

## [ Orthopaedic Surgery ]

# Rowing Injuries

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**Context:** Rowing is one of the original modern Olympic sports and was one of the most popular spectator sports in the United States. Its popularity has been increasing since the enactment of Title IX. The injury patterns in this sport are unique because of the stress applied during the rowing stroke.

**Evidence Acquisition:** This review summarizes the existing literature describing the biomechanics of the rowing stroke and rowing-related injury patterns. Data were obtained from previously published peer-reviewed literature through a search of the entire PubMed database (up to December, 2011) as well as from textbook chapters and rowing coaching manuals.

**Results:** Rowing injuries are primarily overuse related. The knee, lumbar spine, and ribs are most commonly affected. The injury incidence is directly related to the volume of training and technique.

**Conclusion:** Familiarity of the injury patterns and the biomechanical forces affecting the rowing athlete will aid in prompt diagnosis and appropriate management.

**Keywords:** rowing; rowing injuries; overuse injuries; rib stress fractures; lumbar degenerative disc disease

The origins of rowing began some time after 1000 BC when it was discovered that an oar working against a fulcrum was mechanically more efficient than a paddle and that a sliding seat allowed greater force to be exerted against the oar, thus generating more boat speed. In the United States, boatmen were able to support themselves financially by rowing. By the time of the Civil War, James Hamlon and the Biglin and Ward brothers had gained a national reputation in the United States racing for \$50 to \$3000 a race. These individuals provided the sporting public with the first heroes, and they were promoted by various companies, including Hopbiggers Medicine, which called itself the “Invalids Friend and Hope.” Murad cigarettes originated a trading card series of 25 collegiate rowers in 1911.<sup>12</sup>

In 1896, rowing was one of the inaugural events of the modern Olympics, although this event was canceled because of poor weather conditions. The first Olympic regatta for heavyweight men occurred in 1900, and women's events were added in 1976. In 1996, the Olympic rowing competition was expanded to include lightweight men and women.

Following the enactment of Title IX in 1972, there has been nearly a doubling of the number of intercollegiate rowing programs for women in the United States (US Rowing, personal communication, 2011). These opportunities have rekindled the interest and enthusiasm for a sport, which was once the greatest spectator sport in the United States.<sup>12</sup>

With the rapid growth and interest in rowing, a great deal of attention has been focused on the injury patterns occurring in this sport. The majority of rowing injuries are overuse injuries due to an abrupt change in training volume, alterations in technique, or the type of boat rowed. To better understand, evaluate, and treat rowing injuries, a thorough understanding of the sport is essential. The type of boat that is rowed characterizes the rowers. Sweep rowing involves the use of a single oar; the boats are composed of 2, 4, or 8 rowers. Sculling utilizes 2 oars working together and may include a single rower or 2 or 4. At the intercollegiate and international levels, a crew of rowers participates in the open weight or lightweight classification; the lightweight male rowers average 72.5 kg, and the lightweight women average 59 kg. Special attention must be provided to all rowing athletes to encourage proper nutrition, and appropriate evaluation is necessary to determine which athletes may safely participate in the lightweight events.

Rowing is an unusual sport in that the athletes sit facing the stern of the boat with their feet anchored in sneakers attached to a foot stretcher. Their backs are facing the finish line, and the bow of the boat crosses the finish line first.

The rowing stroke begins at the finish with the knees fully extended, the back in a laid-back position from vertical, with hips relatively extended and the elbows flexed into the body at waist height (Figure 1A). The recovery phase begins with

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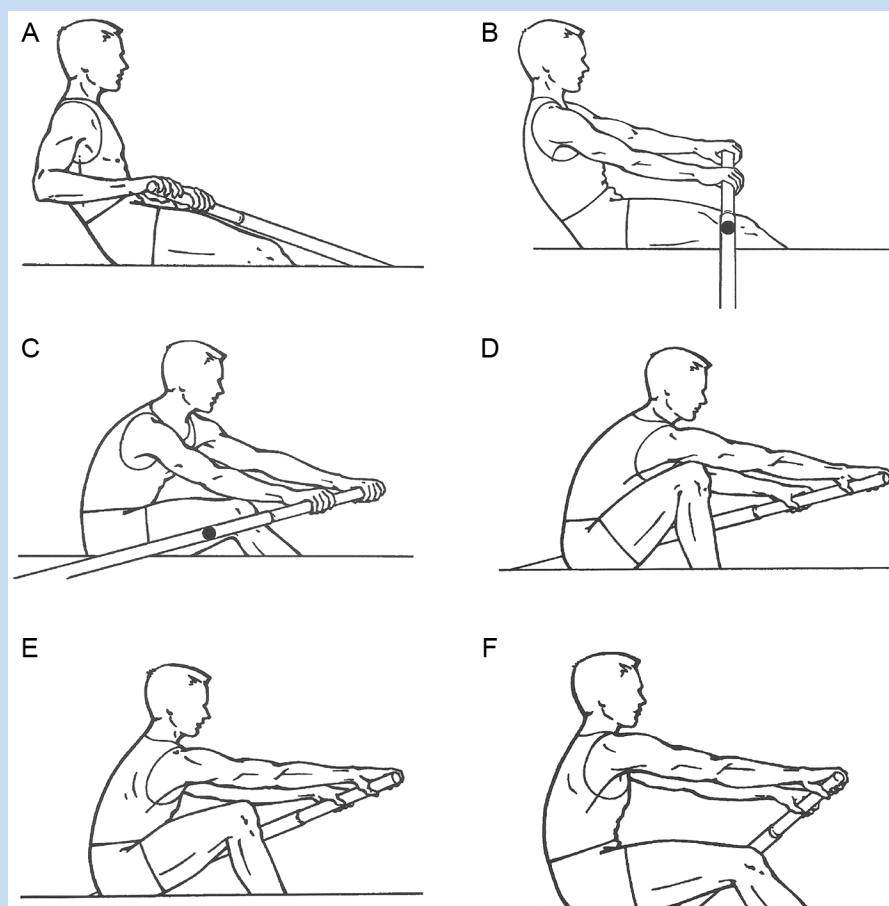


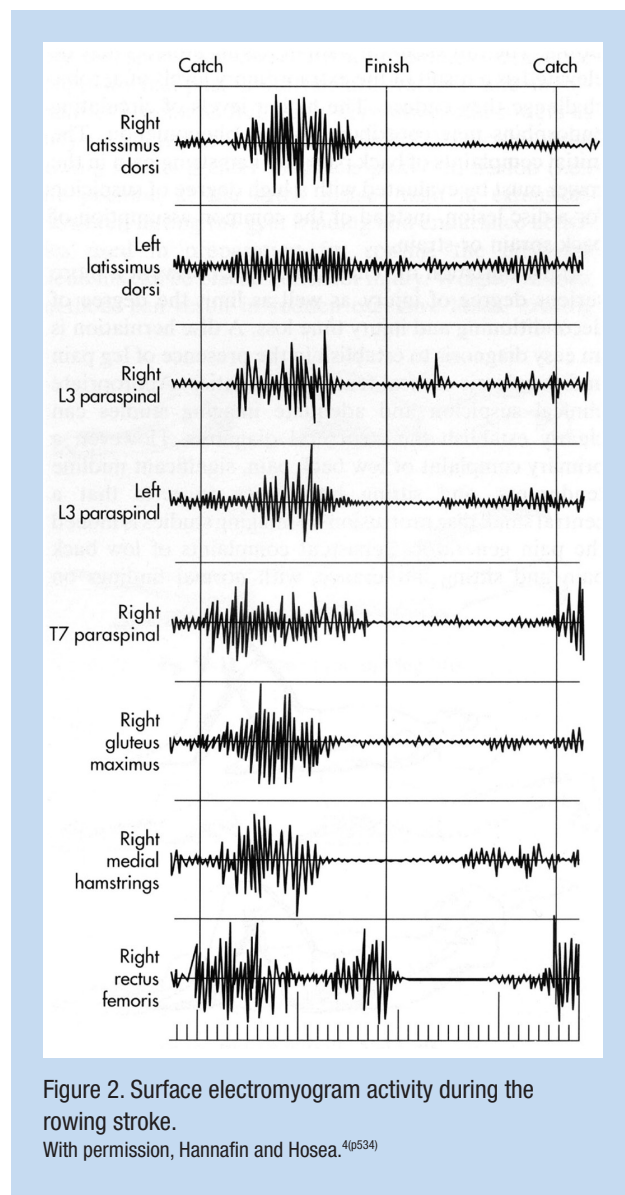
Figure 1. Phases of the rowing stroke: A, the finish; B, early recovery; C, late recovery; D, the catch; E, early drive; F, late drive. With permission, US Rowing Level I coaches manual.<sup>21</sup>

movement of the hands away from the body toward the sternum of the boat, followed by forward flexion at the hip and the forward movement of the spine (Figure 1B, 1C). When the body and shoulders are forward of the hips and the hands past the knees, the legs slowly begin to flex until the catch position is reached with the knees flexed approximately 110° to 120°. The hip is maximally flexed, and the shoulders are fully extended (Figure 1D). At this compressed position, there is a great deal of potential energy stored in the legs, back, and arms in preparation for the drive phase of the stroke. At the catch, the oar is placed into the water, followed by the legs driving the body back toward the bow of the boat, pulling the bow past the anchored oar (Figure 1E). The back, shoulder, and arms function as a braced cantilever so that the force generated by the legs can be applied to the oar and not dissipated (Figure 1F). The drive phase ends at the finish, and the same cycle is repeated over and over for the length of the race or practice.

Myoelectric analysis of a female Olympic rower demonstrates that the firing of the rectus femoris and thoracic

paraspinal muscles initiates the drive phase of the rowing stroke (Figure 2). The rectus femoris muscles provide the power, and the thoracic and lumbar paraspinal muscles stabilize the spine to enable the transfer of the force to the oar. As the knees and hips extend during the drive phase of the rowing stroke, the gluteus maximus and hamstrings fire, controlling the drive and stabilizing the pelvis. The back acts as a braced cantilever and provides an additional source of power by extending from 30° of flexion at the catch to approximately 30° of extension at the finish (Figure 3). The L3 lumbar paraspinal muscles activate during this drive phase of the stroke, stabilizing the spine for the corresponding increase in lumbar compression and shear loads.

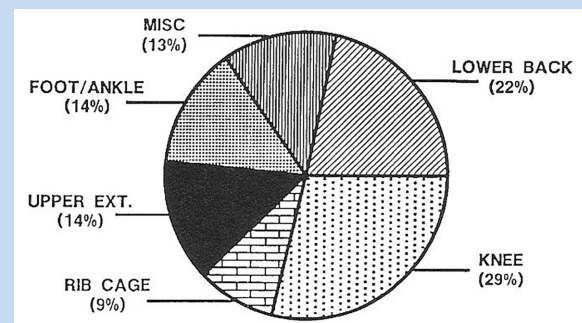
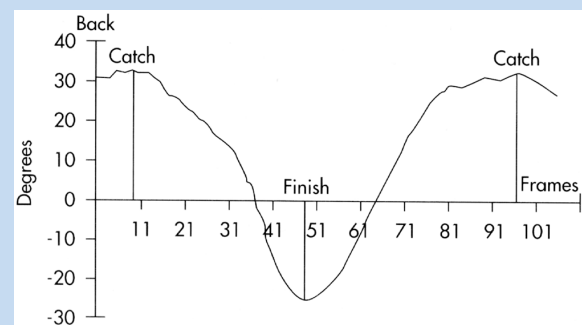
The force generated by the legs and back is transmitted to the oar through the shoulders, which are stabilized by the latissimus dorsi and serratus anterior. Peak acceleration at the middrive causes these muscles to fire maximally and in unison. During the later part of the drive, the rectus femoris continues to fire, keeping the knees extended as the arms pull the oar into the body. At the finish, the previously mentioned major



muscle groups generate minimal activity, while the rectus and external oblique muscles fire stabilizing the trunk, which is in the extended position. During the recovery phase with the body in a forward position and the knees and hips flexing and compressing, there is little to no activity of the paraspinal muscles, reflecting the minimal load on the lumbar discs. The hamstrings then fire submaximally to flex the knees and initiate the movement back up the slide to the catch position to begin the next stroke.<sup>2,4,7,21</sup>

## COMMON INJURIES

Rowing involves a continuous repetitive motion stressing various anatomic areas continually depending on the stroke phase. Off-water training for rowing also involves similar repetitive activities, such as weight lifting, running, stair



running, cross-country skiing, rowing in tanks, and using a rowing ergometer. These activities may predispose individuals to stress fractures, primarily affecting the ribs. The rowing stress pattern is also thought to be responsible for the high incidence of discogenic back pain. The majority of the knee injuries involved chondromalacia patella and iliotibial band (ITB) friction syndrome, reflecting the constant flexion and extension of the knee under load. The necessity to feather (flip) the oar perpendicular and parallel to the water results in extensor tenosynovitis.

The injuries effecting rowers are primarily from overuse.<sup>7,10,16</sup> A review of the injury patterns at the rowing programs at Harvard and Rutgers universities revealed 180 injuries to oarsmen and oarswomen over a 3-year period (Figure 4). The occurrence corresponds to the periods of intense training in the fall and winter months prior to the racing season (Figure 5).<sup>2,7</sup> At these institutions, the knee was the most common site of pain, followed by the back, upper extremity, and rib cage.

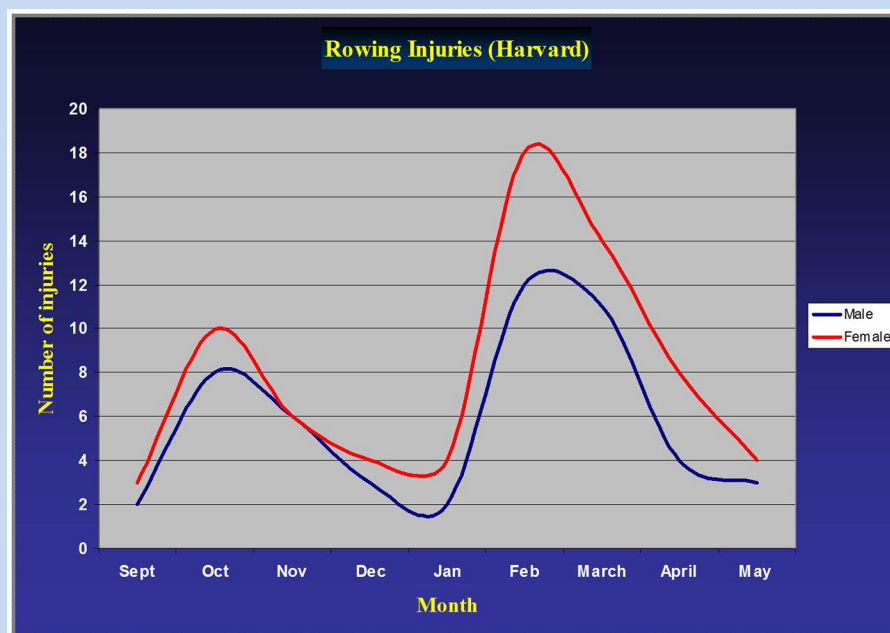


Figure 5. Monthly incidence of rowing injuries at Harvard University showing an increasing number of injuries during the months of intense training prior to the racing season in the fall and spring.

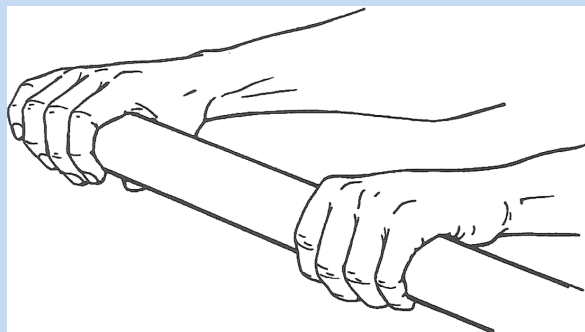


Figure 6. The sweep grip position: the inside hand feathers (rotates) the oar parallel and perpendicular to the water. This constant motion may lead to the development of crossover extensor tenosynovitis.

With permission, Hannafin and Hosea.<sup>4(p539)</sup>

## EXTENSOR TENOSYNOVITIS OF THE WRIST

During the rowing stroke, the oar blade is removed from the water at the finish. It then rotates parallel to the water and is rerotated back perpendicular at the catch prior to its placement into the water. This feathering motion is different for the sculler and sweep rowers. The sweep rowers use 1 hand to

rotate (feather) the oar, while the sculling rowers, by necessity, have to use both hands (Figures 6 and 7).

When feathering, the abductor pollicis longus, extensor pollicis brevis, and the extensor carpi radialis long and brevis are utilized. Surgical exploration has revealed that extensor tenosynovitis in the wrist in rowers is caused by compression of the radial extensor tendons beneath the swollen hypertrophied belly of the abductor pollicis longus and extensor pollicis brevis (Figure 8).<sup>23</sup> Extensor tenosynovitis is a common overuse injury in rowers and generally manifests itself in early spring when there is a return to high-intensity rowing on the water and in relatively cold weather. This is associated with pain, swelling, and crepitus with motion of the involved tendons. It is a cause of considerable functional disability, not only with rowing, but occasionally with activities of daily living. Conventional treatment involves rest with the use of a cock-up wrist splint, anti-inflammatory medication, and physical therapy modalities, such as ultrasound and whirlpool. Local corticosteroid injections may be helpful. Conservative management has generally provided relief in 2 to 3 weeks. The key to prevention of extensor tenosynovitis is keeping the hand and wrist warm by using long sleeves and commercially available fleece covers that protect the hand and wrist while rowing outdoors.

Williams has reported excellent results with surgical decompression of the abductor pollicis longus and extensor brevis.<sup>23</sup>

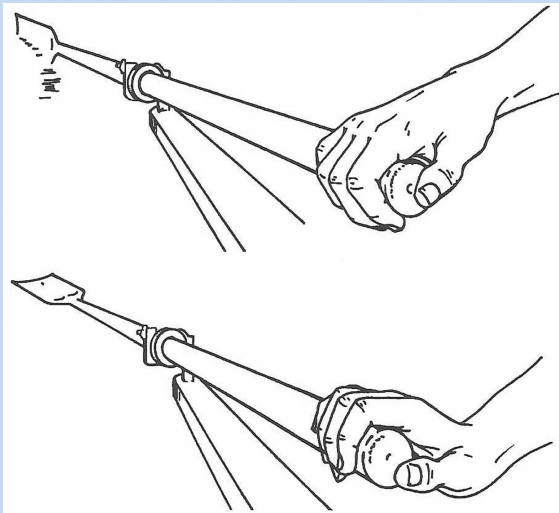


Figure 7. The sculling grip: the wrist dorsiflexes and causes the oar to rotate. Both hands rotate their oars simultaneously.

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## CHONDROMALACIA PATELLA AND ITB FRICTION SYNDROME

Rowing involves extreme loading of the patellofemoral joint. In addition, the training activities designed to increase the strength of the quadriceps mechanism, including stair running and squat jumps, cause significant patella pressure. In a survey of rowing-related injuries, the knee was the most commonly affected site,<sup>7</sup> with chondromalacia patella and ITB friction syndrome the most common diagnoses.

Chondromalacia patella presents with complaints of anterior knee pain with rowing and quad-strengthening training activities. If a rower has either genu valgum or genu varum, rowing may precipitate the development of either patella-femoral arthralgia or chondromalacia in the case of the former or ITB friction syndrome in the case of the latter. Patellofemoral pain is commonly found in those with genu valgum, increased femoral anteversion, and secondary external rotation of the tibia. Pain with ascending and descending stairs, swelling, crepitus, and/or a clicking sensation during the rowing stroke may be present. Examination of the knee generally reveals lateral patellar facet tenderness. Of particular note in the rowing population is the presence of tight quadriceps, hip flexors, and the ITB.

Treatment for the individual with chondromalacia patella consists of nonsteroidal anti-inflammatory medication and an aggressive stretching program of the anterior hip, quadriceps, and ITB. In addition, strengthening the vastus medialis obliquus and medial quadriceps with progressive resistance exercises are important components of the rehabilitation program. McConnell

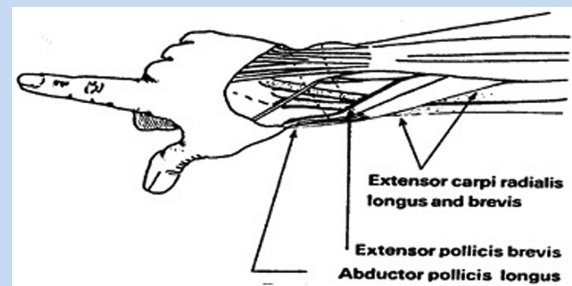


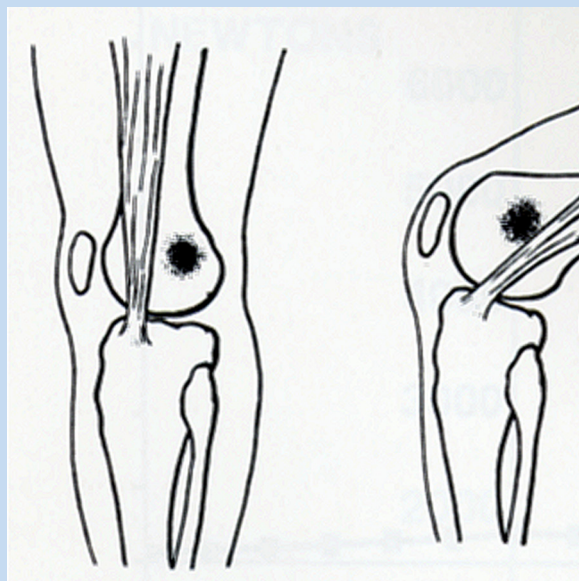
Figure 8. Crossover extensor tenosynovitis: the extensor pollicis brevis and abductor pollicis longus tendons (first dorsal compartment) cross over the extensor carpi radialis longus and brevis (second dorsal compartment). The constant feathering motion of the oar may lead to pain, swelling, and crepitus, especially in cold weather.

taping and lateral tracking bracing techniques have been helpful. In a markedly symptomatic rower, all rowing and squatting activities should stop until pain relief is obtained.

Modifications in the position of the foot stretcher can alter the patellofemoral mechanics: A decrease in the knee flexion angle at the catch and, thus, a decrease in patella compression can be achieved by raising the height of the foot stretcher. Functional knee varus or valgus can be addressed by changing the rotation of the toe-in or toe-out position of the sneakers. Front or back stops can be placed on the track of the sliding seat of the shell or ergometer to limit the arc for knee flexion or extension.<sup>4</sup> Surgical management of patellofemoral pain has rarely been necessary in the rowing population. However, a novice rower with significant preexisting chondromalacia patella associated with pain and crepitus should be cautious about participation in this sport.

The ITB friction syndrome is also fairly common in the rowing population. This condition occurs secondary to pressure from the ITB against the lateral femoral condyle as it moves from a position anterior to the femoral condyle in extension to posterior with knee flexion (Figure 9). The ITB originates as the tendinous extension of the fascia covering the gluteus maximus and tensor fascia lata muscles proximally and attaches to Gerdy tubercle on the proximal aspect of the anterolateral tibial metaphysis. While sending fibers to the lateral intramuscular septum and the lateral aspect of the patella over the lateral femoral condyle, the ITB is free to glide anteriorly and posteriorly. Either motion may produce inflammation over the lateral femoral condyle resulting in localized pain. The ITB friction syndrome may also present with crepitus and swelling of the lateral aspect of the knee. The Ober test is universally positive; this syndrome is more common in individuals with slight genu varum. Treatment for the ITB friction syndrome consists of rest, ice, anti-inflammatory medications, ultrasound, and occasional local





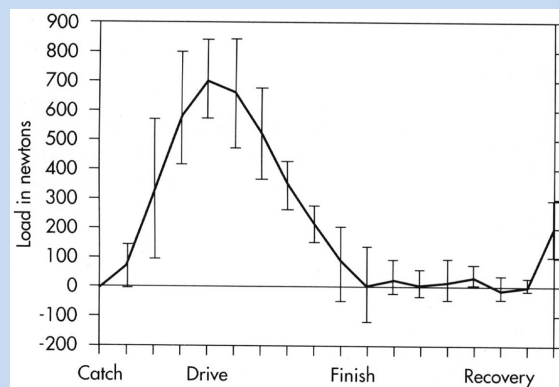
**Figure 9.** Iliotibial band friction syndrome.  
With permission, Nicholas JA, Hershman EB. *The Spine and Extremity in Sports Medicine*. St Louis, MO: Mosby Yearbook; 1995:928.

corticosteroid injection. In addition, comprehensive stretching exercises can correct the static contracture. Stair running and squatting activities should be eliminated in the training program. These individuals can usually continue rowing except for the most severe cases.

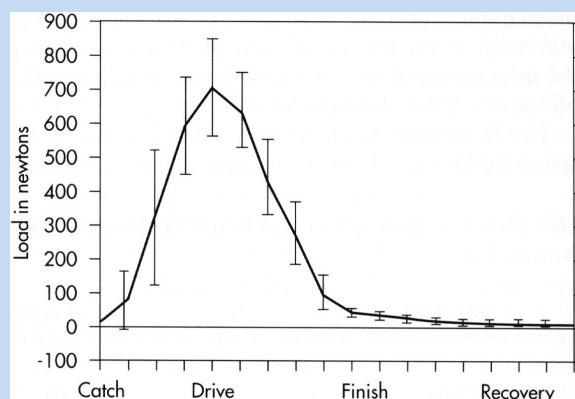
## LOW BACK PAIN

Low back pain is a common complaint in the rowing population.<sup>2,4,7,10,11,16,19</sup> Howell's studies of elite lightweight female rowers revealed an 82.2% incidence of low back pain compared with an age- and sex-matched general population of 20% to 30%.<sup>5</sup> Stallard stated "that a back ache is suffered by almost all those in serious rowing training."<sup>17</sup>

The review of 2 intercollegiate programs revealed the lower back as the second-most-common area injured.<sup>4,7</sup> Among junior rowers at the world championships, it was the most common complaint.<sup>16</sup> Kinetic and myoelectric analysis of the lower spine during the rowing stroke reveals significant loading with each stroke. The back functions as a braced cantilever during the rowing stroke and is the major connection in the transfer of power from the legs to the oar. These forces are similar for sculling and ergometer rowing. Sweep rowing adds a torsional and lateral bending stress to the already-existing sheer and compression loads of the sculling rowing stroke. At the catch, there is a rapid generation of force at the oar. This force accelerates to a peak at the middrive and tapers to the finish. This pattern is similar for men and women. The anterior shear loading while rowing mirrors the resistance at the oar (Figures 10 and 11).<sup>2,4,7</sup> The peak shear load during a



**Figure 10.** The anterior shear loading of the L3-4 motion segment during the rowing stroke. This demonstrates the rapid increase in the shear load following the catch, which peaks at middrive and tapers to the finish.  
With permission, Hannafin and Hosea.<sup>4(p534)</sup>



**Figure 11.** The load generated at the oar as measured by a strain gauge. The rapid increase is related to the leg drive and peaks at midportion of the drive phase of the rowing stroke.  
With permission, Hannafin and Hosea.<sup>4(p534)</sup>

simulated race piece on the ergometer averaged  $848 \pm 133$  N for the males and 660 to 717  $\pm$  117 to 69 N for the females.<sup>7,13</sup> This shear load is essentially the same for both sexes when normalized for body weight. Current training programs involve long aerobic pieces on the ergometer with a lower stroke rate and a relatively higher load per stroke. Ergometer pieces longer than 30 minutes are significantly related to the development of low back pain.<sup>19</sup> Evaluation of the load at the oar while maintaining a steady pace and changing the stroke rate revealed a significant decrease in load and associated shear

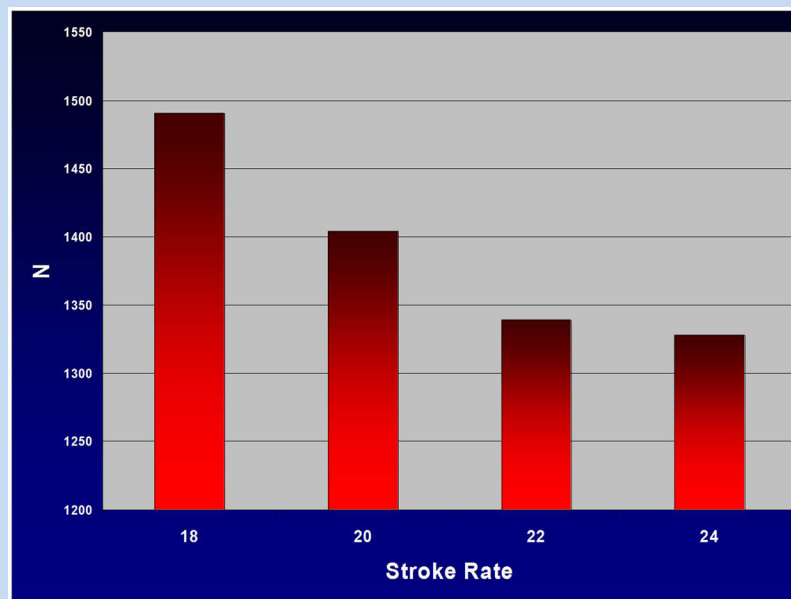


Figure 12. Decrease in the peak load at the oar with increasing stroke rate while maintaining the same pace during an aerobic workout.

load with increasing stroke rate, indicating the advantage of using a higher rowing cadence to decrease the stress on the lower back (Figure 12).

Biomechanical studies reveal significant increases in lumbar flexion during a rowing trial with evidence of fatigue of the erector spinae muscles.<sup>3,6</sup> Males demonstrate a greater flexion angle at the catch than do females. A spine flexion angle of approximately 30° at the catch to 28° at the finish has been shown.<sup>2,7</sup> The peak compression load occurs during a latter portion of the drive phase as the spine passes over the pelvis into the extended position. The compression force at this point of the rowing stroke, which corresponded to the peak shear force, normalized for body weight that averaged approximately 6.8 to 7 x body weight for the females and males, respectively.<sup>2,7</sup>

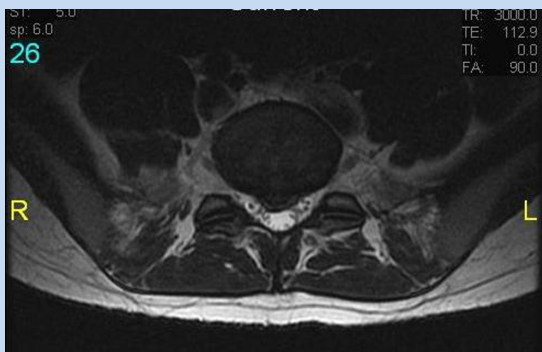
The forces generated by the rowing stroke were similar to those producing pathologic changes in cadaveric specimens.<sup>1</sup> While the spine motion is well suited to resist compression, the shear load generated, as well as those of lateral bending and torque in the sweep rower, makes the intervertebral disc susceptible to injury.

Maurer et al demonstrated a marked increase in the incidence of lumbar spine abnormalities on magnetic resonance imaging (MRI) compared with a control group.<sup>11</sup> A review of 38 female and 26 male rowers with a mean age of nearly 18 years revealed a significant incidence of degenerative and herniated lumbar discs: 95.2% of the male rowers had positive MRI results; 46% had a disc herniation; and 27% had 2 or more lumbar spinal levels of degenerative discs or herniation. The

female rowers had a positive MRI incidence of 78.9%, with 59.9% of the MRI studies showing a disc herniation. Despite these findings on MRI in a young rowing population averaging approximately 18 years of age, only 27% of the females and 15% of the males revealed any neurological signs or symptoms. Despite this paucity of neurological deficits, pain with sitting and pain radiating into the legs or buttock correlates significantly with abnormal MRI results.<sup>8</sup>

Teitz et al<sup>19</sup> identified factors associated with the development of back pain in the intercollegiate rowing population: rowing before age 16 years, the hatchet oar, training with free weights, and ergometer training pieces longer than 30 minutes. Sweep rowers who changed sides during a season also had a significantly greater chance of developing low back pain than did those who did not change sides. Those who regularly performed 10 minutes of posttraining stretching had a lower incidence of acute back injuries.<sup>16</sup> Rowers who entered college with a preexisting history of back pain were more likely to be symptomatic in college but were less likely to miss extended periods of practice time or end their rowing careers because of back pain.<sup>15</sup> Yet former rowers with back pain in college had a lifetime prevalence of back pain equal to that of the general population.<sup>20</sup> They had a significantly lower prevalence of obesity compared with the general population.<sup>14</sup>

Back pain may present differently depending on age, sweep versus sculling, and ergometer use. A central disc herniation (Figure 13) presents with lower lumbar pain without radiation into the legs and an absence of neurological findings. The overall incidence of neurological findings on physical



**Figure 13.** MRI of a L5-S1 central disc herniation in an 18-year-old female rower.

examination is extremely low despite the presence of lumbar disc degenerative changes and herniation on MRI.<sup>8</sup> In the older rower with a longstanding history of degenerative disc disease, the posterior elements and facets may be associated with the development of lower back pain.<sup>2</sup> A young rower presenting with lower back pain should be thoroughly evaluated with radiographs to rule out spondylolisthesis, infection, tumor, segmental instability, or fracture. MRI is the study most likely to identify discogenic pathology. Because of the high incidence of discogenic disease in the rowing population, obtaining the studies early in the evaluation of the complaint of back pain is important to an accurate, timely diagnosis and treatment.<sup>8</sup>

Treatment for discogenic lower back pain includes cessation of rowing, active rest as tolerated, local modalities, nonsteroidal anti-inflammatory medications, and occasionally antispasmodic medications.<sup>18</sup> Once the acute symptoms have subsided and the pain has largely resolved, a comprehensive rehabilitation program is initiated beginning with hamstring stretching and lumbosacral range of motion exercises associated with core strengthening, instruction in proper body mechanics, and progression to rowing. In individuals with persistent symptomatic radiculopathy or discogenic pain, epidural corticosteroid injections may be warranted. If the neurological deficit persists or progresses despite conservative management and correlates with objective findings on physical examination and diagnostic studies, surgical intervention may be indicated.

Spondylolysis is a defect of the pars intra-articularis and, in most cases, represents an overuse stress injury caused by the repetitive loading of the lumbar spine. The rowing athlete usually presents with lower back pain without sciatica. The pain is localized lateral to the midline and is exacerbated with hyperextension of the spine without neurological deficits. Radiographs should include lumbar oblique views, which may identify a pars defect. Radiographs may be inconclusive. A single-photon emission computed tomography bone scan can identify the injury. A lumbar MRI may show the increased signal on the T2-weighted images associated with the pars stress reaction. Symptomatic individuals should follow a

comprehensive back program with emphasis on lower extremity and trunk stretching as well as strengthening. While the athlete is symptomatic, rowing should be avoided. For individuals with persistent symptoms, Boston bracing may be helpful.

Facet joint arthropathy occurs as a result of aging and minor trauma. Rowers with degenerative facet changes generally complain of vague lower back pain without radicular symptoms. As the process progresses, the pain is described as dull, deep, and aching, referred to the lumbosacral area, buttock, and upper thighs. It is exacerbated by ambulation and relieved by sitting. Physical examination may reveal loss of the normal lumbar lordosis with decreased lumbar range of motion. Significant paraspinal spasm may be present and elicited by palpation over the affected facet joints. Neurological examination reflects the level of motion segment involvement with associated nerve root compression. If facet hypertrophy is extensive, the nerve root exiting 1 level below may be involved, thus presenting a complex clinical picture. Radiographs, computed tomography scan, and MRI may be helpful in defining the pathology. Limitation of activities, nonsteroidal anti-inflammatory drugs, and a lumbar support will generally provide relief. A trunk and hamstring stretching program should be instituted.

Low back pain in the rowing population is common and directly related to the loads placed on the lumbar spine. Management includes a prompt, accurate diagnosis and appropriate management with an emphasis on maintaining the aerobic performance of the rower while rehabilitating the lower back injury.

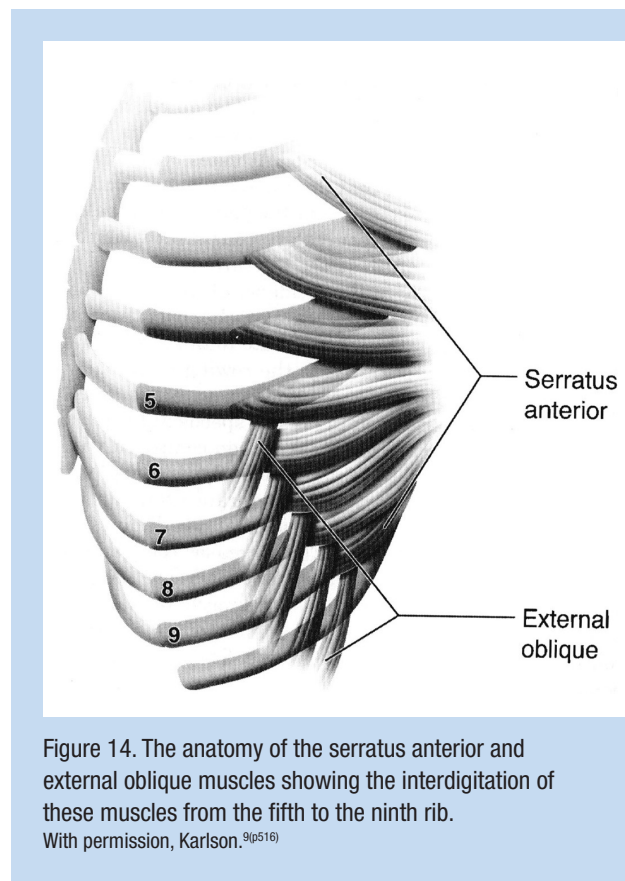
## RIBS AND THORAX

Rib cage pain is common in the rowing population. The majority of these injuries are rib stress fractures. Studies of the collegiate rowing programs and the Canadian national rowing team revealed that rib stress fractures make up approximately 10% of all rowing injuries.<sup>4,5,7</sup> The rib stress fracture in the rowing population primarily affects the fifth through ninth rib.<sup>7,10</sup>

Biomechanical analysis of the ribs predicts that the bending moment occurs at the middle third of the rib in its posterolateral segment.<sup>9</sup> The opposing actions of the serratus anterior and external oblique muscles are major contributors to development of a stress fracture.<sup>10</sup> Vinther et al identified an increased thoracic muscle co-contraction and a reduced leg:arm strength ratio in elite rowers with a rib stress fracture compared with a control group.<sup>22</sup> The serratus anterior muscle originates at the medial border of the scapula and inserts into the anterolateral aspect of the first through ninth ribs (Figure 14). It interdigitates with origin of the external oblique muscle on the fifth to ninth ribs and fires maximally at the catch phase of the rowing stroke. This activity continues through the drive phase and is “turned off” at the finish (Figure 15). The serratus anterior stabilizes the scapula allowing the transfer of the power generated by the legs to the oar.

The external oblique muscle increases the lateral segment bend of the rib by pulling it inward and downward. To





fire maximally at the finish of the rowing stroke when the shoulders are behind the hips and scapulae are fully retracted, the serratus anterior muscle must fire eccentrically. The opposing action of these 2 muscles results in repetitive bending forces in the middle segment of the rib. With intense training and increasing loads, this firing pattern results in a rib stress fracture.

Rib stress fractures generally occur during periods of intense training with a relatively low stroke rate and high load per stroke. This occurs during the fall and winter training months when the rowers are doing long aerobic pieces on the rowing ergometer.

Rib stress fracture generally presents with a vague, ill-defined thoracic discomfort before progressing to an obviously painful stress fracture. Recognizing the insidious onset and changing the rib stress patterns at that time may prevent the onset of the acute rib stress fracture.

The stress fracture presents with sharp stabbing pain, which is exacerbated by coughing, deep breathing, and change in position, occasionally accompanied by winging of the scapula. The pain is discretely localized over the affected rib in the posterolateral corner and radiates to the anterior axillary line. It is reproduced with thoracic compression as well as stressing the serratus anterior muscle on the affected side. Fracture can also occur anterolaterally, although this is less common.

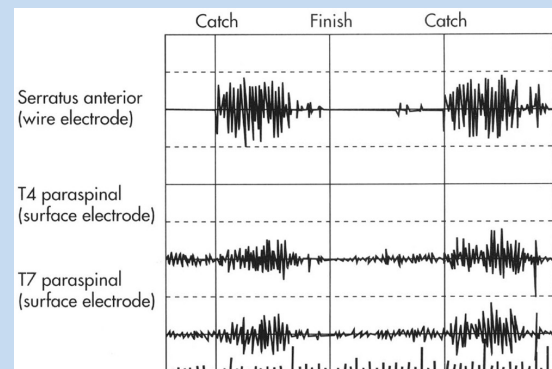


Figure 15. Electromyogram activity of the serratus anterior and the thoracic paraspinal musculature during the rowing stroke. The activity of the serratus anterior is maximal during the drive phase, corresponding to the stabilization of the scapula allowing the transfer of the power to the oar. With permission, Hannafin and Hosea.<sup>4(p537)</sup>

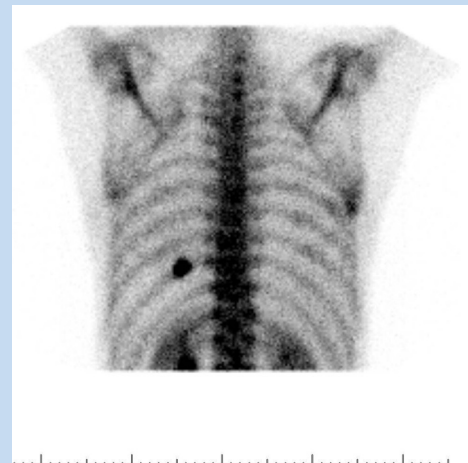


Figure 16. Bone scan of a rib stress fracture in an elite female rower.

The diagnosis is confirmed by a bone scan, which identifies the increased uptake in the rib (Figure 16). The acute stress fracture is rarely seen on routine radiographs; radiographic results become positive when the fracture callus becomes visible. Hypertrophic nonunion following an unrecognized rib stress fracture can occur (Figure 17). Rib stress fractures generally heal within 6 to 8 weeks if recognized early and treated appropriately. With the onset of symptoms, the rower should cease all activities until comfortable with activities of daily living. This generally takes 5 to 7 days. At this point, the

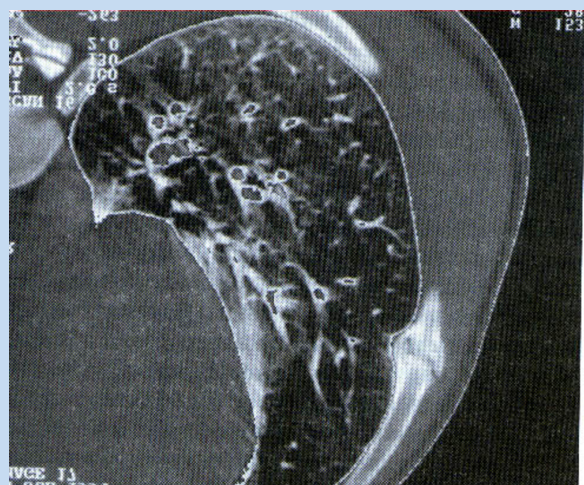


Figure 17. Hypertrophic nonunion of a rib stress fracture in a 20-year-old intercollegiate male rower.

With permission, Hannafin and Hosea.<sup>4(p537)</sup>

rower continues to avoid rowing activities and begins cross-training to maintain aerobic fitness, using devices such as a bicycle ergometer and stair-climber machines. Running and impact loading activities tend to exacerbate the discomfort and are avoided during the early healing period. As the fracture heals and the rib becomes less symptomatic, training on the rowing ergometer is allowed, with minimal resistance at a relatively high stroke rate. The rower then progresses with slightly increasing resistance and lowering the stroke rate as tolerated until able to resume normal training activities. Symptomatic relief is provided with analgesics and nonsteroidal anti-inflammatory medications. Strengthening of the scapulothoracic stabilizing muscles should prevent recurrence of the injury.

Costochondritis is also common in the rowing population. Unlike the rib stress fracture, which is typically painful in the posterior axillary line, costochondritis presents anteriorly at the rib costocartilage interface. The onset is usually insidious and exacerbated with the oar striking the chest at the finish of the stroke. The fifth, sixth, or seventh costochondral junction is point tender and rarely associated with swelling or crepitus. X-rays and a 3-phase bone scan usually do not identify the affected area; the bone scan may become positive with time. Treatment involves eliminating the activity that aggravates the pain and decreasing the inflammation with iontophoresis. Topical nonsteroidal anti-inflammatory medications are helpful in alleviating the symptoms. A local corticosteroid injection may help alleviate the symptoms.

Myofascial pain and trigger points have been identified along the rhomboids and thoracic paraspinal musculature or at the insertion of the levator scapulae into the medial superior of the scapula. These rarely require the cessation of rowing and usually respond to deep massage and trigger point therapy.

## SUMMARY

Rowing injuries are due to overuse and related to the stress of the rowing stroke. While the rowing athlete may experience low back pain during periods of intense training, the intercollegiate rower has less of a chance of low back pain than that of the general population (51.4% vs 60%-80%). Rowers who develop back pain in college are more likely to have future episodes of back pain than are rowers who were asymptomatic in college. Rowers have a significantly lower risk of obesity than that of the general population, both in college and throughout their lifetime. Rowing provides excellent aerobic conditioning and lifelong benefits.

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