Bone stress injury is a common overuse syndrome in the athletic population, which accounts for 5–15% of all sports-related injuries. Bone stress injuries are seen most often in long-distance runners, dancers, and track and field athletes and have been reported to account for 50% of all injuries sustained by runners.

Previous research has documented that bone stress injuries vary in incidence and location among sports. A recent study of college athletes found that distance runners had the highest incidence of stress injury (54%) and that the tibia was the most frequently involved bone (37%), which is consistent with previous research findings.

Traditional management of bone stress injury has emphasized reduction of stress on the affected bone, which requires modification of activity (i.e., rest, immobilization, and/or limited weight bearing) often for weeks or months. Such an approach deprives the athlete of valuable training time and may result in the loss of opportunity to compete.

The use of low-intensity pulsed ultrasound (LIPUS) has been extensively studied as a means to promote healing of acute and nonunion fractures. The literature presents conflicting evidence about the efficacy of LIPUS in accelerating bone stress injury healing. The purpose of this case report is to describe the use of low-intensity pulsed ultrasound, delivered by an AutoSound™ ultrasound device, for the treatment of a bone stress injury sustained by a competitive cross-country and track athlete.

Case History

A 19-year-old NCAA Division I female cross-country and track athlete complained of recurring pain in her left lower leg for 4 months. At the initial presentation, the athlete was competing as a middle-distance and steeplechase runner. At the same time, she was performing long-distance runs 5–6 days per week, which averaged 30 miles per week. The athlete reported a history of lower leg pain during running, which was characterized as “on and off for the last three cross-country and track seasons” (i.e., her junior and senior years of high school and her freshman year of college). She denied any history of trauma and reported that the pain increased with prolonged running and decreased with rest. She had continued to train and compete but often had to alter her running routine due to pain. Alterations included workouts on an elliptical trainer and decreased running mile-
age. She reported the occasional use of ibuprofen for pain control but stated that it did not provide long-term relief. She also reported having previously experienced minimal pain relief when treated with cryotherapy and occasional “e-stim” therapy.

**Examination**

The athlete reported that pain was localized in the proximal region of her left tibia on its medial aspect. Using a 0–10 numeric pain rating scale (NPRS), which has been demonstrated to be a reliable, valid, and sensitive measure of pain intensity, she recorded her pain as a 5/10 (i.e., 0 = no pain and 10 = worst possible pain).

Palpation elicited tenderness over the proximal one-third of the left medial tibia. Range of motion and strength of the left lower extremity were judged to be within normal limits. Using the supine 90/90 test as described by Magee, decreased flexibility of her hamstrings was observed bilaterally (left = 22 degrees; right = 20 degrees). Postural assessment or gait assessment did not identify any abnormalities.

**Diagnosis and Prognosis**

The athlete’s history, volume of training, and physical examination results led to a diagnosis of tibial stress. Most patients with a tibial stress injury report localized pain that was aggravated by physical activity and relieved by rest. Diagnostic images were not obtained, because they were not deemed necessary to establish the diagnosis. The sensitivity of radiographs for identification of bone stress injury in its early stages has been reported to be as low as 10%. Arendt et al. reported radiographs to be initially negative in up to two-thirds of college athletes with stress fractures. Because of poor radiograph sensitivity, confirmation of bone stress injury has often been based on bone scintigraphy. Despite nearly 100% sensitivity, bone scintigraphy is inferior to radiography in terms of specificity.

The athlete’s prognosis for return to her normal training regimen and participation in competitive events without pain was anticipated to be 4 weeks, assuming that she would comply with instructions to reduce her activity level. After discussing the diagnosis and treatment strategy with the athlete, she was unwilling to modify her training and competition schedule.

**Treatment**

There is conflicting evidence about the efficacy of LIPUS in accelerating healing of bone stress injuries, but there have been published reports of positive effects. Based on the athlete’s unwillingness to alter her training and competition schedule, the athletic trainer (AT) suggested LIPUS treatment. Such treatment is typically administered by a portable bone-stimulator device (20 minutes, 1 to 2 times per day) that must be prescribed by a physician. The average cost of a bone-stimulator device is approximately $3,000, which is cost prohibitive in many settings.

The AutoSound™ (Rich-Mar, Chattanooga, TN) clinical ultrasound unit, which has a hands-free transducer, was used to treat the athlete. The device was programmed to deliver ultrasound at a frequency of 3 MHz, with a duty cycle of 20% and an intensity of 0.5 W/cm². The 3 MHz frequency was chosen to focus the treatment superficially on the proximal tibia. The duty cycle and intensity parameters were chosen in an attempt to replicate the nonthermal effect of a bone stimulator device.

The athlete was placed in a supine position, and the hands-free transducer was secured over the area of proximal tibia pain with two straps. LIPUS was administered for 20 minutes, 1–2 times per day on most days of the week, depending on the athlete’s availability. Twice daily treatments were preferred to replicate the protocol for use of a bone stimulator device. When two treatments were administered on the same day, they were separated by a minimum of 6 hours. The athlete reported no adverse effects during or following the treatment sessions. She continued her usual training regimen and competition schedule as tolerated (Table 1). A stretching program that had been initiated prior to the LIPUS treatments was continued, with emphasis on the hamstrings.

The LIPUS treatments were administered for approximately 3 weeks (19 days), which included a total of 23 treatment sessions within 13 days. Missed treatment days were due to out-of-town track meets (6 days). Pain was rated during the afternoon treatment sessions using the NPRS and the athlete recorded her training/competition activities in a daily log.

**Outcome**

On the initial day of treatment, the athlete reported pain as 5/10. Pain had decreased by the 4th treatment
<table>
<thead>
<tr>
<th>Day</th>
<th>AM Workout</th>
<th>PM Workout</th>
<th>Distance</th>
<th>LIPUS Treatment</th>
<th>NPRS</th>
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<tr>
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<td>None</td>
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<td>Yes (2)</td>
<td>5</td>
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<tr>
<td>2</td>
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<td>350 m 300 m 250 m 200 m 150 m 1000 m Distance run</td>
<td>4 miles (time not reported)</td>
<td>Yes (1)</td>
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<td>3</td>
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<td>Distance run 4 × 1 min pick-ups Hurdle walkovers Steeple training</td>
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<tr>
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<td>7</td>
<td>Ab workout</td>
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<td>No</td>
<td>4</td>
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<td>Distance run</td>
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</table>
session (3rd day of treatment), and the athlete was running pain free within 10 days of treatment initiation (10 treatment sessions; see Figure 1). Treatment was continued until the athlete had reported pain-free (0/10) running for 5 consecutive days. She was able to continue her training regimen and competition schedule throughout the treatment period, and she reported a personal-best performance in the 1500-meter event at 3 weeks after treatment initiation (23 treatment sessions). At 4 weeks after discharge, she reported continued pain-free running, with no alteration of her training or competition schedule.

Discussion

Traditional management of bone stress injury emphasizes activity restriction for restoration of balance between osteoblastic and osteoclastic activity and the administration of therapeutic modalities for pain control. As pain subsides, the athlete is allowed to gradually return to a preinjury activity level with the required amount of time dependent on the severity of the injury. Arendt and Griffiths used a three-phase protocol that emphasized maintenance of the patient’s activity level below the pain threshold. The time required for return to normal activity was related to the grade of stress injury determined from MRI. The average time lost from normal activity was 4 weeks for grade 1 injury and 8 weeks for grade 2 injury. MRI evidence of periosteal and cortical involvement (i.e., grade 3 and grade 4) required longer activity restriction.

The approach to treatment for the reported case was based on evidence supporting the use of LIPUS for acceleration of fracture healing, and the limited evidence supporting the use of LIPUS for stress injury healing. The use of LIPUS for treatment of acute and nonunion fractures has been extensively studied. Busse et al conducted a meta-analysis of randomized controlled trials and reported that LIPUS significantly reduced the time required for fracture healing by an average of 64 days (an average weighted effect size of 6.41). Needle and Kaminski performed a systematic review that identified 56 relevant articles on stress injury and LIPUS, but only three studies met their inclusion criteria. LIPUS demonstrated positive effects in both an animal study and a case series involving human subjects, but a better quality clinical study in humans did not support a positive therapeutic effect.

Careful analysis of the athlete’s NPRS scores and treatment history appears to demonstrate a dose-response relationship. A one-point decrease in the NPRS score (5/10 to 4/10) occurred after five LIPUS treatments (three treatment days). The athlete was unavailable for LIPUS treatments on days 4 through 7, and she reported no further change in pain during this period. After four additional LIPUS treatments (two treatments/day on days 8 and 9), the NPRS score decreased to 1/10. On day 10, two LIPUS treatments were administered and the NPRS score decreased to 0/10. This trend suggests a dose-response relationship, which will require further research to confirm.

Figure 1 Pain intensity throughout course of treatment.
The administration of therapeutic ultrasound over a fracture site has historically been viewed as a contraindication. Early animal studies demonstrated delayed bone healing and tissue damage that was attributed to ultrasound treatment. More recent research has demonstrated, however, that the effect of ultrasound on bone healing is determined by the intensity level and duty cycle. High-intensity (i.e., ≥ 1.0 W/cm²) continuous ultrasound appears to be harmful to bone healing, whereas low-intensity (≤ 30 mW/cm²) pulsed ultrasound appears to promote bone healing. The exact mechanism by which therapeutic ultrasound promotes bone repair is unknown.

The treatment approach reported for this case of bone stress injury is not commonly used. The administration of LIPUS by a clinical ultrasound unit was cost effective and did not require a physician’s prescription. Despite a lack of previous research evidence to support the use of this therapeutic intervention, the athlete demonstrated a substantial decrease in pain, the ability to continue training and competition, and an improved time in a competitive race. Further research is needed to establish that LIPUS delivered by a clinical ultrasound unit is an effective treatment for a bone stress injury.

References

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