.

6.2 Modification of Risk Factors

As with any overuse injury, it is not sufficient to merely treat the stress fracture itself. An essential component of the management an athlete's overuse injury involves identification of the factors that have contributed to the injury and, where possible, correction or modification of some of these factors to reduce the risk of the injury recurring.

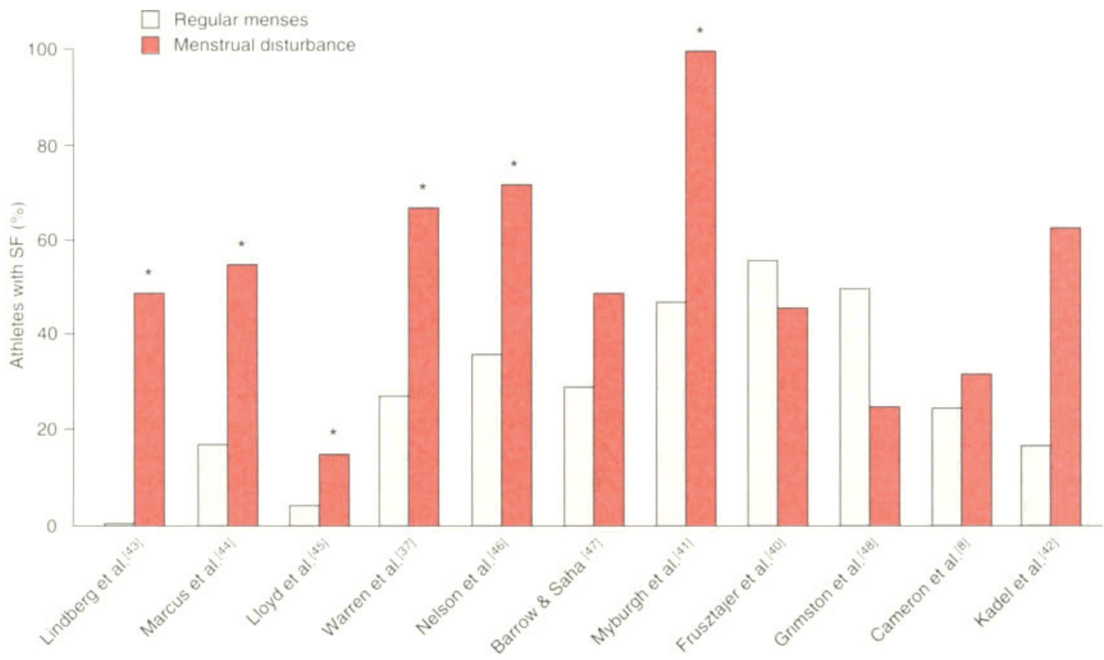

Fig. 3. Cross-sectional studies where the percentage of athletes with stress fractures (SF) could be compared in groups with and without menstrual disturbances. *Symbol:* *$p < 0.05$.

The fact that stress fractures have a high rate of recurrence is an indication that this part of the management programme is often neglected.

A number of risk factors for the development of stress fractures have been suggested. While it is beyond the scope of this article to discuss these in detail, they include:
- genetic predisposition
- menstrual disturbances
- low bone density
- bone geometry
- dietary insufficiency
- biomechanical abnormalities
- training errors.

The most important of these precipitating factors are probably training errors. Therefore, it is important to identify these and to discuss them with the athlete and, where appropriate, her coach. Another important contributing factor may be inadequate equipment, especially running shoes. These shoes may be inappropriate for the particular foot type of the athlete, may have generally inadequate support or may be worn out.

Numerous studies have been performed examining the relationship between stress fractures and menstrual disturbances. These studies are summarised in figure 3. They suggest that stress fractures are more common in athletes experiencing menstrual disturbances. The relationship between age of menarche and risk of stress fracture is uncertain. Some authors have found that athletes with stress fractures have a later age of menarche,[37-39] while others have found no difference.[40-42] In our prospective study,[11] we found that age of menarche was an independent risk factor for stress fracture, with the risk increasing by a factor of 4.1 for every additional year of age at menarche.

It is widely believed that the higher incidence of menstrual disturbance in female athletes with stress fracture is a direct result of decreased bone mineral density in athletes with menstrual disturbances. However, these women also exhibit other risk factors such as lower calcium intake,[49] greater training load[50] and differences in soft tissue composition.[51] Since these were not always controlled for in studies, it is difficult to ascertain which are the contributory factors.

The role of hormone replacement in the management of female athletes with stress fractures who have menstrual disturbances and/or lowered bone mineral density is unclear at this stage. Further prospective studies need to be performed.

Biomechanical abnormalities are also thought to be an important contributing factor to the development of overuse injuries in general and stress fractures in particular. Both excessively supinated and excessively pronated feet can be contributing factors to the development of stress fractures. Excessively supinated feet generally give poor absorption and require footwear that gives good absorption. Athletes with excessively pronated feet require appropriate footwear for their foot type and also may require the use of custom-made orthotics.

It is important that by the time the athlete resumes training these risk factors are corrected. When training resumes, it is important to allow adequate recovery time after hard sessions or hard weeks of training and, in view of the history of stress fracture, it is advisable that some form of cross-training (e.g. swimming and cycling for a runner) be introduced to reduce the stress on the previously injured area and thus the likelihood of a recurrence.

6.3 Stress Fractures Requiring Specific Treatment

While the majority of stress fractures will heal without complications in a relatively short time, there are types of stress fractures which require specific additional treatment. These include those at the neck of the femur,[52] the anterior cortex, mid-shaft tibia,[53-56] the navicular,[57] the fifth metatarsal or Jones's fracture[58,59] and the base of the second metatarsal.[60,61]

7. Conclusion

Stress fractures are a frequent problem in female athletes, although it is uncertain whether they are more susceptible than their male counterparts. Clinically, stress fractures present with a typical history of exercise-related pain and examination findings of a focal area of bony tenderness. The diagnosis can be confirmed with the use of one or more imaging techniques. Treatment of most stress fractures is relatively straightforward and involves rest from the aggravating activity, gradual resumption of that activity and modification of risk factors. Certain risk factors for the development of stress fractures have been identified. Future directions should involve evaluation of interventions such as hormonal replacement in the female athlete with menstrual abnormalities, biomechanical correction and muscle-strengthening programmes. The adoption of sensible training regimens will also help reduce the incidence of stress fractures.

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