# BONE STRESS INJURIES IN THE ARMY CADETS OF PAKISTAN MILITARY ACADEMY

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**Background:** Bone stress injuries are common among army cadets during training period and these injuries give rise to morbidity and loss of training hours. Some cadets with stress fractures re-join their duties while some are kept out of services resulting in attrition and economic loss. A retrospective analysis of bone stress injuries of one hundred and twenty cadets between June 2006 and Dec 2007 was conducted from the case documents available at Institute of Nuclear Medicine, Oncology & Radiotherapy (INOR) Abbottabad. **Results:** The occurrence of stress fractures among cadets at Pakistan Military Academy, presenting with exercise induced pain was 68.3% amongst these cadets. Seventy fours percent f the fractures were labelled grade-I. High grade fractures were confined to tibia. Tibia was the commonest site of stress fractures in both sexes, accounting for about 73% of all stress fractures. Fifty percent of these patients were labelled as having shin splints and 3% as thigh splints. **Conclusions:** Most of the stress injuries were confined to the tibia. The referral was considered early as most of the stress injuries were of low grade.
**Keywords:** Bone Stress, Stress fractures

## INTRODUCTION

Bone stress injuries may be fatigue fractures, which occur after application of abnormal, repetitive stress to normal bone with normal elastic resistance, and insufficiency fractures, which result when normal stress is exerted on abnormal bone with deficient elastic resistance.[1,2] Pathophysiology of bone stress injuries represents a wide spectrum of events from accelerated remodelling to stress fracture.[3]

According to Wolff's Law, intermittent forces applied to bone stimulate remodelling of its architecture to withstand the new mechanical environmental optimally.[4,5] In the cortical bone, the stresses related to normal daily physical activities stimulate the remodelling processes, which occur at the osteoids. What exact mechanism activates this process is not known, but some studies have indicated that it is related to the development of micro fractures. The initial response to an increase in stress is the osteoclastic resorption, which leads to small resorption areas at the site of the micro fractures. This happens approximately 3 weeks after peak bone loss.[6] The resorption cavities formed are subsequently filled with lamellar bone, but the formation of bone is slower than its resorption, taking at least 90 days. This outcome of an imbalance between resorption and formation of bone result in bone weakening.[7,8] Endosteal and periosteal proliferation may produce new bone formation at the site of stress in an apparent attempt to buttress the temporarily weakened cortex.[7] In cancellous bone, the stress may result in micro fractures of the trabeculae, and micro callus is produced along these microfractures.[6] This physiologic phenomenon of micro damage becomes pathologic when the repair mechanisms are exceeded. This pathological process results in accumulation of micro damage and a subsequent fatigue stress injury of cancellous or cortical bone.[8,9] If the inciting activity is reduced, the damage may heal prior to the development of a true fracture.[10]

The general symptom of a bone stress injury is pain related to increased physical activity. Pain typically begins after a march, run, or exercise and becomes more intensive if the physical activity continues. Pain generally disappears with rest. When bone stress injuries become more severe, pain can progress and become constant. The pain is mainly local, but may be radiating or more diffuse. The onset of pain can be acute or insidious. In the acute form, the patient can identify the exact time when the pain begun, but in insidious cases it usually develops within 2 to 3 weeks.[11]

The sensitivity, the specificity of bone scintigraphy in stress fractures reaches 100% despite its low spatial resolution. In conventional bone scintigraphy, only delayed scans are used, obtained 2 to 4 hours after intravenous injection of the radiopharmaceutical. By this time, urinary excretion of the radiopharmaceutical has cleared substantially all the soft tissue activity. The delayed scan therefore demonstrates uptake only in the osseous structures. To increase the specificity of the bone scintigraphy, three-phase bone scintigraphy can be used to differentiate between osseous and soft tissue pathologies.[12,13]

The aim of the study was to evaluate the occurrence, site and grade of stress fractures in the army cadets presenting with exercise induced lower limb pains.

## MATERIALS AND METHODS

A total of 120 male and female military recruits, aged 18–23 year (mean 21 year), complaining of gradual onset of localized bone pain and/or swelling and limping, were referred by Combined Military Hospital

Abbottabad, for bone scintigraphy, from June, 2006 to December, 2007. Bone stress injuries were suspected after excluding bone trauma.

The bone scans were performed using a large field-of-view gamma camera and a parallel hole, high-resolution collimator, 3 to 4 hour following iv injection of 20 mCi technetium-$^{99m}$ methylene diphosphonate. The scans routinely included spot images of anterior and posterior views of the pelvis, anterior and lateral views of lower extremities, and anterior and posterior views axial skeleton. For each view 750 Kcounts were collected with single head gamma camera loaded with Low Energy General Purpose (LEGP) collimator.

Stress fracture lesions demonstrated on bone scintigraphy were classified into clinical and scintigraphic parameters. Comparison was made of the painful bone sites reported by the subject and the scintigraphy picture, and four nuclear physicians with consensus carefully evaluated the lesions.

Stress fracture scintigraphic patterns were classified into four grades of bone response according to dimension, bone extension, and tracer concentration in the lesions (Figure-1)[14]:

1. Grade I: Small, ill-defined lesion with mildly increased activity in the cortical region.
2. Grade II: Larger than grade I, well-defined, elongated lesion with moderately increased activity in the cortical region.
3. Grade III: Wide fusiform lesion with highly increased activity in the cortico-medullary region.
4. Grade IV: Full thickness bone lesion with intense tracer uptake in the trans-cortical bone.

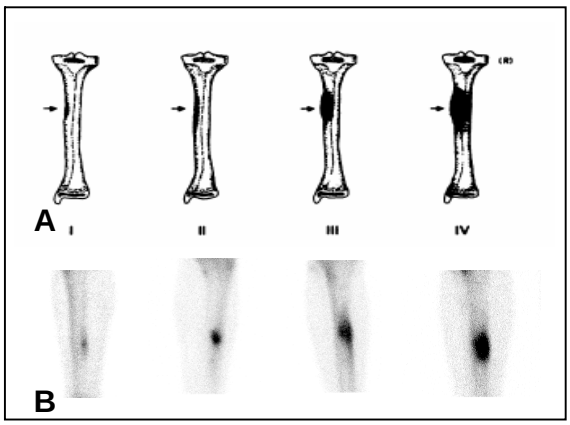


**Figure-1: Classification of stress fractures**
A: Sketch representing grade-I–IV stress fractures. B: Scintigraphs showing corresponding grades of stress fractures.

Shin splints and thigh splints were labelled when there is linear uptake along the border of long bone, covering more than 1/3 of the bony length.

## RESULTS

A total of 82 cadets, out of 120 were clinically and scintigraphically diagnosed as cases of stress fractures, providing an overall incidence rate of 68.3% amongst the selected cadets. A total of 123 stress fracture sites are observed. Seventy four percent of the fractures were recorded as grade-I fractures (91 fracture sites), 12% as grade-II (15 fracture sites), 8% as grade-III (10 fracture sites) and 6% as grade-IV (7 fracture sites) (Figure-2)

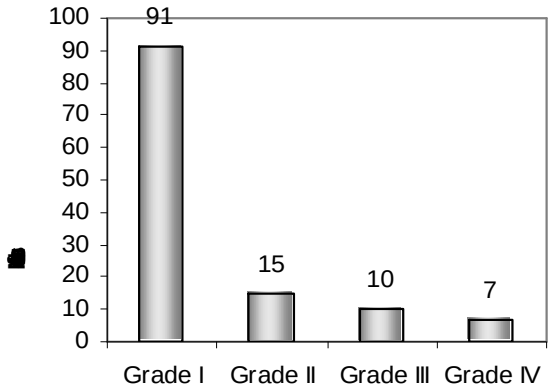


**Figure 2: Stress fractures in grades observed in the study population.**

Most of the fractures were seen in the tibiae, accounting for about 73% of all the fractures (88 fracture sites), followed by the femuri, accounting for about 21% of fractures (26 fracture sites). Six percent of the fractures were seen in the hips, especially the inferior rami and feet (Figure-3).

Out of a total of 88 fracture sites in the tibiae, 45% (40 fracture sites) were found in the upper third, 41% (36 fracture sites) in the middle third and only 14% (12 fracture sites) in the lower third.

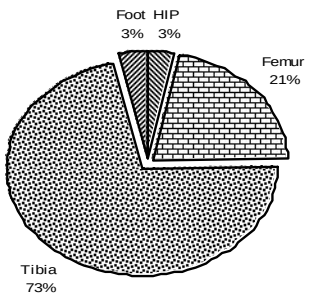


**Figure 3: Occurrence of stress fractures at various sites of the lower limb in percent distribution.**

The high grade fractures were seen only in the tibiae. The tibial fractures constitute 100% of grade-III and grade-IV fractures, 93% of grade-II fractures and 46% of grade-I fractures while the femuri constitute 7% of grade-II and 29% of grade-I fractures (Figure-4).

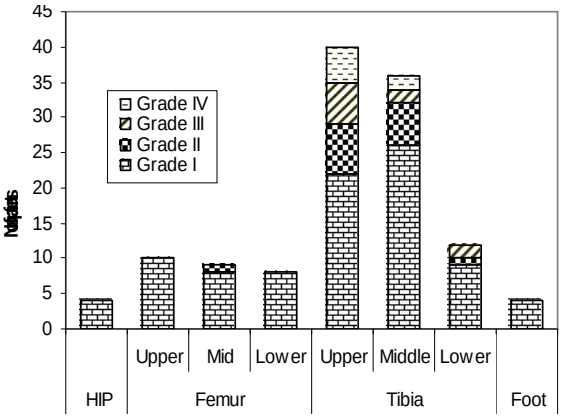


**Figure 4: Distribution of stress fracture in various parts of the lower limb, along with its grades**

Splints were observed in about 53% of the patients (64 out of 120), out of which 94% showed shin splints (60 patients) and 6% showed thigh splints (4 patients) (Figure-5). Except 2 patients, other patients showed bilateral shin or thigh splints. Out of total of 120 subjects, 103 (86%) showed abnormal increased uptake in the knee joints, ankle joints or feet.

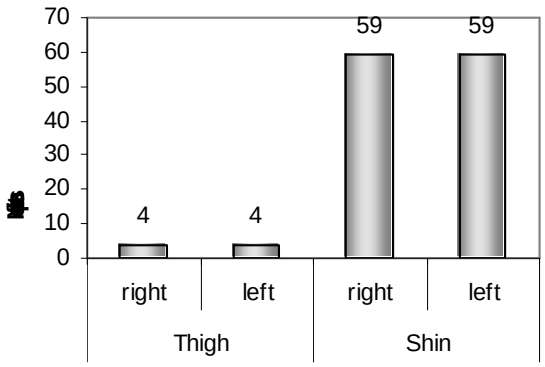


**Figure-5: Shin splints and thigh splints observed in the study population**

## DISCUSSION

Stress bone injuries are very common in army personnel, especially in the army recruits during their basic military training. The inherently high contrast resolution of the bone scintigraphy leads to rapid detection of the changes following trauma at the nascent stage. Such changes precede structural abnormalities and therefore can be detected earlier than plain radiography and computed tomography (CT) and in a similar time course to magnetic resonance imaging (MRI).[15]

The incidence of bone stress injuries varies in various army recruits, depending on the differences in military branches, training programs, sports, length of activity, physical rigor, equipment, case definition, and methodology.

In the Finnish Defence Forces, the incidence of bone stress injuries has ranged from 1.0% to 24.5% depending on the military branch and training program.[16] In the U.S. armed forces, this incidence ranges from 0.2 to 4.0% for male recruits and for female recruits from 1 to 7%.[17-21]

In the current study, approximately 68% of the cadets under study showed some degree of stress fractures. Most of these fractures were low grade, as 74% of the fracture sites were labelled as grade-I and only 7% of the these sites were labelled as grade-IV stress fractures.

The tibia and the fibula are the most common sites of bone stress injury, accounting for 40% to 70% of all cases, and are most commonly seen in long distance running and military training. After the tibia and fibula, the bones of the foot are the next most common site, accounting for 20% to 35% of all cases, and are most commonly associated with marching, stamping on the ground, and long-distance running. Bone stress injuries above the knee are rarer; the incidence ranges from 10% to 20%.[16-21]

In the current study we noted that approximately 73% of the fractures were confined to the tibiae. The second most commonly involved bone was femur, accounting for about 21% of all fracture sites that shows the high incidence of stress fractures in the long bones of the lower limb. Further more, the high grade fractures (grade-III and grade-IV fractures) were observed confined to the tibia, suggestive of high stress to the bone in these young cadets.

Shin splints appeared as diffuse non-focal periosteal uptake, mild in intensity, along the anterolateral border of the tibiae, extending along the proximal two-thirds of the bone shaft. Stress fractures, on the other hand, were always located along the medial cortex, focal, single or multiple, elongated, fusiform, or transverse areas of increased uptake.[21]

In the current study, it is observed that 50% of these cadets were labelled as having shin splints and approximately 3% having thigh splints, with or without stress fractures.

## CONCLUSIONS

The study showed the following conclusions:

1. Most of the army recruits are sent early for the management as most the stress injuries are of low grade.
2. Tibia is the most commonly involved bone and most of the high grade fractures are confined to the bone.
3. Shin splints are common; however thigh splints are also seen.

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