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Increased risk of stress fractures of the ribs in elite rowers

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In rowing, stress fractures are rare. However, the intensity of training has increased in terms of more specific rowing movements throughout the year. Simultaneously, new equipment has been developed resulting in faster rowing over the racing distance with increased risk of injuries on bones, muscles and ligaments. We report five cases of chest pain and one case of pain in the shoulder in national elite rowers, diagnosed as stress fractures of the ribs employing ^{99m}Technetium-MDP bone scan. In all cases, an increase or alteration in physical activity in the weeks prior to the injury and an increase in specific rowing movements with special emphasis on the new equipment, combined with increased biomechanical stress applied to the thoratic skeleton in the catch and the early part of the drive phase of the stroke, most probably caused the injuries.

E. Christiansen, I.-L. Kanstrup

Team Denmark, Headquarter of Rowing, Department of Clinical Physiology and Nuclear Medicine, Herlev Hospital, University of Copenhagen, Copenhagen, Denmark

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Erik Christiansen, MD, Team Denmark, Headquarter of Rowing, Skovalleen 40, 2880 Bagsværd, Denmark

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Stress fractures occur in a variety of conditions within the field of physical exercise. Stress fractures are well known in military recruits, as described more than 100 years ago (1). Not well recognized, but rather frequent, the Charcot foot seen in insulin-dependent diabetes mellitus can be characterized as a stress fracture (2). Within sports, approximately 90% of stress fractures are seen in the lower extremities, with the predominant locations being tibial, metatarsal and femoral stress fractures (3,4). Less than 10% of stress fractures are located in the upper extremities and columna (3,4). The predominant activities in which stress fractures occur include running, from short distance to long distance running, athletics and ball games of various kinds, and ballet dancing (3–5). Sporadically, stress fractures of the ribs have been diagnosed in baseball pitchers, golfers, canoers and rowers (6–10).

Stress fractures of the ribs have presumably existed in rowing for decades; however, reports of stress fractures in rowing are rare (7, 9). In 1985, the first report of four cases of stress fratures in the ribs of female rowers located in the posterolateral part of the fifth to seventh rib around the scapula was published (7). In 1989 the second case constituted a stress fracture of the ninth rib anterolaterally in a male rower (9). In rowing, the intensity of specific rowing movements has increased during the on-water season as well as in the off-water training sessions. Simultaneously, new equipment has been developed resulting in 5–10 seconds faster rowing over the racing distance of 2000 m during the last 3 years. Within a period of 14 months, six cases of rib stress fractures were diagnosed in national female and male elite rowers. As this extraordinary number of rib stress fractures has not been reported previously, combined with the recent development in equipment in rowing, this article deals with etiology, diagnosis and possible preventive interventions.

Case histories

Clinical characteristics of the cases are presented in Table 1.

Case 1

A 20-year-old female rower presented with increasing right-sided shoulder pain and left-handed wrist pain for 5 months following increased training intensity. Physiotherapy had no effect on the symptoms. A physical examination revealed no specific tenderness of the ribs. However, ^{99m}Technetium-MDP bone scan demonstrated a well-defined focus of the left seventh rib posterolaterally. She recovered after a few weeks of decreased physical activity. One year later she had renewed complaints of left-sided chest pain 3–4 days after she had started with increased physical training during the winter season. A renewed ^{99m}Technetium-

Table 1. Clinical characteristics of six rowers with stress fractures of the ribs

	Age	Sex	Location of pain	Duration of symptoms	Rib number	Side
Case 1	20	Female	Right shoulder	Five months	Seventh	Left, posterolaterally
Case 2	23	Female	Chest, left-sided	One week	Sixth	Left, posteriorly
Case 3	24	Male	Chest, right-sided	One week	Sixth	Right, laterally
Case 4	21	Male	Chest, left-sided	One week	Fifth	Left, laterally
Case 5	24	Male	Chest, left-sided	One week	Sixth	Left, laterally
Case 6	26	Male	Chest, left-sided	Two days	Seventh	Left, laterally

MDP bone scan showed accumulation of tracer in the same position as the original stress fracture of the seventh rib. Again, she recovered within a few weeks of decreased physical activity, and has now reached normal physical capacity level.

Case 2

A 23-year-old female rower complained of left-sided chest pain for 1 week occurring after a single training session in a rowing ergometer during the on-water season due to bad weather conditions. A stress fracture of the sixth rib posteriorly close to columna was confirmed by ^{99m}Technetium-MDP bone scan. Although physical training ceased for 4 months, she still complained of left-sided chest pain. A renewed ^{99m}Technetium-MDP bone scan revealed no abnormalities. She has now stopped rowing.

Case 3

A 24-year-old male lightweight rower presented with increasing right-sided chest pain for 1 week following the use of a new sweep-oar just before a training camp prior to the World Championships in 1993. The physical examination revealed intense tenderness diffusely in the sixth to eighth right rib laterally. A ^{99m}Technetium-MDP bone scan demonstrated a stress fracture of the eighth right rib laterally (Fig. 1). He recovered within 8 weeks without any problems.

Case 4

A 21-year-old male lightweight rower complained of increasing left-sided chest pain 1 week after his training was restarted after a short period of training cessation due to tendovaginitis of the distal antebrachium. The physical examination revealed intense tenderness of the fifth left rib laterally. A ^{99m}Technetium-MDP bone scan demonstrated focally increased radionuclide uptake of the same rib laterally. He recovered without problems in 3 weeks.

Case 5

A 24-year-old male lightweight rower had increasing left-sided chest pain for 1 week. He was a substitute in the sweep-national team, and often shifted from starboard to port side rowing. A ^{99m}Technetium-MDP bone scan demonstrated a stress fracture in the sixth left rib laterally. He recovered within 4 weeks.

Case 6

A 26-year-old male heavyweight previous olympic rower, who had started intense training to make a comeback to the national team, complained of left-sided chest pain for 2 days, with intense tenderness at the seventh rib anterolaterally. He was originally rowing port side but had been shifted to starboard. A ^{99m}Technetium-MDP bone scan confirmed the suspicion of a stress fracture in the seventh rib laterally. He recovered within 6 weeks.

Discussion

These reported cases demonstrate what we have interpreted as a marked increase in rib stress fractures in elite rowers as this was an observational study where the rowers sought medical care due to chest pain. Stress fractures in other locations of the body have not been reported in rowing. The cases were characterized by various ribs being affected by stress fractures. However, the stress fractures occurred in the fifth to the eighth ribs, respectively, and a lateral location was seen in four of the six cases, in whom all were sweep-oarsmen. There was no association between the chest side of the injury and port side or starboard rowing, respectively. Two of the cases were scullers, and the stress fracture was located posteriorly and posterolaterally. The injury seems to occur year round, since no seasonal pattern was observed, and none of the stress fractures occurred during competition. Three of the cases occurred in lightweight rowers, which has not previously been reported. All three were experienced athletes and had shown no signs of bone disease. In all cases it was possible to pinpoint alterations or increments in habitual physical activity, precipitating and presumably causing the injury. The incidence within the national team, consisting of 50 rowers competing at a high international level, was 12%. Both men and women were injured. Previously it has been mentioned that women are more prone to stress fractures than men (4,7). In this report two of the six cases were women, but since

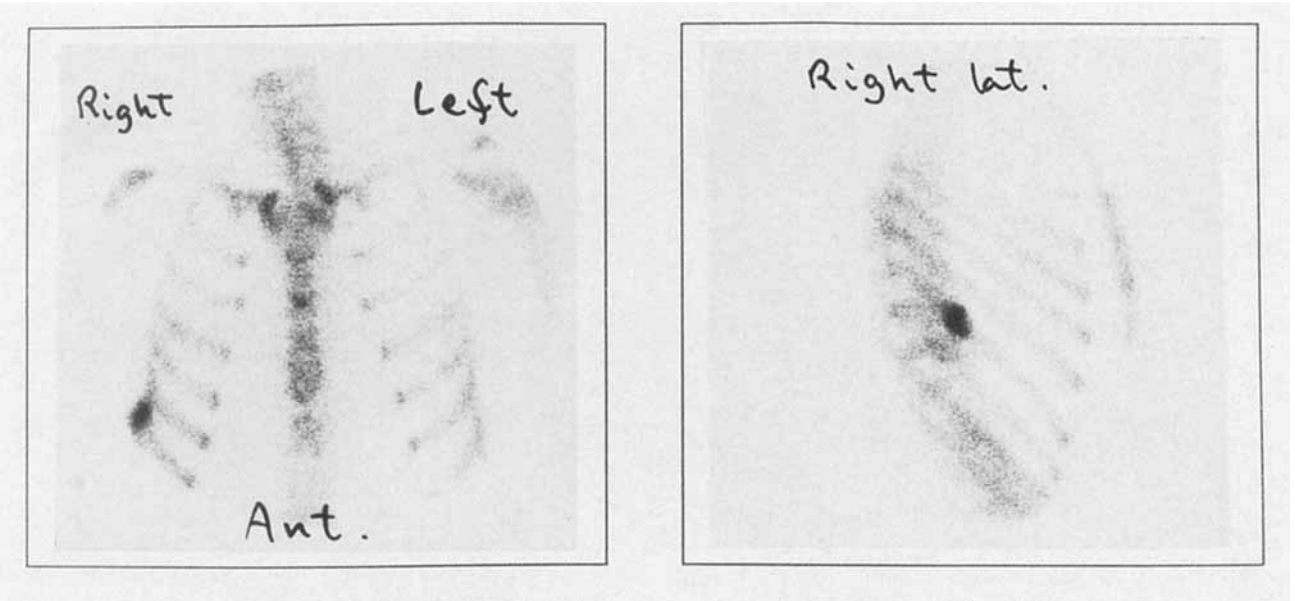

Fig. 1. Bone scan demonstrating increased radionuclide uptake indicating a stress fracture of the eighth right rib in a 24-year-old lightweight rower.

our material is small, it allows no definite conclusions with respect to sexual differences in incidence or susceptibility due to hormonal dysfunction and decreased bone mineral content.

In the present study, the first case of stress fracture draws attention to the risk of stress injuries in the thorax in rowing, since the complaints leading to a bone scan at the time of the first injury were clearly not related to the findings in the bone scan. Secondly, we observed that renewed bone scan, due to new complaints, indicated either a reccurrence of a stress fracture of the rib in the same position or a new stress fracture near the old one, which to our knowledge has not been reported previously, although a negative bone scan in between the positive bone scans was never verified. A possible delayed healing cannot be ruled out, although the athlete was without symptoms and fully active in participation of her sport between the two episodes. The biomechanics of rowing has been described previously, in which the stroke can be divided into the catch, drive phase, finish and recovery phase (11, 12). Several theories as to the part of the stroke, mechanism and pathophysiology of stress fractures to the ribs have been presented. The theory of wear and tear stress due to overuse/overload stress resulting in microtrauma of the bone predominantly at the insertion site of the thoratic muscles presumably also applies to stress fractures in rowing. Is does not seem likely that an acute overload, such as a sprain, has contributed to the injuries, since none of the stress fractures occurred during competition. Therefore, a gradual development of the fractures is more likely to be expected. The maximal bending stress of the rib during the stroke in rowing is seen in the posterolateral part of the rib and involves the serratus anterior, and major and minor rhomboids (13). Therefore, stress fractures have been suggested to occur at the end of the drive phase and in the recovery phase of the stroke, especially in sculling (7, 9). Two of the cases in this report were scullers and had stress fractures posteriorly/posterolaterally, supporting previous findings (7). In our series, two-thirds of the cases were laterally located and occurred only in sweep-oarsmen, indicating that the different movement in sweep-rowing versus sculling involves another mechanism or other part of the stroke in the pathogenesis of the stress fracture, which will be discussed below.

In the present study, two additional components can be added to the generel effect of rowing on high intensity training levels, and they contributed presumably heavily to the development of the injuries. First, a new oar type was used in all cases either shortly or for some time. This oar is characterized by being shorter than a traditional oar, and the shape and size of the blade has been changed so it is rectangular in shape, and it is broader and shorter and asymmetrically mounted on the shaft compared to the traditional blade (Fig. 2). This results in an oar which is easier to handle, gives a greater stability in the water and prevents back watering at the shaft end. Further, this altered construction generates a greater force at the handle and slower velocity at the blade, when the same load is applied to the handle of the oar. Thus, theoretically, the stroke becomes more efficient and generates a greater speed of the boat. To obtain this greater speed more strain is ap-

Fig. 2. The new blade introduced in 1991 (left) being rectangular in shape, broader and shorter compared with the traditional blade (right).

plied to the thoratic muscles involved in the catch and early part of the drive phase, dominated by the serratus anterior, latissimus dorsi muscle, intercostal muscles and external abdominal oblique muscles. Secondly, another improvement in the specific rowing movement and potential increase in rowing capacity comes from the further development of the rowing ergometer, which has also been adapted to be highly efficient throughout the stroke. Therefore we hypothesize that an increase or alteration in physical activity in the weeks prior to the injury and an increase in specific rowing movements with special emphasis on the new equipment, combined with increased biomechanical stress applied to the thoratic skeleton in the catch and the early part of the drive phase of the stroke caused the injuries, especially in the sweep-oarsmen.

Often the diagnosis of stress fractures is delayed due to neglect of the symptoms by the patients, and possibly lack of awareness of the existence of stress fractures in the ribs by physicians and general practitioners. Complaints are interpreted by patients and physicians to be of muscular origin, which may lead to treatment with painkillers, with the risk of worsening the injury. However, subjective complaints may be weak or with a wide clinical presentation. At physical examination the result may range from no obvious signs present (as illustrated in case 1) to intense tenderness of the affected rib. The pain often radiates along the affected rib corresponding to the intercostal nerve. Radiographs have previously been used for the diagnosis of stress fractures. However, bone remodelling may not be present until several weeks after stress injury, demonstrated by only 10% of radiographs being abnormal at the time of presentation (4). Since 1971, the early recognition of stress bone injuries has been facilitated by the introduction of bone scanning, in which focal increases in radionuclide uptake disclose disturbed bone remodelling (14). In the present study, all cases demonstrated a well-defined focus characterizing a stress fracture.

As to the treatment, rest for 1 or 2 weeks was combined with analgesic treatment, especially since intense pain is frequently seen in the patients. Thereafter, non-rowing, non-pain producing activities were allowed. No local anaesthesic blocks were given. This period was followed by a slow return to rowing with low-impact intensity for 1–2 weeks, and subsequently a progressive return to the pre-injury physical level. Furthermore, the incidence of the reported cases clearly emphasises the importance of primary prophylactic intervention from coaches, doctors and physiotherapists, when alterations occur or are planned in physical activity at high intensity level.

In conclusion, an increase in stress fractures of the ribs in elite rowers was seen, presumably as a result of the development of high-efficient new rowing equipment (rowing ergometers and blades). We speculate that increased biomehanical stress upon the thoratic skeleton in the catch and the early part of the drive phase of the stroke enforced by the new equipment, combined with increased training intensity to improve performance, exert the potential risk of stress fractures of the ribs in elite rowers. The condition might well be underdiagnosed in rowers complaining of chest pains. Three cases were seen in lightweight rowers. Bone scan should be the earliest objective tool in diagnosing chest pain with suspected disturbed bone remodelling in stress injuries.

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