Research Article / Araştırma Makalesi

Spor Hekimliği Dergisi, 55(1):14-20;2020
Turkish Journal of Sports Medicine
DOI: 10.5152/tjsm.2020.154

Bilateral Tibial Stress Injuries in Recreational Athletes of Army

Rekreasyonel Asker Sporcularda Bilateral Tibia Stres Yaralanmaları

Aslı Ayan[1], Aydan Örsçelik[2]

[1]*Nuclear Medicine Department, Gülhane Training and Research Hospital, University of Health Sciences, Ankara, Turkey*
[2]*Sports Medicine Medicine Department, Gülhane Training and Research Hospital, University of Health Sciences, Ankara, Turkey*

ABSTRACT

Objective: Lower extremity stress injuries cause moderate to severe functional restrictions that frequently preclude attendance in sports, recreational and occupational activities involving vigorous, repetitive lower limb training. The purpose of this study is to evaluate the relation between diagnosis and symptom duration and exercise periods in cases with bilateral stress injuries diagnosed by physical examination and radionuclide imaging.

Materials and Methods: Twenty-five patients pre-diagnosed with bilateral stress injuries, aged between 19 and 35 years (3 female, 22 male) were enrolled in this study. Patient anamnesis, demographic information, the time span of painful period, duration of exercise per week, bones scans and SPECT/CT findings were evaluated. Stress injury groups were identified as bilateral shin splints (SS), bilateral stress fractures (SF), shin splint and stress fractures (SS+SF) according to their uptake properties on three phase bone scan (TPBS) and SPECT/CT images and physical examination findings.

Results: There were no statistically significant differences between the groups according to age, and duration of symptoms ($\chi2 = 3,327$, $p=0,344$).

Conclusion: Bilateral stress injury is a rare condition in military personnel and athletes. Duration of exercise seems to be the major risk factor for the stress injury development.

Keywords: Stress fractures, Medial Tibial Stress Syndrome, recreational athlete

ÖZ

Amaç: Alt ekstremite stres yaralanmaları, güçlü, tekrarlayan alt ekstremite antrenmanını içeren spor, rekreasyonel ve mesleki aktivitelere sık sık katılımı engelleyen orta ila şiddetli fonksiyonel kısıtlamalara neden olur. Bu çalışmanın amacı, fizik muayene ve radyonüklid görüntüleme ile tanı konan bilateral stres yaralanmalı olgularda tanı ve semptom süresi ile egzersiz süreleri arasındaki ilişkiyi değerlendirmektir.

Gereç ve Yöntemler: İki taraflı bacak ağrısı olan ve bilateral stres yaralanmalası düşünülen, 19 - 35 yaşları arasında (3 kadın, 22 erkek) 25 hasta çalışmaya dahil edildi. Hasta anamnezleri, demografik bilgiler, ağrılı süre, haftada egzersiz süresi, kemik taraması ve SPECT / CT bulguları değerlendirildi. Stres yaralanması grupları, üç faz kemik taraması (TPBS) ve SPECT / CT görüntüleri ile fizik muayene bulgularına göre bilateral shin splint (SS), bilateral stres kırıkları (SF), shin splint ve stres kırıkları (SS + SF) olarak tanımlandı.

Bulgular: Gruplar arasında yaş ve semptom süresine göre istatistiksel olarak anlamlı fark saptanmadı ($\chi2 = 3,327$, $p = 0,344$).

Sonuç: Bilateral stres yaralanması askeri personelde ve sporcularda nadir görülen bir durumdur. Egzersiz süresi bilateral stress yaralanması gelişiminde ana risk faktörü olabilir.

Anahtar Sözcükler: Stres kırığı; Medial Tibial Stres Sendromu, rekreasyonel sporcu

A. Ayan
0000-0001-6311-1785

A. Örsçelik
0000-0002-8610-8869

Geliş Tarihi/Date Received:
28.02.2019

Kabul Tarihi/Date Accepted:
14.05.2019

Yayın Tarihi/Published Online:
01.10.2019

Yazışma Adresi / Corresponding Author:
Aydan Örsçelik
Sağlık Bilimleri Üniversitesi
Gülhane Tıp Fakültesi, Ankara, Turkey

E-mail:
aydanozcan@yahoo.com

Available at: http://journalofsportsmedicine.org and http://dx.doi.org/10.5152/tjsm.2020.154
Cite this article as: Ayan A, Orscelik A. Bilateral tibial stress injuries in recreational athletes of army. *Turk J Sports Med.* 2020;55(1):14-20.

INTRODUCTION

Lower limb pain associated with a spontaneous activity, particularly around the tibia region, is an important disorder in army recruits and athletes (1). Lower extremity stress injuries cause moderate to severe functional restrictions that frequently preclude attendance in sports, recreational and occupational activities involving vigorous, repetitive lower limb training (2,3). Chronic repetitive training may result as bone stress injuries. Bone stress injuries can vary from a stress reaction to a cortical fracture. These are more frequent in specific athletic populations especially in long distance runners. Although these injuries are responsible from 10% of all sports injuries, bilateral involvements are quite rare (4,5). Pain can occur as a result of excessive exercises which usually ends up with pathologic situations. These may comprise soft tissue injuries with bone remodeling defects. Bone remodeling defects lead to bone stress reactions and/or stress fractures (1). Comprehensive knowledge about this problem will provide a better understanding and developing new prevention or treatment strategies.

Shin splint (SS) is a common recurrent stress injury of the lower extremity (6). It is characterized by diffuse periostitis of medial tibial surfaces. The most frequent site is middle and distal thirds of the tibial medial edge (6,7). Etiopathology of this problem remains unclear. Any active athlete with lower extremity pain due to exercise can have a stress reaction. This reaction can proceed to a fracture (1). Stress fracture (SF) is a common pathology that come upon in many patient demographics (8). There is a balance among damage accumulation and remodeling activity. This balance results in the skeletal integrity under normal conditions (1). The fatigue fracture appears by an abnormal repetitive load onto normal bone. Also, it appears throughout a sudden rise in duration, frequency or intensity of training when osteoclastic bone resorption is more than osteoblastic replacement. The fatigue fracture type of SF is usually seen in active young individuals such as recreational athletes or army recruits (7). Army recruits are the first patient group diagnosed with stress injuries, by the Prussian army physician Breithaupt in 1855. He defined SF in army recruits as "a syndrome characterized by edematous and painful feet following long marches." Since then many stress fracture reports have been published, primarily in army recruits (9).

The X-ray examinations are the first radiodiagnostic tools that have a low sensitivity (approximately 10%) in early stages. If standard radiographs are negative in the presence of clinical signs compatible with stress injury, they should be supported by other diagnostic studies (10). Radionuclide bone scan may detect early changes even at the stress reaction level of these injuries (1,11). Bone scintigraphy detects pathologic bone responses that appears in the periost at the early stages of injury. Bone single photon emission computed tomography (SPECT) combined with computed tomography (SPECT/CT) has some advantages compared with other imaging techniques. It displays metabolic and anatomic changes together. It readily allows assessment of joints or skeleton parts during the same study which are suspected as pathologic (12).

The purpose of this study is to evaluate the relation between diagnosis and symptom duration and exercise periods in cases with bilateral stress injuries diagnosed by physical examination and radionuclide imaging.

MATERIAL AND METHODS

Twenty-five patients suffering bilateral leg pain aged between 19 and 35 years (3 female, 22 male) were enrolled in this study. Recreational athletes were officers, petty officers and cadets who were performing regular exercise, especially running as a part of the army physical fitness program. Military personnel who were not currently involved in the army's competitive sports teams and performing similar sports activities were included in the study. Biomechanical problems such as pes planus, hallux valgus, pathological Q angle were checked and patient who had any of these conditions were dismissed. Running activities in the morning were performed by army boots, whereas physical education lessons and other sports activities were done with sports shoes. A three-phase dynamic Tc99m - MDP bone scintigraphy and SPECT/CT have been implemented to these patients between January 2014 and May 2016. The study protocol was approved by decision number 50687469-1491-422-16/1648-1535 of Gülhane Hospital Institutional Ethics Committee.

Patient anamnesis, demographic information, the time span of painful period, duration of exercise per week, bones scans and SPECT/CT findings were evaluated. Stress injury types were identified as SS or SF according to their uptake properties and intensity on three-phase dynamic scan images and SPECT/CT findings. If there were subtle, ambiguous uptake or existence of uptake in other sites rather than legs on whole-body images, an additional SPECT/CT scan was also performed.

Patients were divided into four groups as bilateral SF (SF, n=9), bilateral SS (SS, n=8), one leg SF and other leg SS (SF+SS, n=4), negative bone scan group (NBS) (n=4). Age, symptomatic period, weekly exercise time, and SPECT/CT findings were statistically analyzed.

Three-phase Tc99m-MDP dynamic bone scintigraphy and SPECT/CT imaging protocol: Following intravenous injection of 740 MBq of Tc99m - MDP (methylene-diphosphonate) image acquisition was performed by a dual-head gamma camera equipped with a low-energy high-resolution collimator (Discovery NM / CT 670, GE Healthcare). Initial dynamic imaging of the blood flow (perfusion) phase (60 frames of 2 seconds each, 64×64 matrix size) started after visualization of the tracer activity in suspected locations post injection. After the dynamic perfusion phase, blood pool image and a whole-body screening were taken at 3rd-4th hours after injection for 10 minutes in an imaging was acquired for 5 minutes in a 256×256 sized matrix.

We used the Discovery NM / CT 670 (GE Healthcare) system for SPECT / CT scans. The SPECT scans were acquired using low-energy high-resolution collimation, 180° tomography, a 64×64 matrix of 4.8 mm pixel size and 30 steps of 20 seconds in a continuous-rotation mode. Subsequent to the SPECT acquisition, a low-dose CT scan was acquired with 120 kV and 20 mAs using adaptive dose modulation. The CT data were generated with a 5-mm slice thickness using a smooth reconstruction kernel. SPECT reconstruction was performed using Flash3D. Flash3D is an ordered subset expectation maximization (OSEM) reconstruction algorithm with depth-dependent 3D (axial and transaxial) resolution recovery, scatter correction using scatter window subtraction (dual-energy window approach) and attenuation correction based on attenuation maps derived from the CT data filtered with the B08s kernel. The OSEM SPECT reconstruction used four subsets and eight iterations without post-smoothing.

A nuclear medicine physician who had the information about patient history and physical examination findings separately interpreted planar bone scintigraphy and SPECT / CT images. All patients were visually evaluated for any asymmetric tracer uptake in the suspected location. A focal or linear increased uptake in tibial bones on any of the three phases as compared to the other sites of bone was considered as a positive sign.

Patients having increased activity of perfusion and/or blood pool phases on three-phase bone scan, intense focal uptake on delayed phase, visible fracture line or cortical thickening on CT component of SPECT/CT images diagnosed as SF. Patients with linearly increased perfusion and/or blood pool phases activity of three-phase bone scan, linear activity accumulation on delayed static phase; without cortical thickening on SPECT/CT's CT component of images were accepted as SS.

Statistical analysis

Data analysis was performed by SPSS (Statistical Package for Social Science) for Windows 15.0. Descriptive statistics were defined as a mean ± standard deviation with minimum - maximum values for continuous variables; case number (n) and percentage (%) for categorical variables. Suitability of continuous variables to the normal distribution was measured with the Kolmogorov-Smirnov test. Kruskal-Wallis test was used for continuous variables, Chi-Square test for categorical variables in the comparisons between groups. Values of $p<0.05$ were accepted as statistically significant.

RESULTS

There were no statistically significant differences between the groups according to age and duration of symptoms (Table 1), (χ^2 = 3,327, p=0,344).

All the patients with bilateral lower extremity pain were performers of the army physical fitness program for 5 hours or more. 100% of SS+SF, 78% of SF, 75% of SS and 50% of NBS group patients performed sports 10 hours or more, and this is correlated with symptom durations of the groups (19±22, 13.3±15.9, 11±7.4 and 6±6.7, respectively). The results of the percentage of weekly exercise duration in the groups and their statistical comparison were shown in Table 2. SPECT/CT images revealed unilateral second metatarsal SF in one patient, and a knee fibroxanthoma in a patient of NBS group, a calcaneocuboid SF was present in a patient of SF+SS group.

Table 1. Mean age and duration of symptoms in patient groups

Groups	SF (n=9) (Mean±SD)	SS (n=8) (Mean±SD)	SF/SS (n=4) (Mean±SD)	NBS (n=4) (Mean±SD)	Test Statistics
Age (years)	22,66±3,60	22,25±5,23	20,75±0,96	25,25±5,44	χ^2 = 4,048* p=0,256
Duration of symptoms (weeks)	13,33±15,90	11,00±7,40	19,00±22,00	6,00±6,73	χ^2 = 3,327 p=0,344

SS: Bilateral shin splints; SF: Bilateral stress fractures; SS+SF: Shin splint and stressfractures; NBS: Negative bone scan group
**Kruskal Wallis test Test Statistics Value*

Table 2. Percentage of weekly exercise duration in the groups.

Exercise per week	SF (n, %)	SS (n, %)	SF+SS (n, %)	NBS (n, %)
1-5 hours	0, 0	0, 0	0, 0	0, 0
5-10 hours	2, 22	2, 25	0, 0	2, 50
More than 10 hours	7, 78	6, 75	4, 100	2, 50
Total (n, %)	9, 100	8, 100	4, 100	4, 100

SS: Bilateral shin splints; SF: Bilateral stress fractures; SS+SF: Shin splint and stress fractures; NBS: Negative bone scan group

DISCUSSION

It is of great importance to find out the exact diagnosis and the nature of the lesions causing pain to plan the proper treatment in patients with bilateral stress injuries.

Nye et al. reported 414 cases of USA Air Force trainees having a final diagnosis of a stress fracture on bone scan (13). They showed only 66.4% of stress fractures at the symptomatic site, 21% elicited at both symptomatic and asymptomatic sites, and 5.8% had in asymptomatic sites (13). We evaluated the recreational athletes with bilateral leg pain and seen that 84% of the cases had stress injury in the symptomatic location, 4% was negative in the symptomatic site but positive in an asymptomatic location, 4% had stress injuries both in the symptomatic and asymptomatic site.

Lower limb pain, especially around tibia is an important disorder in army recruits and recreational athletes. On the other hand, they may have sports-related stress injuries in other sites rather than legs and also systemic or local pathologies may imitate stress injuries. In this study, SPECT/CT images revealed stress injuries in other sites than legs, systemic or locoregional pathologies in 12% of the patients (unilateral second metatarsal stress fracture in one patient, and unilateral knee fibroxanthoma in one patient in SF- group, calcaneocuboid stress fracture in one patient in SF+SS group). Therefore, they require particular expertise in diagnosis and management.

Tibia, metatarsal bones and fibula are the most often reported locations of stress fractures and locations are usually related with sport branches (14). Calcaneus and metatarsal bones were the most commonly reported injury sites in the army, especially in new recruits (14). Tibial and metatarsal stress fractures are common among track and field athletes, tibia and fibula mostly involved in distance runners (14). The location of injury is related with loading points to knee and lower leg (15). Tibia is the most affected bone, which represents approximately 40% of stress fractures, it is followed by fibula (25%) (16). Long-distance runners show high ratios of bone stress injury (14, 17). In this study, all the patients had bilateral leg pain and the most often location of stress reactions and/or fractures is tibia, as well (12, 18).

Longer exercise durations per week might be an increased risk factor for bilateral lower extremity stress injury. Increased exercise time may exert more power on the bone, rendering it vulnerable to stress injuries. This is also congruent with the previous studies in literature (19).

In this study, we did not find a significant difference between the duration of symptoms and stress injury type ($\chi 2$ = 3,327, p=0,344). We hypothesized that longer the duration of symptoms the graver the illness. Mean duration of symptoms was higher in the SF+SS group than in the SF and SS groups. However, there was not a statistical difference between the groups.

Radiographs and radionuclide bone scans are the classic diagnostic instruments for stress injuries. If standard radiographs are negative in the presence of clinical signs compatible with stress injury, they should be supported by other diagnostic studies that are more susceptible to bone stress injury (4). Sensitivities of 100% and accuracies of 75% or higher were achieved by bone scintigraphy, although it has been criticized for its high false-positive results (20). Rising of radionuclide uptake is very sensitive, but not specific to certain pathologies. The scintigraphic pattern of SS is described as a superficial periosteal hyper-concentration of the tracer. A dense focal increased tracer uptake at the location of the fracture is seen on bone scan while x-rays are frequently normal (21). Radionuclide bone scanning indicates an osteoblastic/osteoclastic response of bone and uptake may be due to many reasons including diseases associated with bone such as metastasis, inflammation, and infection or other traumas to the bone. Thus, although bone scintigraphy is a significant diagnostic instrument, the findings require consideration with anamnesis and symptoms of the patient for an accurate interpretation (7).

Lately, it has been claimed that magnetic resonance imaging (MRI) should be the selection method for stress fracture diagnosis if it is present. Because MRI is a noninvasive, and quickly applied method than bone scintigraphy, also has no ionizing radiation (20). It depicts bone marrow edema, periosteal reaction and subtle fracture lines (14). However, MRI has also high false-positives and demands an experienced interpreter. Unfortunately, we could not compare our findings with MRI, and this may be a limitation of our study.

In our study, 84% of our patients had stress injury detected by three-phase bone scan and SPECT/CT. SPECT/CT revealed the cause of pain with the exact location and detecting the disorders mimicking stress injury.

Determination of specific risk factors and use of newer techniques will provide accurate diagnosis and enhance patient management (22,23). Reinking et al. studied lower extremity overuse bone injuries in collegiate athletes and found the incidence as 10%; sport branch and decreased left calcaneal bone mineral density were depicted as main risk factors (24).

The major limitation of this study was unable to get the duration of symptoms of legs separately, due to the retrospective design and limited number of patients.

CONCLUSION

Bilateral stress injury is a rare condition in military personnel and athletes. The nature of lesion should be investigated, since there may be other reasons than stress injuries in athletes. Lower extremity mechanic problems such as hallux valgus, pes planus, chondromalacia patella, femoroacetabular impingement may lead to development of stress injuries. Metabolic events, vitamin deficiencies and decreased bone mineral density may be also be the underlying causes.

Duration of weekly exercise may be the major risk factor for the stress injury development in recreational athletes and should be further investigated. TPBS is a classic method for the assessment of stress injuries and SPECT/CT imaging contributes to differential diagnosis.

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