Journal of Athletic Training 2000;35(4):445–449

www.journalofathletictraining.org

Stress Fracture of the Eighth Rib in a Female Collegiate Rower: A Case Report

Adam Galilee-Belfer, MA, ATC; Kevin M. Guskiewicz, PhD, ATC

University of North Carolina at Chapel Hill, Chapel Hill, NC

Objective: To present the case of a stress fracture of the eighth rib in a female collegiate rower.

Background: A female collegiate rower experienced severe pain in her chest, increasing with movement, deep breathing, and erect posture. No acute mechanism of injury was apparent. The team physician diagnosed a rib stress reaction based on clinical examination. The athlete rested for 2 days and then was able to resume rowing workouts. Five months later, she experienced the same sharp pain, with the diagnosis and treatment being the same. The athlete was able to compete in the championships 3 weeks later. At the end of the season, a bone scan revealed a stress fracture of the eighth rib. The athlete rested for 3 weeks and then returned to activity.

Differential Diagnosis: Intercostal muscle strain, serratus anterior muscle strain.

Treatment: Active rest, involving pain-free cardiovascular workouts and weight training, cessation of rowing until the athlete was asymptomatic, strengthening of dynamic support structures, and analgesic modalities.

Uniqueness: Most stress fractures occur in the lower extremity. Those that do occur in the rib cage most often involve the first rib. A limited number of published works have addressed stress fractures to the remaining ribs; of these, posterior and posterolateral fracture sites are most often reported. This case is unique in that the fracture site was on the anterolateral aspect of the eighth rib.

Conclusions: Stress fractures are thought to result from a variety of causes, including muscular fatigue, sudden changes in training intensity or duration, and microtrauma to bone at the muscular origin and insertion sites ("wear-and-tear" theory). In addition, hormonal factors in women can predispose an athlete with amenorrhea to a decrease in bone mineral content. Athletic trainers should be aware of these potential causes and focus on the prevention of stress fractures.

Key Words: overuse injury, rowing injury, amenorrhea, female athlete

Rowing is the oldest competitive collegiate sport, evolving from the first race held in long wooden boats in 1829 between Oxford and Cambridge Universities to the sleek fiberglass sculls used by today's crews.[1] Rowing is a nonimpact sport that demands both endurance and explosive power from its participants. Elite rowers train throughout the year on ergometers (rowing machines) and on the water. Accordingly, most injuries in rowing are chronic or overuse injuries. We document an elite-level university rower who sustained a stress fracture of the eighth rib.

Stress fractures to the ribs are not uncommon, although few cases have been reported. The first rib is most commonly affected. However, a limited number of publications have addressed stress fractures to the remaining ribs, particularly in rowers. Brukner and Khan[2] reported on stress fractures of the seventh and eighth ribs in a female sculler. Holden and Jackson[3] described 4 cases of posterior rib stress fractures in female scullers. McKenzie[4] discussed a stress fracture in the ninth rib of a male sweep rower. Several other rib stress fractures have been documented in rowers, most often affecting the posterior or posterolateral ribs.[1,5–8] This case involves a female collegiate rower and is unique in that the fracture site was on the anterolateral aspect of the eighth rib, which is an extremely uncommon location for this type of rowing-induced injury.

Address correspondence to Kevin M. Guskiewicz, PhD, ATC, University of North Carolina at Chapel Hill, CB#8700, Fetzer Gymnasium, Chapel Hill, NC 27599-8700. E-mail address: gus@email.unc.edu

CASE HISTORY

A 20-year-old female rower (height = 1.75 m, weight = 70.5 kg) presented with intense, left-sided chest pain. She rowed starboard on a boat of 8, and her team, which had recently completed the fall season, had begun its indoor training season several weeks earlier. The athlete described waking up that morning experiencing severe pain. Her pain increased with movement, deep inspiration and expiration, and erect posture. No obvious swelling or deformity was noted. No mechanism suggesting an acute injury was discovered. Her pain was localized over the anterolateral aspect of the eighth rib and did not radiate along the body of the rib. Her pain increased with shoulder flexion, abduction, and extension, trunk flexion, and end-range extension. In addition, her pain intensified with resistance to any upper extremity movements, particularly scapular protraction and retraction.

A rib stress reaction was suspected based on clinical evaluation. However, the athlete vehemently expressed her desire to continue rowing, regardless of pain. Unless the injury was life threatening, she planned to participate. The team physician decided that no further diagnostic tools (eg, radiographs or a bone scan) would be used because the course of treatment did not depend on a definitive diagnosis. The physician permitted a return to participation as soon as she was asymptomatic.

The athlete rested for 2 days and then returned to her ergometer workouts; modification of activity was moderate at best. Ice, intercostal massage, and electric stimulation were all used with the goal of pain relief. In addition, pain-free scapular protraction exercises to strengthen the serratus anterior muscle were initiated and added to the permanent weight-training routine (Figure 1). The athlete remained relatively asymptomatic for several months, complaining only of occasional pain.

Approximately 5 months later, the athlete was moved to a bow-coxed boat of 4 to prepare for the national championships. One week later, she had to stop in the middle of an intense workout due to severe chest pain, described as identical to the previous incidence. The course of treatment again involved 2 days' rest and analgesic modalities. The athlete was able to return to participation and competed in the championships 3 weeks later.

After the end of the season, a chest roentgenogram was obtained and revealed no abnormalities (Figure 2); however, a technetium-99 bone scan taken 1 week later revealed a stress fracture of the eighth rib (Figure 3), with significant uptake of

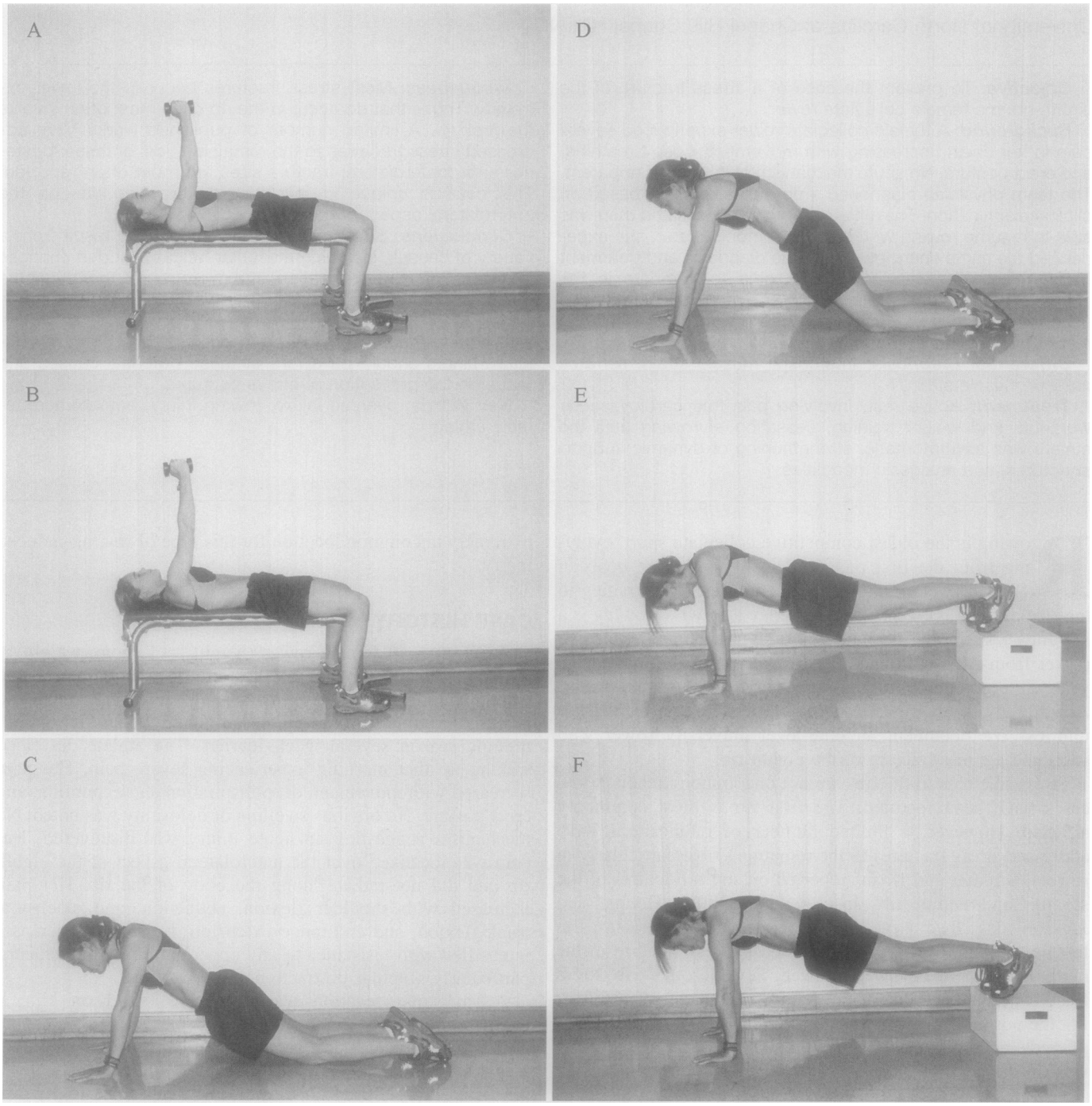

Figure 1. Rehabilitation progression. Rehabilitation progression used to strengthen the serratus anterior, the primary dynamic supporter of the ribs. A, Starting, and B, finishing positions for the initial, nonweightbearing exercise. C, Starting, and D, finishing positions for the second stage of the strengthening progression. E, Starting, and F, finishing positions for the advanced stage of the strengthening progression. All of the exercises were performed throughout the full functional range of motion.

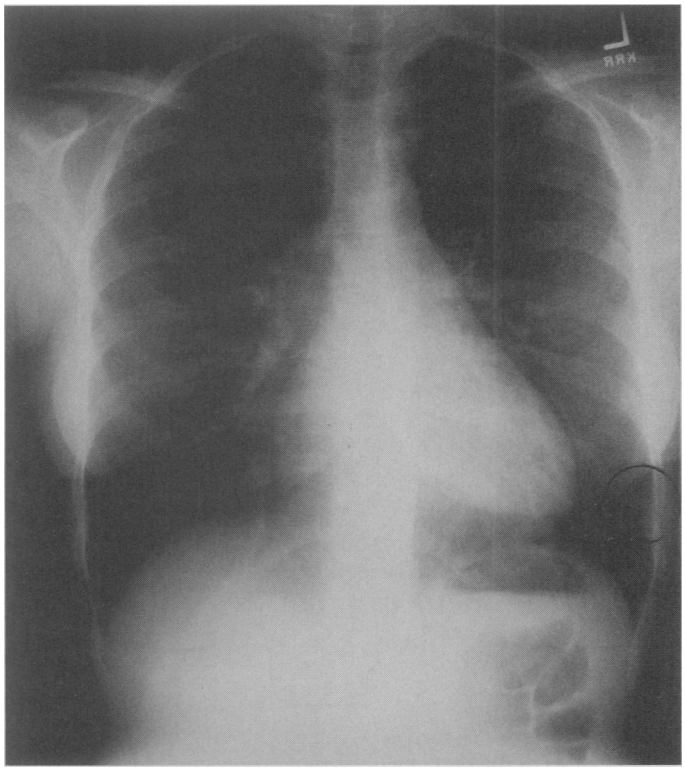

Figure 2. Chest x-ray film taken at the end of the competitive season revealed no abnormalities at the site of the fracture (circled area).

the isotope along the anterolateral aspect of the rib. The results of the bone scan were convincing enough to the athlete that she immediately modified her training regimen. She limited her cardiovascular workouts to biking and running and eliminated ergometer training. The team physician instructed her to resume ergometer training only after she had gone a full week without chest pain. A time frame of 4 to 6 weeks was anticipated to allow for adequate healing of her injured rib, but the athlete returned to ergometer training 3 weeks later with no chest pain. A follow-up chest roentgenogram 4 months later revealed callus formation on the eighth rib at the fracture site (Figure 4). She has been asymptomatic for more than a year, while continuing to row and participate in ergometer training.

DISCUSSION

Only 10% of all stress fractures in athletes affect the upper extremity.[5] However, the repetitive, near-maximal isotonic contractions performed by rowers predispose them to upper extremity chronic injuries, such as stress fractures. Stress fractures may occur when muscle weakness or fatigue causes a redistribution of force to the underlying bone.[4] When activity is initiated, a considerable percentage of the external force is dissipated by the supporting musculature. In this case, the serratus anterior and the abdominal oblique muscles dissipate the bending stresses exerted upon the rib. However, when the muscle fatigues, the bone is forced to absorb the bending stress, which is greatest at the focal portions of the bone.[4] In the past, this has been considered applicable to weightbearing activities only. However, segments of the ribs undergo significant bending stresses on activation of the force couple of the rhomboids and the serratus anterior. In addition, the activation and repetitive contractions of the external abdominal oblique muscle result in significant stress being placed upon the origins of these muscles along the eighth rib.[3,6] The origins of these muscles combine to create focal points of stress along the bone.

The long periods of cyclic contraction and relaxation of muscle have been theorized to lead to a fatigue mode of loading.[9] This loading pattern also lends itself to the "wear-and-tear" theory: that overuse and overload of muscle result in microtrauma to the bone, predominantly at the origin sites of these thoracic muscles.[5] Also, stress along the surface of the underlying rib is notable, as the muscle pull across the bone generates significant forces. The stress fracture occurs where the bending stresses are maximal.[4,7]

Previous authors[3,4] have theorized that the point of maximal stress occurs over the posterior or posterolateral aspect of the ribs. Most of the published reports have focused primarily on

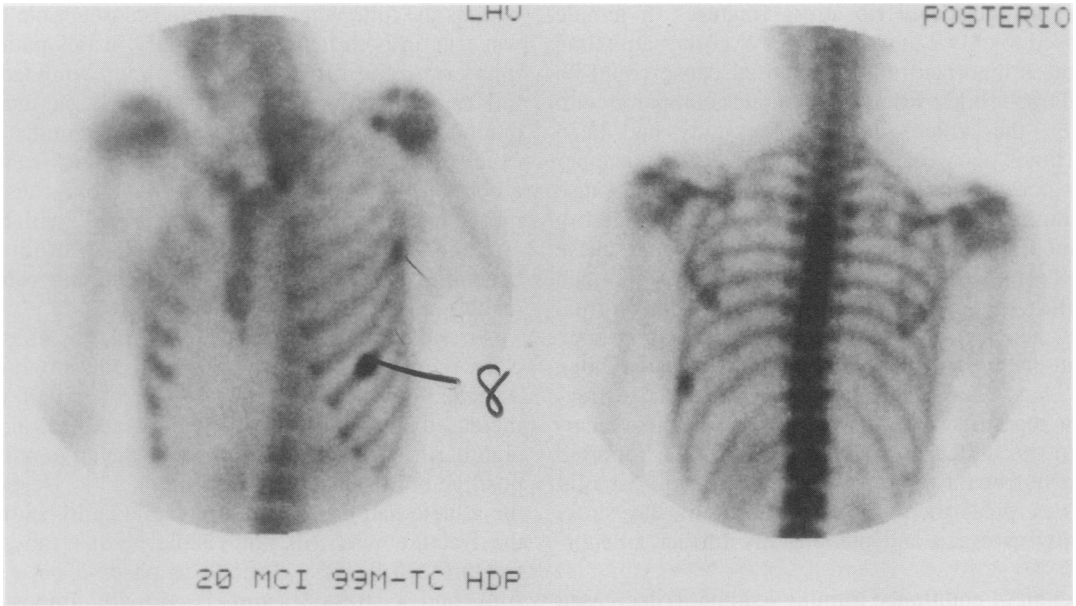

Figure 3. Technetium-99 bone scan revealed a stress fracture along the anterolateral aspect of the eighth rib.

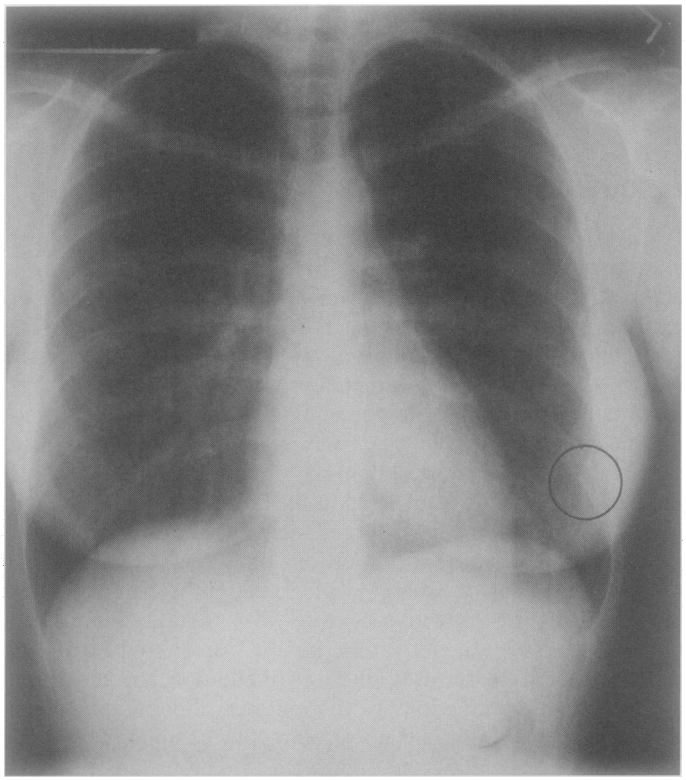

Figure 4. Follow-up chest x-ray film taken 4 months after the previous film revealed callus formation on the eighth rib at the location of the stress fracture.

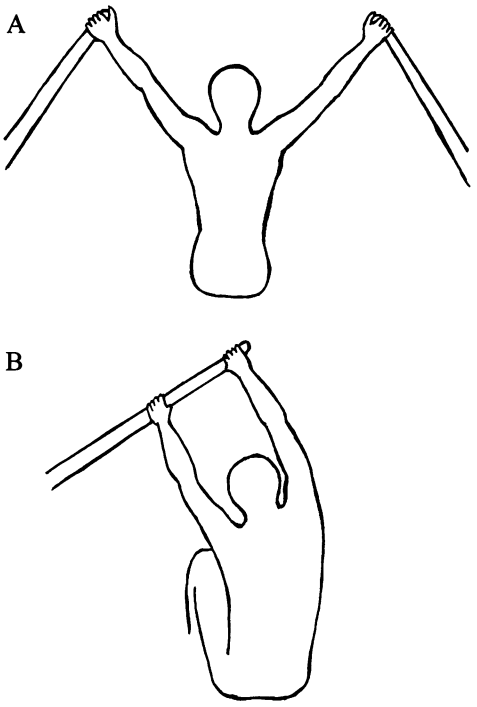

Figure 5. Compressive forces. A, Equal distribution of shear forces on both sides of the body as displayed in sculling. B, Lateral trunk shift, which is characteristic of sweep rowing. It is theorized that this lateral shift could result in compressive forces along the inside aspect of the thoracic cavity, providing a potential cause for a rib stress fracture.

sculling, in which an athlete uses 2 oars; sweep rowing can result in a lateral shift of pressure on the ribs because the rower uses 2 hands on a single oar.[5] While sculling is a linear motion, sweep rowing is characterized by a diagonal movement pattern (Figure 5). Repetition of this movement results in compression along the inside aspect of the thoracic cavity. This compression is concentrated along the anterolateral aspect of the ribs, consistent with the unique location of the stress fracture in this patient.

A 9-year study at the Australian Institute of Sport[6] demonstrated 15 cases of suspected rib stress fractures in female rowers, as opposed to only 2 in male rowers over the same time frame. The authors theorized that 1 potential cause could be underdeveloped upper body strength in females compared with males. However, the athlete in our case study had been weightlifting 3 times per week for the past 3 years. Her upper body strength was well above average. Another potential cause for the higher number of female stress fractures is related to hormonal factors. Endurance training has been proven to cause changes in the hormone levels of a female athlete. This can lead to amenorrhea, or the disruption or cessation of the normal menstrual cycle, which in turn can lead to a decrease in bone mineral content due to the lack of estrogen-mediated bone synthesis.[3,6,10] Thus, weakened bones are vulnerable to fractures caused by repetitive external stresses. This theory certainly applies to the athlete in this case study, who reported intermittent amenorrhea for the last 2 to 3 years. An oral contraceptive was prescribed upon diagnosis of the stress fracture to supply estrogen and prevent any further amenorrhea.

The phenomenon of endurance training leading to decreased bone density should not deter a female athlete from pursuing endurance activities. Under controlled conditions, these activities will increase bone density and strength in accordance with the Wolff law. The endurance demands placed on the body will eventually lead to stronger bones and muscles. The key to this change is a gradual increase in activity. The body must be given ample time to adapt to higher external forces and demands; 1 of the well-documented causes for a stress fracture is a sharp increase in level of activity.[1,3–5,11] The delay between increased activity levels and increased strength of bone is the time when the athlete is susceptible to injury.[8] This was true in both instances of injury in this patient. The initial injury occurred 1 to 2 weeks after the rowing team finished the fall season outdoors and concentrated on indoor ergometer practice. The recurrence of injury 5 months later occurred exactly 1 week after the athlete was moved from a boat of 8 to a boat of 4. The athlete felt that this move caused her to exert more pressure and create a "stronger pull" with her inside (left) arm and side of the body. Both instances of injury might have been prevented if the changes in training routine had been made gradually.

After the second incidence of injury, the athlete underwent a chest roentgenogram, which revealed no obvious deformities. A techetium-99 bone scan was then performed, which revealed increased isotope uptake on the anterolateral aspect of the eighth rib. The combination of a negative x-ray film and a positive bone scan is not uncommon.[2,4,5,8] Despite the fact that the athlete had developed a palpable callus on the injured rib, the fracture was still not visible at that time. A simple rib fracture can be very difficult to observe on a standard x-ray film, and a stress fracture is virtually impossible to see.[4,8] However, a follow-up X-ray film at the preparticipation exam-

ination several months later revealed callus over the previous fracture site.

It is important to note the possibility that either occurrence of injury could have been an acute fracture. The onset of pain in both instances is consistent with that of an acute fracture. An acute fracture would look the same as a stress fracture on a bone scan; any standard chest x-ray film can miss a fracture unless dedicated rib views are obtained.

CONCLUSIONS

This case study documents a rare injury in sport: a stress fracture of the eighth rib in a female collegiate rower. She was initially diagnosed with a possible stress reaction after the fall season, and after slight activity modification, she returned to activity 2 to 3 days later. She remained mostly asymptomatic until a reinjury 5 months later. Once again, treatment involved moderate activity modification and analgesic modalities. A positive bone scan after the season revealed a stress fracture of the eighth rib. The course of treatment included a progression of scapular protraction exercises, oral contraceptives, and 3 weeks of active rest.

Many theories have been advanced as to the causes of stress fractures. These include muscular fatigue that redistributes external force to bone and repetitive microtrauma along muscular origins (the "wear-and-tear" theory). In addition, hormonal factors can play a significant role in a stress fracture in a female athlete. Amenorrhea leading to decreased bone mineral content should be addressed in the course of treatment. A gradual increase in level of training allows the necessary time for the body to adapt, potentially preventing stress fractures.

REFERENCES

1. Hosea TM, Boland AL. Rowing injuries. In: *Postgraduate Advances in Sports Medicine: An Independent Study Course Designed for Individual Continuing Education.* Philadelphia, PA: University of Pennsylvania School of Medicine; 1989:1–16.
2. Brukner P, Khan K. Stress fracture of the neck of the seventh and eighth ribs: a case report. *Clin J Sports Med.* 1996;6:204–206.
3. Holden DL, Jackson DW. Stress fracture of the ribs in female rowers. *Am J Sports Med.* 1985;13:342–248.
4. McKenzie DC. Stress fracture of the rib in an elite oarsman. *Intl J Sports Med.* 1989;10:220–222.
5. Christiansen E, Kanstrup IL. Increased risk of stress fracture of the ribs in elite rowers. *Scand J Med Sci Sports.* 1997;7:49–52.
6. Hickey GJ, Fricker PA, McDonald WA. Injuries to elite rowers over a 10-yr period. *Med Sci Sports Exerc.* 1997;29:1567–1572.
7. Mosler A, Wajswelner H. The assessment and management of elite rowing injuries. Presented at: Australian Institute of Sport: Australian Conference of Science and Medicine in Sport; October 17–20, 1995; Hobart, Australia.
8. Strayer LM. The myth of the intercostal muscle pull. *Am Rowing.* 1990;22:42–44.
9. Mickelson TC, Hagerman FC. Functional anatomy of the rowing stroke. *Oarsman.* 1979;11:6–9.
10. Puustjarvi K, Arnala I, Arokoski J. Bone mineral less after long term running in association with decreased osteoid formation and estradiol level. Presented at: 39th Annual Meeting, Orthopaedic Research Society; February 15–18, 1993; San Francisco, CA.
11. Lord MJ, Ha KI, Song KS. Stress fracture of the ribs in golfers. *Am J Sports Med.* 1996;24:118–122.