Stress Fractures and Stress Reactions of the Diaphyseal Femur in Collegiate Athletes: An Analysis of 25 Cases

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Abstract

In this review of prospectively collected data, representing the largest series of its kind, we identified 25 stress injuries of the diaphyseal femur in 20 athletes at an NCAA (National Collegiate Athletic Association) Division I university. All 20 patients successfully completed rehabilitation and returned to activity without limitations. Seventeen of these patients (representing 22 injuries) were female, and all 5 patients who sustained 2 stress injuries were female. The higher proportion of injured females in this study, and the histories of menstrual irregularities and disordered eating, raised the concern that the female athlete triad may be a factor.

It is important to consider the diagnosis of stress injuries of the diaphyseal femur when evaluating thigh pain in running athletes, especially females, as early diagnosis and treatment lead to excellent outcomes and full return to activity. Magnetic resonance imaging should be considered the gold standard in the diagnostic evaluation of these injuries. Further, as stress fractures may be the first presentation of the female athlete triad, it is also important for orthopedic surgeons to identify the presence of risk factors that may predispose athletes to recurrent stress injuries and other health problems.

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> "The female athlete triad should always be considered when treating female athletes with stress fractures, especially stress fractures of the femur."

Stress reactions and fractures, common overuse conditions in athletes, comprise as much as 10% of all sports injuries.[1] Initially described in military recruits, stress reactions and fractures have become increasingly associated with runners and other aerobic athletes. These injuries result when bone tissue does not mount an adequate response to repetitive stress and cannot sufficiently remodel itself.[2] There are 2 types of stress fractures: Fatigue fractures result from excessive, repetitive stress on normal bone, and insufficiency fractures are caused by normal muscular activity on weakened bone.[3] Stress fractures usually occur in the lower extremity, the tibia being the most common site. Stress fractures of the femur are estimated to make up only 2.8% to 7.2% of stress injuries in athletes.[4-7]

Risk factors for stress injury include rapid increase in training intensity, training on hard surfaces, poor physical fitness, biomechanical predisposition, poor gait, and improper footwear.[8,9] It is also important to consider systemic factors, such as nutritional deficiencies and hormonal abnormalities, especially in women, who are at elevated risk for stress injuries.[3,8,10] Regardless of the etiology, stress injuries are an important contributor to morbidity in athletes.

Our study of 25 stress injuries of the diaphyseal femur in collegiate athletes, reported here, represents the largest series of its kind. This is a review of prospectively collected data pertaining to injuries occurring at a National Collegiate Athletic Association (NCAA) Division I university.

Methods

We reviewed prospectively collected injury data compiled at a NCAA Division I university and identified all athletes who were diagnosed with a stress injury of the diaphyseal femur between 1995 and 2002. Once identified, data were collected from clinical charts, pre-participation history and physical examinations, and radiologic

Figure 1. In the fulcrum test, the examiner uses one arm to exert downward pressure over the patient's knee while placing the other arm under the injured leg to create a fulcrum. Thigh pain in response to downward pressure is often a sign of femoral stress fracture. Illustration by Jennifer Alt.

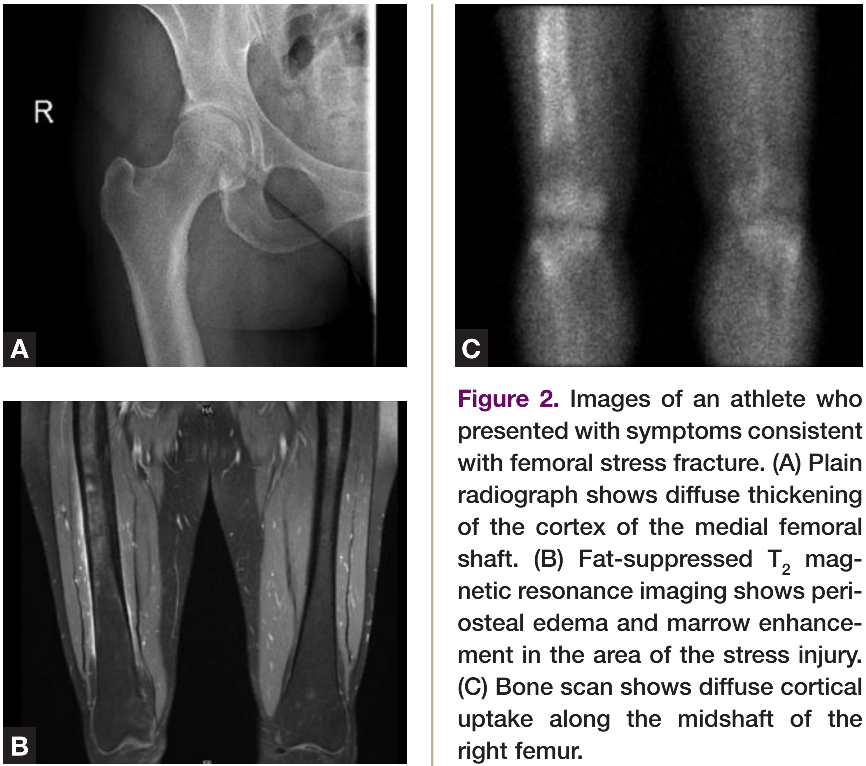

Figure 2. Images of an athlete who presented with symptoms consistent with femoral stress fracture. (A) Plain radiograph shows diffuse thickening of the cortex of the medial femoral shaft. (B) Fat-suppressed T_2 magnetic resonance imaging shows periosteal edema and marrow enhancement in the area of the stress injury. (C) Bone scan shows diffuse cortical uptake along the midshaft of the right femur.

studies. Personal information, including sex, sport, documented disordered eating, competition surface, and time of season when injury occurred, was collected for analysis. A specific endocrine assessment of age at menarche, regularity of menses, and use of estrogen/progesterone therapy for contraception was obtained for all female patients. Height, weight, and body mass index (BMI) were compared with the same data from other athletes participating in the same sports. Factors evaluated in the physical examination included site of pain, pain on weight-bearing, nature of the pain, swelling, point tenderness, and presence of a fulcrum sign. The fulcrum sign is positive when pain is elicited in the patient's thigh when the examiner uses his or her arm as a fulcrum under the femur while exerting downward pressure on the knee (Figure 1). This sign has been shown to be quite sensitive in the diagnosis of femoral stress fractures.[11]

Table. Data on 25 Cases (20 Patients) of Stress Injuries of the Diaphyseal Femur

Patient	Injury Side	Sex	Sport	Injury Type	Menstrual Irregularities	Disordered Eating	BMI	Radiograph	MRI	Bone Scan
1	R	F	Field hockey	Reaction	No	No	26	Negative	Not performed	Positive
2	L	F	Field hockey	Reaction	No	No	25	Negative	Positive	Not performed
	R		Field hockey	Reaction	No	No	25	Not performed	Positive	Not performed
3	L	F	Lacrosse	Reaction	Yes	Yes	25	Negative	Positive	Not performed
	L		Lacrosse	Reaction	Yes	Yes	25	Negative	Positive	Not performed
4	R	F	Lacrosse	Reaction	No	No	22	Negative	Not performed	Positive
5	R	F	Lacrosse	Reaction	No	No	21	Negative	Positive	Positive
	L		Lacrosse	Reaction	No	No	21	Negative	Positive	Negative
6	R	M	Track	Reaction	NA	No	21	Negative	Positive	Not performed
7	L	M	Track	Reaction	NA	No	21	Negative	Positive	Not performed
8	R	F	Track	Reaction	Yes	No	24	Negative	Positive	Not performed
9	R	F	Cross country/track	Fracture	No	Yes	20	Positive	Not performed	Positive
10	L	F	Track	Reaction	No	No	23	Negative	Positive	Not performed
11	R	F	Track	Reaction	Yes	No	22	Negative	Positive	Not performed
12	R	M	Football	Fracture	NA	No	24	Positive	Not performed	Positive
13	R	F	Crew	Reaction	Yes	Yes	21	Negative	Positive	Not performed
	L		Crew	Reaction	Yes	Yes	21	Negative	Positive	Not performed
14	L	F	Track	Fracture	No	No	22	Not performed	Positive	Not performed
15	L	F	Track	Reaction	Yes	No	19	Negative	Positive	Not performed
	L		Track	Reaction	Yes	No	19	Negative	Positive	Not performed
16	L	F	Track	Reaction	No	No	22	Positive	Not performed	Positive
17	R	F	Track	Reaction	No	Yes	20	Negative	Not performed	Positive
18	R	F	Cross country/track	Fracture	Yes	No	21	Negative	Positive	Not performed
19	L	F	Crew	Reaction	No	No	24	Negative	Positive	Not performed
20	R	F	Cross country/track	Reaction	No	No	19	Negative	Positive	Not performed

Abbreviations: BMI, body mass index; MRI, magnetic resonance imaging; R, right; L, left; F, female; M, male; NA, not applicable.

All patients were treated under a standard rehabilitation protocol. They initially underwent a 6- to 8-week, non-weight-bearing recovery period and then progressed through 3-week intervals of pool-based exercise, limited training, and, finally, normal training. If at any point a patient felt pain over the area of injury, he or she repeated that part of the protocol until pain-free.

Differences between these injured athletes and other, healthy athletes at the university were compared statistically. The 2-tailed Student *t* test was performed when appropriate. Statistical significance was set at $P<.05$.

Results

Twenty-five stress injuries of the diaphyseal femur were identified in 20 athletes (data summarized in Table). Seventeen of these patients (22 injuries) were female. All 5 patients who sustained 2 stress injuries were female. These injuries were bilateral in 4 of the 5 cases. The patient who sustained 2 stress injuries in the same leg (at the same location) had a 2-year asymptomatic period during which she participated at high levels of athletic competition. Therefore, these 2 injuries were judged to be separate injuries, not a single injury that had healed incompletely.

Of the 25 lesions, 4 were characterized as stress fractures, and 21 as stress reactions. All fractures were unicortical and stable; no fracture was displaced. All 20 patients underwent the rehabilitation profile described. Track and cross-country runners sustained 13 (52%) of the 25 femoral stress injuries; of the other 12 injuries (48%), 5 were sustained by lacrosse players (25%), 3 by field hockey players (12%), 3 by rowers (12%), and 1 by a football player (4%). It should be noted that the 5 lacrosse injuries occurred in only 3 female athletes. Of the 25 injuries, 12 (48%) were diagnosed during preseason workouts, 9 (36%) during midseason or late in the season, and 4 (16%) during the postseason.

Of the 17 females, 6 (35%) had reported irregularities in their menstrual cycle, consisting of abnormal intervals between menses or prolonged amenorrhea. Mean age at menarche was 13 years (range, 11-18 years). Only 2 patients were taking estrogen/progesterone replacement in the form of oral contraceptive pills; neither reported menstrual irregularities. Four female patients (24%) had a documented history of disordered eating; 2 of these were among the 6 who had also reported abnormal menses in the form of prolonged amenorrhea. Determination of the presence of disordered eating was based solely on documentation in patient charts or on patients' answers in pre-participation surveys. It is possible that other patients may have had symptoms of disordered eating but were not identified or diagnosed. BMI was calculated for all patients and for uninjured females participating in the 4 sports identified in the study. Patients' mean BMI was 22 (range, 19-26), and noninjured females' mean BMI was 23 (range, 16-35); the difference in mean BMIs did not reach statistical significance ($P = .48$).

On physical examination, all patients complained of vague, aching midthigh pain that worsened with weight-bearing. Obvious swelling or point tenderness was not evident in any case. The fulcrum test was positive in 24 (96%) of the 25 injuries. Radiologic evaluation of patients with suspected femoral stress injuries consisted of plain radiographs, magnetic resonance imaging (MRI), and bone scintigraphy (Figures 2, 3). For 23 suspected stress injuries, plain radiographs successfully identified stress fractures in 3 cases (13%). MRI was positive for stress injuries in all 19 cases in which this modality was utilized (100%). Bone scintigraphy demonstrated stress injuries in 7 (87.5%) of 8 patients. All 20 patients in this study successfully completed rehabilitation and returned to activity without limitations. There was no need for surgical intervention, and there was no evidence of displacement or nonunion of fractures.

> **"...in the diagnosis of femoral stress injuries, MRI appears to be the gold standard."**

Figure 3. Image of same athlete 2 months after initial studies show the extent of the healing process. Diffuse medial cortical thickening at the stress injury site is evident on the plain radiograph.

Discussion

Although stress injuries of the diaphyseal femur are not common, we documented 25 cases (20 patients) at a Division I university over a 7-year study period. Our study population's higher injury rate is unusual and raises the concern that a mechanism other than overtraining might be at work. Specifically, the athletes in this study trained on a track with a very hard surface (the base of the track was concrete). After the results of this study were reported to the university, a rubberized track was installed in an attempt to reduce the number of these injuries.

Stress injuries make up 10% of all sports injuries, but stress fractures of the femur are less common than those of the tibia, tarsals, and metatarsals.[4] Further, stress injuries of the femur are more typically associated with older patients than with collegiate athletes. These injuries are purported to be bilateral in 17% of patients.[4] In our study, bilateral injury was found in 4 of the 5 patients with 2 stress injuries. The contralateral leg was not examined in patients with an isolated injury.

The predominance of females in this study (17/20) is not unexpected, given that females are more susceptible to stress injuries. Track and cross-country runners were most commonly affected (also to be expected). Menstrual irregularities were reported in 6 (35%) of the 17 females and disordered eating in 4 (24%) of the 17. The higher proportion of injured females in this study, and the histories of menstrual irregularities and disordered eating, raised the concern that the female athlete triad may be a factor. The *female athlete triad* consists of disordered eating, menstrual irregularities, and osteoporosis. It has been proposed that inadequate caloric intake for the athlete's level of activity results in an energy drain, causing dysfunction of the hypothalamic–pituitary axis and thus amenorrhea. The resultant estrogen-deficient state results in diminished bone density and increased propensity for development of stress injuries.[12,13] While the female athlete is amenorrheic, 2% to 6% of bone density is lost each year, and the percentage of total bone mass lost can be as high as 25%.[14] Irreversible bone density losses begin after 3 years without menses.[15]

The female athlete triad should always be considered when treating female athletes with stress fractures, especially stress fractures of the femur or of other, less common areas. Our findings of menstrual irregularities and disordered eating are consistent with previous findings in athletes. Disordered eating has been reported in 15% to 62% of female athletes, as opposed to 1% to 3% of the general population, and is particularly elevated in the collegiate population.[16-20] Amenorrhea has been reported in 1% to 66% of female athletes but in only 2% to 5% of the general population.[21,22]

Previous studies of femoral stress fractures have mostly focused on soldiers. Only recently has the focus changed to athletes. In a recent case series, Kang and colleagues[23] found that an abrupt change in running-surface quality was the only factor common to 7 female lacrosse players with femoral shaft stress fractures. This suggests that factors other than nutrition and amount of training should be considered. It is interesting that, in our study, 5 injuries were sustained by female lacrosse players, who practiced and played on a synthetic surface. Synthetic-running-surface quality must be considered a factor in the development of stress injuries in this particular group of athletes.

The clinical diagnosis of femoral shaft stress fracture is difficult, as pain is often vague and intermittent. Therefore, a high index of suspicion is required when examining athletes (particularly female athletes) who have symptoms and are prone to these injuries. Early detection of a femoral stress injury is very important, as progression to a displaced fracture can be catastrophic to the highly competitive athlete.[24]

Physical examination (including the fulcrum test) and imaging are important factors in the diagnosis of femoral stress injuries. MRI appears to be the gold standard, superior to plain radiographs, computed tomography, and bone scintigraphy.[2,25-31] When we began this study, bone scans were routinely obtained. With the increasing availability, quality, and diagnostic accuracy of MRI, this technology has supplanted bone scans in the diagnosis of femoral stress injuries. We no longer obtain bone scans when MRI is available.

Ivkovic and colleagues[32] recently presented the first formal treatment algorithm for stress fractures of the femoral shaft. The algorithm consists of 4 phases, each lasting 3 weeks, in which the patient progresses from non-weight-bearing to pool-based exercise to limited training and finally to normal training.

Most of the diagnoses in our study were made during the preseason or early in the season. The earlier diagnosis could account for the higher incidence of stress reactions versus stress fractures. In the series of 7 femoral stress fractures reported by Kang and colleagues,[23] all injuries were diagnosed late in the season. It is possible that we had a higher index of suspicion and that our patients' injuries were diagnosed before they could develop into frank stress fractures.

This study was limited by our reliance on self-reporting of symptoms, menstrual irregularities, and disordered eating, which may mean that these findings are underrepresented. Further evaluation of female athletes—using the Eating Disorder Inventory, which has been an effective tool in previous studies—may be helpful in arriving at a more accurate accounting of this risk factor.[33] Prevalence of disordered eating and menstrual abnormalities in noninjured females was not examined either. In addition, when the study was conducted, the athletes were training on a track with a concrete-based surface, which has since been replaced with a rubberized surface. This change in surface should be analyzed with respect to incidence of stress injuries.

Conclusions

It is important to consider the diagnosis of stress injuries of the diaphyseal femur when evaluating thigh pain in running athletes, especially females, as early diagnosis and treatment lead to excellent outcomes and full return to activity. MRI should be considered the gold standard in the diagnostic evaluation of these injuries. Further, as stress fractures may be the first presentation of the female athlete triad, it is also important for orthopedic surgeons to identify the presence of risk factors that may predispose athletes to recurrent stress injuries and other health problems.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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