

# Chapter 9

## MANAGEMENT AND TREATMENT OF TRAINING-RELATED INJURIES IN INITIAL ENTRY TRAINING

KEITH G. HAURET, MPT, MSPH<sup>\*</sup>; BRUCE H. JONES, MD, MPH<sup>†</sup>; AND JOSEPH J. KNAPIK, ScD<sup>‡</sup>

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### SUMMARY

<sup>\*</sup>Lieutenant Colonel, Medical Specialist Corps, US Army (Retired); Epidemiologist, Injury Prevention Program, Directorate of Epidemiology and Disease Surveillance, US Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland 21010

<sup>†</sup>Colonel, Medical Corps, US Army (Retired); Program Manager, Injury Prevention Program, Directorate of Epidemiology and Disease Surveillance, US Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland 21010

<sup>‡</sup>Major, Medical Service Corps, US Army (Retired); Research Physiologist, Injury Prevention Program, Directorate of Epidemiology and Disease Surveillance, US Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland 21010

## INTRODUCTION

Recruits entering the US Army begin their military training at one of the Army's initial entry training (IET) posts. For most recruits, the process begins with basic combat training (BCT), in which fundamental soldier skills, military customs and courtesies, and Army values are introduced. Physical fitness is also an important element of BCT. After graduation from BCT, soldiers begin the second phase of their IET—advanced individual training—that involves job-specific skills training for their assigned military occupational specialty. For some military occupational specialties (including military police, combat engineers, infantry, armor, and field artillery), the BCT and Advanced Individual Training phases are combined and referred to as one-station unit training (OSUT).

Primary prevention of injuries in IET is an important goal of commanders, drill sergeants, and healthcare providers. Some injuries, however, will occur because of the risks involved in training, training errors, or lack

of knowledge about specific injury risk factors. Healthcare providers should recognize injuries at the earliest possible point, treat them immediately, and provide optimal methods of rehabilitation. Thus, the goals of injury management and treatment are to (a) minimize damage once the injury has occurred, (b) return the recruit to unrestricted training, and (c) educate the trainee to minimize the potential for injury recurrence.

The intense training demands during IET present challenges to injured trainees, the cadre, and healthcare providers. Most recruits are highly motivated and focused on completing the required training events for graduation. They might delay or even avoid seeking medical evaluation and treatment for an injury (even in the case of moderate or severe injury), possibly resulting in slower recovery or worsening injury severity. Therefore, healthcare providers need to understand the physical and psychological demands of the training environment and the types of injuries that can occur.

## TYPES OF TRAINING-RELATED INJURIES

In the IET environment, especially during BCT and the early phases of OSUT, most injuries are considered training related and can be classified broadly as either acute (mostly traumatic) injuries or overuse injuries.

Most often, acute injuries result from a single, forceful event (eg, twisting an ankle while running, dislocating a shoulder during unarmed combat training, or fracturing a bone in an obstacle course fall). Whenever ligaments, bones, or muscle and tendon units are subjected to significant and major abrupt forces that exceed the body's inherent capability to absorb and dissipate the energy, structural tissue failure and injury result. In contrast, overuse injuries result from smaller, repetitive forces on the structural (bones and ligaments) and force-generating (muscles and tendons) elements of the body. Over time, excessive use or repetitive physical strain on tissues can exceed the tissue's daily ability to recover and repair itself. The cumulative effect of these successive insults causes overuse injuries,<sup>1</sup> which develop over days or weeks and are characterized by pain and inflammation. Trainees who are not physically fit or who were previously inactive are at higher risk for sustaining overuse injuries, compared with their more physically active and fit counterparts. Examples of overuse injuries are shin-splints, patellofemoral pain syndrome (PFPS), plantar fasciitis, and bone stress injuries (eg, stress fractures).

### Acute Injuries

Table 9-1 describes the types, locations, signs and symptoms, and immediate treatments for common training-related acute injuries seen in IET. The two major types of acute injuries encountered in BCT are sprains of the ligaments around the joints and strains of the muscles and tendons.<sup>2,3</sup>

#### Sprains

A sprain is a stretch or tear of a ligament. Ligaments are fibrous bands of connective tissue that join the end of one bone with another and provide joint stability. Sprains are classified as first, second, or third degree, depending on the severity of ligamentous injury.

First-degree sprains result from minimal tearing of the ligament. These injuries are characterized by microfailure of collagen fibers within the ligament. There is no associated joint instability, only mild pain and swelling. First-degree sprains that do not allow return to full activity within a few days should be evaluated further.

Second-degree sprains are more severe, with partial tearing of the ligament and possible tearing of the joint capsule. There is substantial damage to the collagen fiber and loss of ligamentous integrity. With a second-degree sprain, there might be some joint instability, although at first this might not be apparent if there is

TABLE 9-1

## COMMON TRAINING-RELATED ACUTE (TRAUMATIC) INJURIES

| Type              | Anatomical Location     | Signs/Symptoms                              | Immediate Treatment                           |
|-------------------|-------------------------|---------------------------------------------|-----------------------------------------------|
| Sprain            | Ligament, joint capsule | Pain, swelling, joint instability           | RICE, limited weight-bearing                  |
| Strain            | Muscle, tendon          | Pain, swelling, tightness, loss of function | RICE, limited weight-bearing                  |
| Fracture          | Bone                    | Pain, swelling, deformity                   | Immobilize, transport to emergency department |
| Dislocation       | Joint                   | Pain, swelling, instability                 | Immobilize, transport to emergency department |
| Friction blisters | Skin                    | Pain, swelling, bleeding, infection         | Wound care, sterile dressing                  |

RICE: rest, ice, compression, elevation

associated muscle guarding or spasm. These injuries are characterized by severe pain and marked swelling. A second-degree sprain that is inadequately treated can result in further injury or complete tearing of the ligament.

Third-degree sprains result from a complete tear of the ligament. These injuries are characterized by severe pain at the time of injury and obvious joint instability. Third-degree sprains require bracing to further protect the joint and surrounding structures, as well as intensive rehabilitation. Because surgical reconstruction of the torn ligament and stabilization of the joint might also be required, prompt evaluation by an orthopedic surgeon and a rehabilitation specialist is imperative.

A lateral ankle sprain is the most common sprain in IET; knee sprains (involving the medial collateral ligament or the anterior cruciate ligament) are less frequent, but tend to be serious injuries. Sprains should be evaluated promptly to determine whether self-care by the trainee (see Chapter 23, *Fostering the Practice of Soldier Self-Care*), a temporary profile (ie, a duty limitation), or further evaluation by a medical provider is indicated. The constant and intense training schedule can make it difficult for even first-degree sprains to recover adequately. Therefore, it is better to restrict weight-bearing activities for a short period at the time of injury rather than prolong the recovery and possibly reinjure the joint by continuing unrestricted training. All suspected second- and third-degree sprains must be evaluated immediately by an orthopedic surgeon and a rehabilitation specialist to assess the severity of injury and initiate proper treatment and duty restrictions.

### Strains

Generally, acute muscle strains result from stretching or tearing a muscle. Like sprains, strains are classified as first, second, or third degree by the severity of muscle damage and the resulting loss of function.

First-degree muscle strains produce mild signs and symptoms, including localized pain, tenderness, and muscle tightness or soreness. Pain increases with passive stretching or vigorous contraction of the injured muscle.

Second-degree muscle strains are more severe injuries, with partial tearing of the injured muscles. Substantial pain and weakness occur with a forceful muscle contraction that results in noticeable loss of function. These strains are often accompanied by swelling, hemorrhage, and ecchymosis at the site of injury. Other symptoms include focal tenderness on muscle palpation, pain on passive stretching, and pain with mild to moderate intensity muscle contractions.

Third-degree muscle strains cause marked muscle disruption and possible avulsion of the muscle and tendon unit. Disruption in the continuity of the muscle or tendon is grossly apparent, or a palpable defect in the muscle or tendon might be noted. Any contraction of the affected muscle produces pain with marked weakness. Because third-degree strains require prolonged rehabilitation and might require surgical intervention, these strains should be evaluated promptly by an orthopedic surgeon and a rehabilitation specialist.

Acute muscle strains are common in IET, occurring most frequently in the muscles of the lower extremities (hamstrings, quadriceps, and the gastrocnemius-soleus muscles), lower back, and shoulder girdle (trapezius and rotator cuff). Most of these injuries are first-degree

strains and normally require recovery of 1 week or less. Second- and third-degree strains in IET usually involve muscles of the lower extremity, requiring a few weeks to months of recovery and rehabilitation. To decrease the risk of re-injuring a healing acute strain, it is important to restore flexibility and strength of the injured muscle to near normal before returning to previous levels of activity.

### **Fractures**

In IET, fractures occur less frequently than sprains and strains. On average, they have a greater impact on training and tend to be more severely debilitating. The most common fracture sites among trainees are the lower leg and ankle (eg, falling from obstacle/confidence courses and tripping while running). These injuries result in immediate severe pain, tenderness, swelling, and possibly deformity at the fracture site. Open fractures increase the risk of infection, but are rare in this setting. Suspected fractures should be immobilized (splinted) until medical evaluation can be obtained.

Because of the long recovery and rehabilitation required after a fracture, trainees with fractures are normally unable to continue training with their units. During BCT and the early phases of OSUT, trainees with fractures may be given convalescent leave. When they return to their training posts, they are assigned to the rehabilitation unit to complete the healing and rehabilitation processes. To regain or improve their physical fitness level, trainees perform strengthening and aerobic exercise. This attention to general fitness enables returning soldiers to reintegrate quickly into their units and complete their training.

### **Shoulder Instability and Dislocation**

The shoulder joint has a unique anatomical structure that must balance mobility and stability.<sup>4,5</sup> This dual role makes the shoulder more susceptible to subluxation or dislocation. It is the most commonly dislocated large joint of the body.<sup>6</sup> Shoulder stability depends on two types of stabilizers: dynamic/active stabilizers (eg, deltoid, biceps, and rotator cuff muscles) and static/passive stabilizers (eg, bone architecture, labrum, capsule, and glenohumeral ligaments).<sup>5</sup>

Shoulder instability is classified into two categories: (1) traumatic and (2) hyperlaxity of the static stabilizers in the absence of trauma.<sup>4,7</sup> When sufficient physical force is applied to the shoulder, the dynamic and/or static stabilizers are stretched beyond their physiological limit, resulting in subluxation or dislocation.<sup>8</sup> The

major mechanisms of traumatic instability include elevation with external rotation of the shoulder, direct blows, and falls on the outstretched arm.<sup>4</sup>

In IET, shoulder subluxation and dislocation occur when trainees fall during training events. Among cadets at the US Military Academy, West Point, New York, boxing is one of the leading causes of shoulder dislocation. Arciero et al<sup>9</sup> reported that 92% of West Point cadets with traumatic shoulder dislocations who were treated nonsurgically had a recurrence. Therefore, it is imperative that trainees who sustain significant shoulder injuries receive immediate medical attention to evaluate the extent of their injuries. Healthcare providers must assess whether the trainee is able to continue training, whether he or she needs conservative care consisting of limited duty (temporary profile) and rehabilitation (such as in the Physical Training and Rehabilitation Program),<sup>10,11</sup> or whether the trainee requires surgical repair.

### **Blisters and Open Skin Wounds**

Blisters and open skin wounds (ie, abrasions, lacerations, and punctures), common acute injuries in IET, can become infected if not treated properly. Blisters are friction-related injuries caused by shearing forces that occur between the skin and equipment, such as boots or running shoes, with the hands and feet being especially vulnerable. Keeping the blister top ("the roof") intact and covering it with a sterile dressing promotes faster healing and reduces the risk of infection.<sup>12,13</sup> Intact blisters should be punctured and drained, but the blister top should be left to cover the blister. A sterile needle or surgical blade is used to lance the blister. The torn roofs of blisters should be removed, antibiotic ointment applied, and the injury covered with a sterile dressing or bandage.<sup>13</sup> Hydrogel or hydrocolloid dressings assist with healing.<sup>14,15</sup> Polyurethane films can be affixed to the blister and covered with a pad and tape.<sup>12,14</sup> Keeping the injury clean and covered is extremely important, and a healthcare provider should be consulted if signs of infection appear (such as redness, pus, or increased pain). Effective preventive measures for friction blisters of the foot include keeping the skin dry with socks that wick away moisture and using antiperspirants on the feet. Talcum powder is not effective against preventing blisters.<sup>16</sup>

Open skin wounds can occur during any type of physical activity. Whether it is a blister, abrasion, or laceration, special care must be taken to prevent infection and indirect transfer of blood-borne pathogens (eg, hepatitis B and human immunodeficiency virus). A large, deep wound or significant bleeding indicates the need for immediate medical evaluation and treatment.

## Overuse Injuries

Overuse injuries are caused by repetitive or excessive activity that strains tissues beyond their ability to develop healthy adaptations. The ability of cells to repair minor damage is exceeded by the repetitive microtrauma. Overuse injuries develop over the course of days to weeks of repetitive activity and are characterized by an insidious onset of pain and inflammation.

Overuse injuries can affect most of the musculoskeletal elements (ie, the bursae [bursitis], fascia [fasciitis], tendons [tendinitis and tenosynovitis], muscles [sprains], ligaments [sprains], and bones [stress fractures]). In BCT, approximately 75% of all injuries

are of the overuse type.<sup>2,3</sup> In one BCT study at Fort Jackson, South Carolina, 84% and 88% of the overuse injuries in men and women, respectively, involved the lower extremity.<sup>2</sup> The high volume of repetitive weight-bearing activity, such as running and marching, is associated with the high incidence of overuse injuries to the lower extremity. Although running is the major physical activity associated with overuse injuries in IET,<sup>17</sup> all weight-bearing activities contribute to the progressive overload that can result in these injuries. Other contributing activities include walking, drill and ceremony events, road marching, jumping, and other similar activities. Table 9-2 shows the major types of training-related overuse injuries.

**TABLE 9-2**  
**COMMON TRAINING-RELATED OVERUSE INJURIES**

| Type                          | Anatomical Location                                | Signs/Symptoms                                                                   | Immediate Treatment                                                            |
|-------------------------------|----------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Delayed-onset muscle soreness | Muscle                                             | Soreness, swelling, limitation of motion, loss of strength, pain on stretching   | RICE, NSAIDs                                                                   |
| Strain                        | Muscle, tendon                                     | Pain, swelling, loss of function                                                 | RICE, gentle stretching, NSAIDs                                                |
| Compartment syndrome*         | Enclosed fascial compartment, especially lower leg | Swelling, pain, throbbing, tightness, tightness that increases with stretching   | Immediate evaluation by an orthopedic or general surgeon                       |
| Rhabdomyolysis <sup>†</sup>   | Muscle and other organ systems                     | Generalized myalgia, red-to-brown urine, high creatine kinase                    | Immediate evaluation by a physician                                            |
| Bursitis                      | Bursa                                              | Pain, swelling, warmth, limitation of motion                                     | RICE, NSAIDs                                                                   |
| Tendinitis                    | Tendon                                             | Pain, swelling, limitation of motion                                             | RICE, NSAIDs                                                                   |
| Patellofemoral pain syndrome  | Bone, tendon, cartilage, articular cartilage       | Pain, crepitus, swelling, limitation of motion                                   | RICE, NSAIDs                                                                   |
| Shin splints                  | Bone, muscle/tendon, periosteum                    | Pain, swelling                                                                   | RICE, NSAIDs                                                                   |
| Stress fracture*              | Bone                                               | Localized pain that increases with activity                                      | RICE, NSAIDs, (bone scan and/or x-ray film examination required for diagnosis) |
| Low back pain                 | Vertebrae, disc, joint, ligament, muscle           | Pain, limitation of motion, neurological symptoms                                | RICE, NSAIDs                                                                   |
| Plantar fasciitis             | Fascia                                             | Tender to palpation; pain on weight-bearing, especially on rising in the morning | RICE, NSAIDs, Achilles stretching, heel cups, orthotics                        |
| Metatarsalgia                 | Bone, joint, nerve                                 | Pain at plantar aspect of foot under metatarsal heads, swelling                  | RICE, NSAIDs                                                                   |

NSAIDs: nonsteroidal anti-inflammatory drugs

RICE: rest, ice, compression, elevation

\*Can require immediate surgery.

<sup>†</sup>Can be life-threatening.

### ***Delayed-Onset Muscle Soreness***

Delayed-onset muscle soreness (DOMS) is the common muscle discomfort experienced when a new physical activity is initiated. DOMS is characterized by (a) a loss of muscle strength immediately after exercise, (b) muscle soreness that peaks within 24 to 48 hours postexercise and lasts 5 to 7 days, (c) swelling of the damaged muscle, and (d) increased concentrations of blood proteins (creatine kinase) that peak 5 to 7 days postexercise.<sup>18</sup> During the symptomatic period (usually 5–7 days), motor control, flexibility, and task performance may be impaired. For previously sedentary trainees and those who are physically unconditioned, these symptoms might be somewhat more severe and last longer.

DOMS often results from unfamiliar, predominantly eccentric (ie, muscle-lengthening) activities and exercise, such as walking or running downhill or performing squatting exercises.<sup>19</sup> Muscle injury entails a mechanical disruption of the sarcomeres,<sup>20–22</sup> and soreness results from the inflammatory response of prostaglandin and leukotriene synthesis.<sup>23</sup> Blood creatine kinase levels are elevated with DOMS, indicating disruption or permeability changes in the plasma membrane. Compared with muscle strains—in which the muscle injury and resulting tenderness are isolated in a specific part of the muscle—DOMS is patchy throughout the muscle, and the degree of tenderness varies within the muscle. Swelling results from the movement of cells and fluid from the bloodstream into the interstitial spaces, and it contributes to the pain.<sup>19,23–25</sup>

In BCT and the early phase of OSUT, many trainees develop DOMS within the first few days of training. Because many trainees are physically inactive before joining the Army and may not have previously experienced DOMS, some trainees might misinterpret this condition, even if mild, to be a more serious injury. The wide variety of physical activity during the early phases of training might cause DOMS to be experienced in muscle groups of the upper extremities, trunk, and lower extremities. This soreness can be discouraging at the onset of training. Continued overuse can also result in more extensive muscle strain. Therefore, it is important that experienced drill sergeants and other trainees who are familiar with this condition reassure inexperienced trainees about DOMS and encourage them to seek medical care if symptoms persist.

Treatment of DOMS should include gentle muscle stretching of the affected muscles and application of ice. Because DOMS is a self-limiting condition, self-care under the direction of experienced personnel is usu-

ally sufficient in most cases. Some trainees might need medical evaluation for confirmation of the diagnosis, instruction in specific stretching exercises, and assistance with the use of ice. Evidence is mixed regarding the efficacy of taking nonsteroidal anti-inflammatory drugs (NSAIDs) for treating DOMS symptoms.<sup>19</sup> If signs or symptoms (especially swelling) are greater than expected, medical care should be obtained to rule out other serious diagnoses, such as compartment syndrome and rhabdomyolysis.

### ***Strains***

Although DOMS is self-limiting in the large majority of cases, continued overuse can result in more extensive muscle damage. Although muscle strains can be acute traumatic injuries, they can also result from or be aggravated by overuse, therefore being classified as overuse injuries. The symptoms of overuse strains are similar to those of acute strains, except that they are generally milder. The treatment is also generally the same as for the acute strains.

### ***Compartment Syndrome***

Compartment syndrome occurs when there is increased pressure within an enclosed fascial space (or compartment) that causes tissue hypoxia and secondary ischemic damage to muscles and nerves. Potentially serious complications include contractures, rhabdomyolysis, renal failure, and death. Although blunt trauma and fractures are the major causes, contusions, muscle rupture, and even excessive exercise can cause acute compartment syndrome.<sup>26–29</sup>

In 1945 exercise-induced (exertional) compartment syndrome was first described as “march gangrene.”<sup>29</sup> Since then, it has become a well-recognized, though uncommon, clinical entity following intense exercise.<sup>27–31</sup> Pain and swelling develop in the affected compartment after intense activity, but is usually short-lived and typically resolves with rest. Progression to an acute compartment syndrome, though rare, can occur and requires immediate medical attention.<sup>28</sup> In IET, exercise-induced compartment syndrome is more frequent than cases related to trauma. Although compartment syndrome has been reported in numerous anatomical locations, the major site of exercise-induced compartment syndrome is the lower leg.

Healthcare providers should be on alert any time a patient with a history of trauma or overuse has acute swelling, excessive pain, and muscle weakness. Exercise-induced compartment syndrome should be considered whenever a trainee presents

to the medical treatment facility with intense leg pain and swelling in the absence of trauma.<sup>26</sup> The most important early symptom is pain that is out of proportion to the severity of injury. Trainees might complain of painful throbbing, tightness, aching, or pressure that is worse with palpation and stretching of the affected muscles. Passive stretching of the muscles, however, exacerbates the pain. The involved compartment is firm and acutely painful on palpation. Sensory or motor nerve deficits or both might also be present.

A trainee with suspected compartment syndrome should be transported immediately to the emergency department. Acute compartment syndrome is a surgical emergency requiring fasciotomy of the involved compartment or compartments. Early diagnosis is critical. Compartment syndrome in recruits is explored more fully in Chapter 10, Rhabdomyolysis and Compartment Syndrome in Military Trainees.

### **Rhabdomyolysis**

Rhabdomyolysis results from injury to the skeletal muscle and the consequent release of potentially toxic substances into circulation. The severity of this condition varies from asymptomatic elevation of muscle enzymes to the life-threatening complications of acute renal failure and electrolyte abnormalities.<sup>32</sup> Rhabdomyolysis is included as an overuse injury because, in the IET setting, it can be associated with general overuse of the musculoskeletal system from prolonged, intense exercise or physical activity.<sup>33</sup>

In general, rhabdomyolysis can be classified into four broad categories<sup>32</sup>: (1) excessive muscle activity, (2) trauma or direct muscle injury (eg, crush injuries, burns, and electrical shock), (3) hereditary muscle enzyme defects, and (4) other medical causes (eg, metabolic and endocrine disorders, viral and bacterial infections, temperature alterations [such as heatstroke], and other conditions [including sickle cell anemia]).

Rhabdomyolysis occurs frequently after prolonged physical exertion, and is also seen in marathon runners and other athletes, as well as in unconditioned recruits during IET.<sup>34,35</sup> Muscle injury is related to the duration and intensity of the exercise and is confined frequently to the lower extremities. Mild cases of rhabdomyolysis often go unrecognized.

Because rhabdomyolysis can be life threatening, healthcare personnel should keep a careful watch on patients. Trainees believed to have rhabdomyolysis should be examined immediately by a physician. Knowledge of the causes of this condition is necessary in deciding when to pursue the laboratory stud-

ies needed to confirm the diagnosis. When injury to muscle cells is sufficient, intracellular substances (such as potassium, hydrogen ion, phosphate, creatine kinase, myoglobin, magnesium, and uric acid) are released. These can produce complications (eg, acute renal failure, electrolyte imbalances, compartment syndrome, and pulmonary or hepatic dysfunction). Diagnosis of rhabdomyolysis is based on the presence of significant myalgias, muscle weakness, red to brown urine, and elevated levels of creatine kinase.<sup>36</sup>

The main goals of rhabdomyolysis treatment are to recognize and treat any complications. Although the extent of muscle injury can be so severe that it leads to long-term disability, the release of large amounts of toxic substances from the dying muscles represents the most immediate danger. Early assessment of electrolytes, serum urea nitrogen, creatinine, calcium, phosphorus, magnesium, complete blood cell count, platelets, prothrombin time, and partial prothrombin time are indicated.<sup>32</sup>

Rhabdomyolysis in recruits is explored more fully in Chapter 10, Rhabdomyolysis and Compartment Syndrome in Military Trainees.

### **Bursitis**

Bursitis is inflammation of a bursa, a lubricated synovial lining (or sac) designed to minimize frictional forces between contiguous layers of the musculoskeletal system. Bursae exist between muscles, tendons, ligaments, and bones, especially in areas traversing bony prominences. Two types of bursitis are common during IET: (1) acute and (2) chronic. Acute bursitis can develop from a single occurrence of blunt trauma, repetitive insults, or an unusual pressure applied to structures for a long duration. Chronic bursitis can develop from repetitive acute or subacute episodes that produce a boggy, thickened bursa. In some cases of chronic bursitis, calcification of the bursa can occur, leading to further inflammation and bursal degeneration.<sup>37</sup> Septic bursitis can occur, but is much less frequent in the IET setting.

The major sites of bursitis are the knee (prepatellar bursa, superficial or deep infrapatellar bursa, and pes anserine bursa), the hip (greater trochanteric bursa), and the shoulder (subdeltoid or subacromial bursa). Key symptoms of bursitis include pain and limited motion, with additional symptoms of tenderness on palpation, warmth, and swelling of the bursa. Acute bursitis at any of these locations can greatly impair a recruit's ability to train.

Treatment of acute and chronic bursitis consists of relative rest (requiring only decreased intensity, frequency,

and duration of activity) from precipitating activities, application of ice, and administration of NSAIDs. Physical therapy or assistance with graded exercises or activities might also assist the recruit in returning to full duty as quickly as possible.

### ***Tendinitis***

Tendinitis is acute or chronic painful inflammation of a tendon. The condition results from the repetitive stresses of forceful muscle contractions and leads to overload of the tendon and mechanical fatigue with microtears within the tendon. Compared with concentric (shortening) muscle contractions, tendons sustain higher forces with eccentric (lengthening) muscle contractions occurring in activities like road marching downhill, descending stairs, or lowering a weight. These repetitive high forces are believed to be a major etiological factor for any tendon injury and inflammatory response that develops.

In tendinitis, the structure of the tendon is disrupted by the repetitive strain of training. Collagen fibers begin to break cross-links and denature the tissue. Cumulative microtrauma also degrades the noncollagenous matrix and the vascular elements of the tendon, leading to inflammation and pain. Acute tendinitis is characterized by inflammatory cell reaction, edema, and circulatory impairment. Crepitus, caused by movement of a tendon within a paratenon filled with fibrin exudate, might be present. If acute inflammation persists, adhesions can bind to the tendon or surrounding fascia, resulting in chronic tendinitis distinguished by persistent pain, inflammation, and diminished function. Eventually, decreased circulation, local hypoxia with impaired tissue nutrition, and a persistent inflammatory reaction can lead to tendon degeneration or rupture. Local release of cytokines and a proliferation of myofibroblasts are also implicated in chronic tendinitis.<sup>38</sup>

Tendinitis is classified by the presence or absence of activity-related pain, severity of the pain, and muscle strength. Initially, the primary complaint is pain with activity. Repeated stress results in progressive inflammation, which is characterized by mild pain that generally improves with activity and frequently reappears after activity. This initial stage is identified at the site of injury by varying degrees of point tenderness of the tendon and by pain with passive stretching. Progressive inflammation results in continuous pain, which heralds more serious pathology of the tendon. Later in the development of tendinitis, the degree of inflammation is characterized by swelling, pain, and weakness on forceful contraction of the involved muscle; point

tenderness; and considerable pain when stretching the tendon.

The tendons of the gastrocnemius-soleus (Achilles tendon), rotator cuff, long head of the biceps brachii, and quadriceps (patellar tendon [jumper's knee] and quadriceps tendon) are the major sites of tendinitis encountered in IET. Treatment consists of relative rest, ice massage of the tendon, and administration of NSAIDs. If adequate relative rest for recovery cannot be achieved in training, then the recruit might require time away from the training unit in a rehabilitation program until recovery.

### ***Patellofemoral Pain Syndrome***

The most common cause of overuse knee pain is PFPS, also called retropatellar pain syndrome or patellofemoral stress syndrome. Because this syndrome occurs particularly in runners, it is also referred to as runner's knee. Chondromalacia patella, a softening of the articular cartilage on the posterior aspect of the patella, is often, although inappropriately, used to describe this condition. Chondromalacia describes the specific pathology and appearance of deteriorating articular cartilage.<sup>37,39,40</sup>

The cause of PFPS is complex, but is believed to be associated with abnormal patellofemoral (thigh-knee) mechanics. Multiple biomechanical factors have been cited, including femoral anteversion, squinting patella (femur is rotated slightly inward), shallow femoral groove, weak quadriceps, tight hamstrings, and excessive Q angle. However, the amount of physical activity might be of greater importance.<sup>37,41</sup> The syndrome is often associated with abrupt increases in activity, as is normal in BCT and OSUT. Hill running is often cited as an exacerbatory factor.<sup>42</sup>

The primary symptom of PFPS is pain that increases with activity and localizes to the region below or around the patella. Running downhill, ascending or descending stairs, and prolonged sitting with the knee flexed typically intensify the symptoms. Frequently, the individual complains of instability or giving way of the knee. A grating sensation behind the patella and pain on compression of the patella are other reported symptoms.

General treatment consists of relative rest, application of ice, physical therapy, administration of NSAIDs, and modification of training programs to reduce knee strain. Treatments believed effective in decreasing pain and improving function in patients with PFPS include quadriceps-strengthening exercises, use of a resistive brace, and quadriceps-strengthening exercises in combination with patellar taping and biofeedback.<sup>40,43-45</sup> In

patients with excessive foot pronation, orthotics can be useful in reducing pain. There is also increasing evidence regarding the effectiveness of modifying training schedules.<sup>42,46</sup>

### ***Iliotibial Band Syndrome***

Iliotibial band syndrome (ITBS) (or iliotibial band friction syndrome) is a common cause of lateral knee pain associated with activities requiring repetitive knee flexion and extension, including cycling,<sup>47</sup> running,<sup>48</sup> and military recruit training.<sup>49</sup> The iliotibial band is formed proximally by the coalescence of the fascial investments of the tensor fascia lata, the gluteus maximus, and the gluteus minimus.<sup>50</sup> It attaches along the linea aspera on the femur and attaches distally to the tibia (Gerdy's tubercle and the biceps femoris) and patella.<sup>51</sup> Intermittent or persistent pain localized over the lateral aspect of the knee is characteristic of ITBS.

Potential risk factors for ITBS consist of training and anatomical factors. Clement et al<sup>52</sup> reported that 42% of ITBS cases resulted from training errors, and in 55% of those cases, a single severe training session was related to symptom onset. Other training-related factors include excessive running, a sudden increase in mileage, and hill training.<sup>53</sup> Anatomical factors include a prominent lateral femoral condyle, genu varum, leg length difference, iliotibial band tightness, and abnormal foot mechanics.<sup>47,48,53</sup>

ITBS is a clinical diagnosis based on patient history and physical examination. Typically, pain is located over the lateral femoral condyle and can radiate to the lower leg. Pain usually increases with activities that cause repetitive or increased knee flexion, such as running, climbing or descending stairs, and squatting.<sup>50</sup> A confirmatory test that is often used to evaluate ITBS is the Noble compression test,<sup>48</sup> which involves placing the patient supine with the knee at approximately 90 degrees of flexion and then applying firm pressure on or around the lateral femoral condyle while passively extending the knee. A positive test result elicits pain over the lateral femoral condyle at approximately 30 degrees of flexion.

During IET, most cases of ITBS will respond to conservative treatment within 10 to 14 days. It is important to identify training errors and anatomical risk factors contributing to the onset of symptoms. Relative rest from certain aspects of training might be required, and rest length is determined by symptom severity. Measures to reduce inflammatory response are also necessary, including NSAIDs and cryotherapy.<sup>54</sup> Physical therapy and iliotibial band stretching might also be indicated.<sup>55</sup>

### ***Shin Splints***

Shin splints is a common diagnosis among IET trainees with overuse lower leg pain.<sup>2,3</sup> Although first described in 1913 as "spike soreness" in runners<sup>56</sup> and further defined by the American Medical Association in 1966 as "pain and discomfort in the leg from repetitive activity on hard surfaces," there has been no general consensus concerning the signs and symptoms of this overuse syndrome or its pathophysiology.<sup>57</sup> As currently used, shin splints refers to many overuse injuries of the lower leg. These injuries are defined more accurately by anatomy, specific site of pain, and cause of injury. Key sites of pain are the proximal lateral tibia and the distal medial tibia border. This injury involves inflammation of the musculotendinous units attached to the tibia or stresses on the periosteal or bony tissues. A variety of conditions, acute and chronic, have been grouped together and called shin-splints. Acute conditions include tibial stress reaction or periostitis, enthesitis, fibrositis, myositis, traction periostitis, interosseous membrane pain, bone strains, tenosynovitis, and tendinitis of the anterior tibialis, posterior tibialis, soleus, or flexor hallucis longus muscles.<sup>27</sup> Chronic conditions include a periosteal reaction, traction periostalgia, chronic tendinitis, and chronic compartment syndrome.<sup>57</sup> Generally accepted intrinsic risk factors for shin splints include lack of running experience, competitive running, running excessive distances, poor physical condition, and history of a previous episode of shin splints.<sup>57</sup>

Shin splint symptoms range from mild pain before or after exercise to disabling pain that limits the recruits' ability to ambulate without extreme discomfort. Swelling of the lower leg often accompanies the pain. As noted in Chapter 8, Primary Prevention of Injuries in Initial Entry Training, the tibia is the major site for stress reactions and stress fractures. The greatest challenge for healthcare providers is to distinguish between shin splint pain and the more important stress reaction or stress fracture pain. However, shin splints can limit the ability of a recruit to train, and those with severe cases might require a period of rest away from training.

### ***Stress Fractures***

Stress fractures of the lower extremity are common among athletes and military recruits. The rates for stress fractures are higher for recruits in IET than they are among soldiers who have been on active duty for longer periods. This is true because new recruits tend to arrive with lower levels of physical fitness and

physical activity. In addition, female recruits are at higher risk than male recruits for both stress fractures and also stress reactions. Between 1998 and 2003, data maintained by the Physical Therapy Clinic, Moncrief Army Community Hospital (Fort Jackson, South Carolina) indicated that 0.7% of men and 4.2% of women in BCT sustained at least one stress fracture during the BCT training cycle.<sup>58</sup> The most common anatomical locations of stress fractures in these recruits were the tibia, metatarsals, calcaneus, femur, pelvis, and hip (Table 9-3).

Stress fractures occur in two successive stages in response to repetitive overloading of bones during activities such as running, walking, or marching.<sup>59-61</sup> (1) A normal physiological response (or remodeling) occurs, in which the body attempts to strengthen stressed bone by removing old bone and laying down new bone. If the remodeling is excessive, this response is called a "stress reaction." If the overload stress continues, remodeling might actually weaken the bone by removing more than is being laid down. (2) The weakened bone, which is more susceptible to mechanical failure, develops evidence of a stress fracture.

During IET, healthcare providers should consider the possibility of a stress reaction or stress fracture whenever a trainee presents with an antalgic gait,

complains of well-localized pain with weight-bearing activity, and has no associated trauma. Stress fractures might be confused with tendinitis, thigh-splints, shin splints, muscle strains or other relatively minor musculoskeletal problems. Focal tenderness on palpation and swelling are typically present at the injury site. Failure to heed the early signs and symptoms of a stress fracture can be catastrophic, and providers should take particular care with diagnosis.

Evidence of a stress fracture might not appear on plain radiographs for 2 to 6 weeks after onset of symptoms. Nuclear bone scans are more sensitive than plain radiographs in detecting stress reactions and possible stress fractures early in the clinical course, but have lower specificity. A focal "hot spot" is typically shown on the bone scan at the point of maximal tenderness. Magnetic resonance imaging scans are much better than plain films for initial diagnosis and can characterize the fracture better than bone scans.<sup>62</sup> (See Chapter 11, Comprehensive Evaluation and Management of Stress Fractures in Military Trainees, for further discussion of stress fractures diagnosed by bone scans.)

Femoral neck stress fractures can have serious complications and, therefore, require special attention. The primary symptom of a femoral neck stress fracture is anterior groin and hip pain that is worsened with weight-bearing. Hip movement is painful and limited at internal and external rotation extremes.<sup>63</sup> Femoral neck stress fractures can occur on either the compression side (inferior aspect) or tension side (distraction, superior aspect) of the femoral neck.<sup>64</sup> Compression side stress fractures are more common than those involving the tension side. Because complete displacement of the compression side stress fractures is rare, most cases can be treated nonoperatively. The tension side stress fracture begins at the superior cortex of the femoral neck and may progress across the femoral neck as a fracture line perpendicular to the femoral neck axis. This type of stress fracture has a greater propensity for displacement and requires more aggressive treatment (internal fixation of the femoral neck) than compression side stress fractures.<sup>64</sup>

Potential complications for a displaced femoral neck stress fracture include delayed union, nonunion, varus deformity, and osteonecrosis.<sup>64</sup> Even if these complications are avoided, the individual's functional status will be limited. Johansson et al<sup>65</sup> reported that 60% of patients with displaced femoral neck stress fractures who were appropriately treated were still unable to return to their preinjury activity level. Weistroffer et al<sup>66</sup> found that 68% of patients treated for a femoral neck stress fracture 5 to 7 years before continued to be somewhat bothered by their injury in at least one func-

TABLE 9-3

**MOST COMMON LOCATIONS FOR STRESS FRACTURES IN RECRUITS IN BASIC COMBAT TRAINING, FORT JACKSON, SOUTH CAROLINA (1998–2003)**

| Stress Fractures     | Anatomical Location   | Proportion of Stress Fractures (%) |
|----------------------|-----------------------|------------------------------------|
| Men<br>(n = 1,295)   | Tibia                 | 42                                 |
|                      | Metatarsal            | 32                                 |
|                      | Calcaneus             | 10                                 |
|                      | Femur (excluding hip) | 5                                  |
|                      | Hip                   | 4                                  |
|                      | Other                 | 7                                  |
| Women<br>(n = 4,880) | Tibia                 | 42                                 |
|                      | Metatarsal            | 20                                 |
|                      | Pelvis                | 11                                 |
|                      | Calcaneus             | 8                                  |
|                      | Femur (excluding hip) | 6                                  |
|                      | Hip                   | 5                                  |
|                      | Other                 | 8                                  |

Data source: unpublished data; analyzed 2003, collected 1998–2003 from Fort Jackson, South Carolina.

tional category. Twenty-eight percent of these patients reported feeling disabled from their injury.

Healthcare providers in the IET setting must consider the potential for femoral neck stress fracture whenever a trainee presents with anterior hip/groin pain and an antalgic gait. Early accurate diagnosis is essential for minimizing complications.

### **Low Back Pain**

Low back pain is a common complaint either associated with or exacerbated by physical activity in IET. Low back pain as a result of musculoskeletal injury can be a symptom of damage to the bony structural elements of the spine (vertebrae, intervertebral discs, ligaments, and facet joints) or to the supporting musculature of the back and abdomen. Possible injuries include traumatic and stress fractures of the vertebra, disc herniation, torn or sprained ligaments, and muscle strains or spasms. In patients with neurological symptoms (eg, pain radiating into the buttocks or down one or both legs, numbness or tingling of the legs, weakness, and decreased bowel or bladder control), further diagnostic testing (eg, magnetic resonance imaging scan) should be performed, in consultation with an orthopedist or neurosurgeon. Chronic back pain of unknown origin and severe pain are additional reasons to consult a specialist.<sup>67</sup>

The major cause of low back pain during IET is overuse strains. Initial treatment consists of relative rest, ice application, and analgesics or NSAIDs. The challenge in treating trainees is to provide rest for mitigation of the back pain within the context of continuance of training. Much of the responsibility lies with the recruit, who must participate actively with self-care (using ice, performing exercises if and when instructed, following the limited-duty profile). Flexibility and strengthening exercises are frequently prescribed for treatment. No single set of exercises has proven efficacious for all types of back pain.

In May 1999, the US Army Medical Command developed clinical practice guidelines for managing low back pain. Using an evidence-based approach, the Command steered healthcare providers toward use of the most appropriate diagnostic modalities and

best clinical care strategies. (For more information, see the low back pain clinical practice guideline at: <http://www.cs.amedd.army.mil/qmo/lbp/lbpfr.htm>, accessed November 7, 2005.)

### **Plantar Fasciitis**

Plantar fasciitis is inflammation of the plantar fascia of the foot which provides dynamic arch support. Inflammation is usually secondary to repetitive stretching of the plantar fascia between its origin at the anterior rim of the calcaneus and its insertion into the metatarsal heads. Tenderness to palpation along the medial edge of the fascia (at its origin on the anterior edge of the calcaneus) is common. Typically pain occurs during weight-bearing and can be exacerbated by climbing stairs, walking, running, and other activities. Pain accompanying the first step in the morning is a major early symptom.<sup>68,69</sup> In BCT and OSUT there is a widely held belief that the onset of plantar fasciitis is related to wearing boots during training exercises (ie, many recruits are not accustomed to wearing this type of heavy footwear). However, this hypothesis has not been scientifically substantiated.

Treatments for plantar fasciitis include decreasing weight-bearing activity, applying ice massage, stretching the Achilles tendon, using heel cups, utilizing orthotics, correcting training errors, and administering NSAIDs. Limiting the wearing of boots during training activities might also be beneficial.

### **Metatarsalgia**

Metatarsalgia describes painful overuse injuries of the forefoot. A typical symptom is pain during weight-bearing activity. Tenderness usually occurs on the sole of the foot under the second or third metatarsal head. Metatarsalgia results from chronic foot strain caused by significantly increasing the amount of weight-bearing activity (eg, running, marching). Other conditions that can present with metatarsal pain include stress fractures, neuromas, hallux rigidus, and hallux valgus.<sup>70</sup> These conditions should be considered if forefoot pain does not respond to conservative measures, and appropriate medical evaluation should be obtained.

## **BASIC PRINCIPLES OF CARE FOR TRAINING-RELATED INJURIES**

The immediate goal in managing a musculoskeletal injury (acute or overuse) is to reduce pain, swelling, and inflammation that retards healing and to remove or modify the injury-producing insult. Immediate first aid appropriate for acute muscu-

loskeletal injuries is the "RICE" protocol: rest, ice, compression, and elevation.<sup>1,71-74</sup> In some injury cases, anti-inflammatory medication can also be helpful. Chronic injuries require additional treatment modalities.

## Rest

Reducing physical activity prevents further injury and allows the body sufficient time to recover using its own natural healing processes. The type and amount of activity reduction and rest period length are determined by the type and severity of injury. For minor injuries, the initial rest period should be 1 to 2 days to allow enough time for inflammation to diminish. More severe injuries require several days to weeks of rest to prevent further injury and ensure healing. For mild injuries (both acute and chronic), rest might be relative, requiring only a decrease in the intensity, frequency, and duration of activity. In some cases, it might be sufficient to reduce the volume or intensity of training, such as self-paced running for a specified distance. A trainee who is unable to perform certain exercises or activities might still be able to exercise uninjured parts of the body (eg, a trainee with a leg injury can still perform exercises involving the arms or trunk). A good rule of thumb is that a trainee can return to training when the activity is pain free (ie, both during and after the activity) and physical function is unimpaired (ie, full joint motion and weight bearing).

## Ice

Ice and other cold modalities (cryotherapy) are used in treating acute musculoskeletal injuries. Reported benefits of local application of cold modalities postinjury include local analgesia from reduced nerve conduction velocity,<sup>75,76</sup> decreased peripheral blood flow from vasoconstriction,<sup>77</sup> decreased local inflammatory response,<sup>78</sup> and reduced cellular metabolism that minimizes hypoxic injury and the degree of tissue damage.<sup>79-81</sup>

The degree of cooling depends on the method and duration of cold application, the initial temperature of the ice, and the depth of subcutaneous fat.<sup>80</sup> McMaster et al<sup>82</sup> compared four modes of cryotherapy (ice chips, frozen gel packs, chemical ice, and freon-injected bladders) in terms of their ability to decrease intramuscular temperatures. Although the depth of the temperature recordings is not noted, using ice chips was superior to using other modes of cryotherapy—thus producing a decrease of 3.4°C, 6.9°C, 9.2°C, and 11.3°C after 15, 30, 45, and 60 min, respectively. Hocutt et al<sup>83</sup> noted the insulating effect of subcutaneous fat and suggested that significant cooling occurred to a depth of 2 cm in those with less than 1 cm of fat following a 10-min ice application. Myrer et al<sup>84</sup> found that the depth of adipose tissue was a significant factor in the first 15 min of ice application, showing an inverse relationship between adipose tissue and temperature decrease.

Even though evidence for the physiological cooling effects of cryotherapy is strong, there have been very few randomized controlled studies that have evaluated its effectiveness in shortening the recovery period after a musculoskeletal injury.<sup>79,85</sup> Hocutt et al<sup>83</sup> and Basur et al<sup>86</sup> reported that individuals with ankle sprains were able to return to full function faster when treated immediately with cryotherapy, compared with individuals who received either late or no cryotherapy.<sup>83,86</sup> Hocutt et al<sup>83</sup> compared the effects of cryotherapy applied immediately after a grade 3 ankle sprain, 1 to 36 hours after injury and 48 hours after injury, and thermotherapy in the treatment of ankle sprains. Subjects who used ice within 36 hours after injury were able to return to running and jumping without pain in 6 days, compared with 11 days for those subjects treated with ice after 48 hours and 15 days for those subjects treated with heat within 36 hours of injury. Basur et al<sup>86</sup> compared crepe-bandaging alone to crepe-bandaging treatment combined with cryotherapy for 48 h after an ankle sprain. Of subjects treated with cryotherapy, 42% returned to activity by the second day of follow-up and 84% by the seventh day of follow-up, compared with 29% and 61%, respectively, in the group treated with only crepe-bandaging.

Even though there are no controlled studies on the use of cryotherapy for musculoskeletal injuries in IET, based on its physiological effects and limited research in nonmilitary groups, we recommend that trainees apply ice as early as possible after injury (overuse or traumatic). However, this can be difficult to accomplish because of the limited availability of ice to trainees and time constraints of training.

Complications after cryotherapy are unusual and can be avoided.<sup>87</sup> The most frequently noted complications are frostbite and nerve palsy. The risk of frostbite is reduced by using a damp towel and by not using ice any longer than 30 to 45 min at a time. Nerve palsy is more likely to occur in areas where large nerves are situated directly beneath the skin.<sup>88</sup> In published reports, the nerves most frequently involved are the peroneus and ulnar nerves.<sup>88,89</sup> Contraindications to cryotherapy include individuals with a history of peripheral circulatory problems, cold allergy, or cold hypersensitivity.<sup>87</sup>

## Compression

External compression is normally used in protocols to treat acute musculoskeletal injuries.<sup>71,90</sup> Compression reduces internal bleeding and swelling by decreasing the intramuscular blood flow in the pressure area.<sup>91-93</sup> Moderate compression reduces the intramuscular blood flow by about half of the initial flow values.<sup>94</sup> Compression is most effective during the initial 24 to

48 hours after an injury when the risk of bleeding and edema is greatest.<sup>71,94</sup>

Combining external compression with rest, ice, and elevation is the generally accepted standard of care for early treatment of acute musculoskeletal injuries.<sup>71,72,94</sup> There were no randomized controlled studies reported that compared the effectiveness of treatment protocols with and without external compression, or evaluated such outcomes as duration, amount of swelling, or return to full activity. In addition, there were no identified studies on the effectiveness of external compression in treating injuries in IET.

### Elevation

Elevation of the injured extremity decreases blood flow to the injury site and increases venous return to prevent or manage edema that accompanies acute and overuse injuries.<sup>73</sup> Ideally, the injured extremity should be raised above the level of the heart. The injured body part should be placed comfortably with cushioning or padding. A gentle active range of motion can further enhance circulation and the removal of inflammatory products.<sup>72,73,90</sup>

Combining elevation with rest, ice, and compression is the generally accepted standard of care for early treatment of acute musculoskeletal injuries.<sup>71</sup> There were no randomized controlled studies reported that compared the effectiveness of treatment protocols with and without elevation, or evaluated outcomes such as duration, amount of swelling, or return to full activity. There were no identified studies on the effectiveness of external elevation in treating injuries in IET.

The primary prevention of injuries in IET is a major objective of training personnel and healthcare providers. But when injuries do occur, early detection and diagnosis, followed by prompt treatment and management, are essential. Most injuries that occur during IET can be broadly classified as either (a) acute injuries resulting from an abrupt force causing structural failure and tissue damage or (b) overuse injuries resulting from the cumulative effects of small, repetitive, microtraumatic forces that eventually damage the structural (bones and ligaments) or force-generating (muscles and tendons) elements of the body. These microtraumas accumulate over time until they finally exceed the body's ability to repair itself, resulting in a symptomatic injury.

Typical acute injuries in IET include sprains, strains, fractures, dislocations, blisters, and abrasions or lacerations. Early treatment of sprains and strains

### Nonsteroidal Anti-inflammatory Drugs

NSAIDs are used to reduce inflammation after musculoskeletal injury. These drugs inhibit the cyclooxygenase enzymes (COX-1 and COX-2) involved in prostaglandin production and thereby decrease prostaglandin-mediated inflammation.<sup>74,95</sup> Numerous studies have demonstrated improved muscle recovery, decreased loss of strength, and decreased pain with their early use after injury.<sup>96-98</sup> However, there might be negative effects later in the healing phase<sup>74,99</sup> of the injury. In experimental models, use of NSAIDs has raised concerns about delayed muscle regeneration and subsequent functional loss.<sup>100</sup> These medications should be avoided during the early stage of injury recovery because they might delay bone (stress fracture or traumatic fracture) and soft tissue healing. NSAIDs are best prescribed for chronic, inflammatory conditions like plantar fasciitis or tendinitis. A major limitation of treatment with NSAIDs is the potential severity of their adverse effects. A high incidence of renal and gastrointestinal toxicities is seen with NSAID use.<sup>95</sup> Dehydrated or sodium-depleted trainees should not take NSAIDs because of potential renal complications.

Even though NSAIDs are common and available without prescription, they should not be given to trainees in IET without physician monitoring. Peak anti-inflammatory effect requires up to 60 hours (about 5 half-lives of the medication); therefore, at least 2 weeks is usually required to control significant inflammation.<sup>101</sup> Trainees should be aware that these medications can mask symptoms of injury.

### SUMMARY

generally involves RICE and NSAIDs. Fractures and dislocations must be immobilized, and individuals must be transported to an emergency department. Friction blisters should be drained with their tops left intact. Unroofed blisters, as well as abrasions and lacerations, should be treated with antibiotic ointment, kept clean and covered, and monitored for signs of infection.

The major types of overuse injuries that occur during IET—especially during BCT and the early phases of OSUT—include DOMS, strains, bursitis, tendinitis, PFPS, shin-splints, stress fractures, low back injuries, plantar fasciitis, and metatarsalgia. Early treatment of most overuse injuries normally involves RICE and NSAIDs. Compartment syndrome and rhabdomyolysis are seen infrequently in IET, but considering their serious complications, they must be identified early and referred to the appropriate specialists.

The keys to injury treatment and management in the IET setting are to recognize and diagnose injuries at the earliest possible point, and to provide immediate and effective treatment. Treatment goals must include mini-

mizing tissue damage once the injury has occurred, returning the trainee to unrestricted training as soon as possible, and educating the trainee to minimize the potential for injury recurrence.

## REFERENCES

1. O'Connor FG, Howard TM, Fieseler CM, Nirschl RP. Managing overuse injuries: A systematic approach. *Phys Sportsmed*. 1997;25:88-90,99,102-106,112-113.
2. Knapik JJ, Sharp MA, Canham ML, et al. *Injury Incidence and Injury Risk Factors Among US Army Basic Trainees at Ft Jackson, SC (Including Fitness Training Unit Personnel, Discharges, and Newstarts)*. Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 1999. Epidemiological Consultation Report 29-HE-8370-99.
3. Knapik JJ, Cuthie J, Canham M, et al. *Injury Incidence, Injury Risk Factors, and Physical Fitness of US Army Basic Trainees at Ft Jackson, SC, 1997*. Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 1998. Epidemiological Consultation Report 29-HE-7513-98.
4. Liu SH, Henry MH. Anterior shoulder instability: Current review. *Clin Orthop Relat Res*. 1996;323:327-337.
5. Burkart AC, Debski RE. Anatomy and function of the glenohumeral ligaments in anterior shoulder instability. *Clin Orthop Relat Res*. 2002;400:32-39.
6. McMahon PJ, Lee TQ. Muscles may contribute to shoulder dislocation and stability. *Clin Orthop Relat Res*. 2002;(suppl 403):S18-S25.
7. Gerber C, Nyffeler RW. Classification of glenohumeral joint instability. *Clin Orthop Relat Res*. 2002;400:65-76.
8. Maday MG, Hatner CD, Warner JJ. Shoulder injuries. In: Fu FH, Stone DA, eds. *Sports Injuries: Mechanisms, Prevention and Treatment*. Baltimore, Md: Williams & Wilkins; 1994.
9. Arciero RA, Wheeler JH, Ryan JB, McBride JT. Arthroscopic Bankart repair versus nonoperative treatment for acute, initial anterior shoulder dislocations. *Am J Sports Med*. 1994;22:589-594.
10. Hauret KG, Shippey DL, Knapik JJ. The Physical Training and Rehabilitation Program: Duration of rehabilitation and final outcome of injuries in basic combat training. *Mil Med*. 2001;166:820-826.
11. Hauret KG, Knapik JJ, Lange JL, Heckel HA, Coval DL, Duplessis DH. Outcomes of Fort Jackson's Physical Training and Rehabilitation Program in Army basic combat training: Return to training, graduation, and 2-year retention. *Mil Med*. 2004;169:562-567.
12. Ramsey ML. Managing friction blisters of the feet. *Physician Sportsmed*. 1992;20:117-124.
13. Bergeron BP. A guide to blister management. *Physician Sportsmed*. 1995;23:37-46.
14. Wheeland RG. The newer surgical dressings and wound healing. *Dermatol Clin*. 1987;5:393-407.
15. Hermans MH, van Wingerden S. Treatment of industrial wounds with DuoDERM Bordered: A report on medical and patient comfort aspects. *J Soc Occup Med*. 1990;40:101-102.
16. Knapik JJ, Reynolds KL, Duplantis KL, Jones BH. Friction blisters: Pathophysiology, prevention and treatment. *Sports Med*. 1995;20:136-147.
17. Jones BH, Cowan DN, Knapik JJ. Exercise, training and injuries. *Sports Med*. 1994;18:202-214.
18. Clarkson PM, Hubal MJ. Exercise-induced muscle damage in humans. *Am J Phys Med Rehabil*. 2002;81(suppl 11):S52-S69.

19. Connolly DA, Sayers SP, McHugh MP. Treatment and prevention of delayed onset muscle soreness. *J Strength Cond Res.* 2003;17:197–208.
20. Friden J, Sjostrom M, Ekblom B. Myofibrillar damage following intense eccentric exercise in man. *Int J Sports Med.* 1983;4:170–176.
21. Friden J, Kjorell U, Thornell LE. Delayed muscle soreness and cryoskeletal alterations: An immunocytological study in man. *Int J Sports Med.* 1984;5:15–18.
22. Friden J, Lieber RL. Structural and mechanical basis of exercise-induced muscle injury. *Med Sci Sports Exerc.* 1992;24:521–530.
23. Smith LL. Acute inflammation: The underlying mechanism in delayed onset muscle soreness? *Med Sci Sports Exerc.* 1991;23:542–554.
24. Gleeson M, Almey J, Brooks S, Cave R, Lewis A, Griffiths H. Haematological and acute-phase response associated with delayed-onset muscle soreness in humans. *Eur J Appl Physiol.* 1995;71:137–142.
25. Warren GL, Hayes DA, Lowe DA, Prior BM, Armstrong RB. Materials fatigue initiates eccentric contraction-induced injury in rat soleus muscle. *J Physiol.* 1993;464:477–489.
26. Ehlinger M, Schneider L, Lefebvre Y, Cognet JX, Simon P. Exercise-induced bilateral isolated compartment syndrome of the leg: A report of a rare case [in French]. *Rev Chir Orthop Reparatrice Appar Mot.* 2004;90:165–170.
27. Wilder RP, Seth S. Overuse injuries: Tendinitis, stress fractures, compartment syndrome, and shin splints. *Clin Sports Med.* 2004;23:55–81.
28. McHale KM, Prahinski JR. Acute exertional compartment syndrome occurring after performance of the Army Physical Fitness Test. *Orthop Rev.* 1994;23:749–753.
29. Webb LX, Grossling S. Exertional compartment syndrome in a marine grunt. *Mil Med.* 1992;157:154–155.
30. Archbold HA, Wilson L, Barr RJ. Acute exertional compartment syndrome of the leg: Consequences of a delay in diagnosis: A report of 2 cases. *Clin J Sport Med.* 2004;142:98–100.
31. Bertoldo U, Nicodemo A, Pallavicini J, Masse A. Acute bilateral compartment syndrome of the thigh induced by spinning training. *Injury.* 2003;34:791–792.
32. Allison RC, Bedsole DL. Other medical causes of rhabdomyolysis. *Am J Med Sci.* 2003;326:76–88.
33. Aizawa H, Morita K, Minami H, Sasaki N, Tobise K. Exertional rhabdomyolysis as a result of strenuous military training. *J Neurol Sci.* 1995;132:239–240.
34. Knochel JP. Catastrophic medical events with exhaustive exercise: “White collar rhabdomyolysis.” *Kidney Int.* 1990;38:709–719.
35. Sinert R, Kohl L, Rainone T. Exercise-induced rhabdomyolysis. *Ann Emerg Med.* 1994;23:1301–1306.
36. Sayers SP, Clarkson PM. Exercise-induced rhabdomyolysis. *Curr Sports Med Rep.* 2002;1:59–60.
37. Nisonson B, Hershman E, Scott WN, Yost J. The knee. In: Scott WN, Nisonson B, Nicholas JA, eds. *Principles of Sports Medicine.* Baltimore, Md: Williams & Wilkins; 1984.
38. Leadbetter WB. Soft tissue athletic injuries. In: Fu FH, Stone DA, eds. *Sports Injuries: Mechanisms, Prevention and Treatment.* Philadelphia, Pa: Williams & Wilkins; 1994.
39. Saxena A, Haddad J. The effect of foot orthoses on patellofemoral pain syndrome. *J Am Podiatr Med Assoc.* 2003;93:264–271.

40. Bizzini M, Childs JD, Piva SR, Delitto A. Systematic review of the quality of randomized controlled trials for patellofemoral pain syndrome. *J Orthop Sports Phys Ther.* 2003;33:4–20.
41. Fredricson M. Common injuries in runners. *Sports Med.* 1996;21:49–72.
42. Dorotka R, Jimenez-Roj E, Kypta A, Kollar B. The patellofemoral pain syndrome in recruits undergoing military training: A prospective 2-year follow-up study. *Mil Med.* 2003;168:337–340.
43. Wilson T, Carter N, Thomas G. A multicenter, single-masked study of medial, neutral, and lateral patellar taping in individuals with patellofemoral pain syndrome. *J Orthop Sports Phys Ther.* 2003;33:437–448.
44. D'hondt NE, Stuijs PA, Kerkhoffs GM, Verheul C. Orthotic devices for treating patellofemoral pain syndrome. *Cochrane Database of Systematic Reviews.* 2002;2:CD002267.
45. Heintjes E, Berger MY, Bierma-Zeinstra SM, Bernsen RM, Verhaar JA, Koes BW. Exercise therapy for patellofemoral pain syndrome. *Cochrane Database of Systematic Reviews.* 2003;4:CD003472.
46. Yeung EW, Yeung SS. A systematic review of interventions to prevent lower limb soft tissue running injuries. *Br J Sports Med.* 2001;35:383–389.
47. Holmes JC, Pruitt AL, Whalen NJ. Iliotibial band syndrome in cyclists. *Am J Sports Med.* 1993;21:419–424.
48. Noble CA. Iliotibial band friction syndrome in runners. *Am J Sports Med.* 1980;8:232–234.
49. Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN. Epidemiology of injuries associated with physical training among young men in the army. *Med Sci Sports Exerc.* 1993;25:197–203.
50. Kirk KL, Kuklo T, Klemme W. Iliotibial band friction syndrome. *Orthopedics.* 2000;223:1209–1215.
51. Terry GC, Hughston JC, Norwood LA. The anatomy of the iliopatellar band and iliotibial tract. *Am J Sports Med.* 1986;14:39–45.
52. Clement DB, Taunton JE, Smart GW, McNicol KL. A survey of overuse training injuries. *Phys Sportsmed.* 1981;9:47.
53. Jones DC, James SL. Overuse injuries of the lower extremity: Shin splints, iliotibial band friction syndrome, and exertional compartment syndromes. *Clin Sports Med.* 1987;6:273–290.
54. Aronen JG, Chronister R, Regan K, Hensien MA. Practical, conservative management of iliotibial band syndrome. *Phys Sportsmed.* 1989;17:651–654.
55. Adams, WB. Treatment options in overuse injuries of the knee: Patellofemoral syndrome, iliotibial band syndrome, and degenerative meniscal tears. *Curr Sports Med Rep.* 2004;3:256–260.
56. Hutchins CP. Explanation of spike soreness in running. *Am Phys Ed Rev.* 1913;18:31–35.
57. Thacker SB, Gilcrest J, Stroup DF, Kimsey D. The prevention of shin splints in sports: A systematic review of the literature. *Med Sci Sports Exerc.* 2002;34:32–40.
58. Other data (K.G.H., unpublished data, 2003, collected 1998–2003 from US Army Forts Jackson, Leonard Wood, Benning, Sill, Knox.)
59. Verma RB, Sherman O. Athletic stress fractures: Part I. History, epidemiology, physiology, risk factors, radiography, diagnosis and treatment. *Am J Orthop.* 2001;30:798–806.
60. Verma RB, Sherman O. Athletic stress fractures: Part II. The lower body. Part III. The upper body—with a section on the female athlete. *Am J Orthop.* 2001;30:848–860.

61. Brukner P. Exercise-related lower leg pain: Bone. *Med Sci Sports Exerc.* 2000;32(suppl 3):S15–S26.
62. Spitz DJ, Newberg AH. Imaging of stress fractures in the athlete. *Radiol Clin North Am.* 2002;40:313–331.
63. Boden BP, Speer KP. Femoral stress fractures. *Clin Sports Med.* 1997;16:307–317.
64. Boden BP, Osbahr DC. High-risk stress fractures: evaluation and treatment. *J Am Acad Orthop Surg.* 200;8:344–353.
65. Johansson C, Ekenman I, Tornkvist H, Eriksson E. Stress fractures of the femoral neck in athletes: The consequence of a delay in diagnosis. *Am J Sports Med.* 1990;18:524–528.
66. Weistroffer JK, Muldoon MP, Duncan DD, Fletcher EH, Padgett DE. Femoral neck stress fractures: Outcome analysis at minimum five-year follow-up. *J Orthop Trauma.* 2003;5:334–337.
67. Bono CM. Current concepts review: Low back pain in athletes. *J Bone Joint Surg.* 2004;86:382–396.
68. Omev JL, Micheli LJ. Foot and ankle problems in the young athlete. *Med Sci Sports Exerc.* 1993;31(suppl 7):S450–S486.
69. Huanng HH, Qureshi AA, Biundo JJ Jr. Sports and other soft tissue injuries, tendonitis, bursitis, and occupation-related syndromes. *Curr Opin Rheumatol.* 2000;12:150–154.
70. Hockenbury RT. Forefoot problems in athletes. *Med Sci Sports Exerc.* 1999;31(suppl 7):S448–S458.
71. Webber A. Acute soft tissue injuries in the young athlete. *Clin Sports Med.* 1988;7:611–624.
72. Kellett J. Acute soft tissue injuries — a review of the literature. *Med Sci Sports Exerc.* 1986;18:489–500.
73. Jarvinen TA, Kaariainen M, Jarvinen M, Kalimo H. Muscle strain injuries. *Curr Opin Rheumatol.* 2000;12:155–161.
74. Drezner JA. Practical management: Hamstring muscle injuries. *Clin J Sport Med.* 2003;13:48–52.
75. Lee JM, Warren MP, Mason SM. Effects of ice on nerve conduction velocity. *Physiotherapy.* 1978;64:2–6.
76. Kowal M. Review of physiological effects of cryotherapy. *J Ortho Sports Ther.* 1983;5:66–73.
77. Clarke RS, Hellom RE, Lind AR. Vascular reactions of the human forearm to cold. *Clin Sci.* 1958;17:165–179.
78. Farry PJ, Prentice NG, Hunter AC, Wakelin CA. Ice treatment of injured ligaments: An experimental model. *N Z Med J.* 1980;91:12–14.
79. Bleakley C, McDonough S, MacAuley D. The use of ice in the treatment of acute soft-tissue injury. A systematic review of randomized controlled trials. *Am J Sports Med.* 2004;32:251–261.
80. McLean DA. The use of cold and superficial heat in the treatment of soft tissue injuries. *Br J Sports Med.* 1989;23:53–54.
81. MacAuley DC. Ice therapy: How good is the evidence? *Int J Sports Med.* 2001;22:379–384.
82. McMaster WC, Liddle S, Waugh TR. Laboratory evaluation of various cold therapy modalities. *Am J Sports Med.* 1978;6:291–294.
83. Hocutt JE, Jaffe R, Rylander CR, Beebe JK. Cryotherapy in ankle sprains. *Am J Sports Med.* 1982;10:316–319.
84. Myrer JW, Draper DO, Durrant E. Contrast therapy and intramuscular temperature in the human leg. *J Athl Train.* 1994;29:318–322.
85. Hubbard TJ, Aronson SL, Denegar CR. Does cryotherapy hasten return to participation? A systematic review. *J Athl Train.* 2004;39:88–94.

86. Basur RL, Shephard E, Mouzas GL. A cooling method in the treatment of ankle sprains. *Practitioner*. 1976;216:708–711.
87. Swenson C, Sward L, Karlsson J. Cryotherapy in sports medicine. *Scand J Med Sci Sports*. 1996;6:193–200.
88. Drez D, Faust DC, Evans JP. Cryotherapy and nerve palsy. *Am J Sports Med*. 1981;9:256–257.
89. Bassett F, Kirkpatrick J, Engelhardt D, Malone T. Cryotherapy-induced nerve injury. *Am J Sports Med*. 1992;20:516–518.
90. Wilkerson LA. Ankle injuries in athletes. *Prim Care*. 1992;19:377–392.
91. Ashton H. Effect of inflatable plastic splints on blood flow. *Brit Med J*. 1966;2:1427–1430.
92. Ashton H. The effect of increased tissue pressure on blood flow. *Clin Orthop*. 1975;113:15–26.
93. Nielsen HV. External pressure — blood flow relations during limb compression in man. *Acta Physiol Scand*. 1983;119:253–260.
94. Thorsson O, Hemdal B, Lilja B, Westlin N. The effect of external pressure on intra-muscular blood flow at rest and after running. *Med Sci Sports Exerc*. 1987;19:469–473.
95. Bourne M. Analgesics for orthopedic postoperative pain. *Am J Orthop*. 2004;33:128–135.
96. Hasson SM, Daniels JC, Divine JG, et al. Effect of ibuprofen use on muscle soreness, damage, and performance: A preliminary investigation. *Med Sci Sports Exerc*. 1993;25:9–17.
97. Dudley GA, Czerkawski J, Meinrod A, Gillis G, Baldwin A, Scarpone M. Efficacy of naproxen sodium for exercise-induced dysfunction muscle injury and soreness. *Clin J Sport Med*. 1997;7:3–10.
98. Baldwin AC, Stevenson SW, Dudley GA. Nonsteroidal anti-inflammatory therapy after eccentric exercise in healthy older individuals. *J Gerontol A Biol Sci Med Sci*. 2001;56:M510–M513.
99. Almekinders LC. Anti-inflammatory treatment of muscular injuries in sport. An update of recent studies. *Sports Med*. 1999;28:383–388.
100. Mishra DK, Friden J, Schmitz MC, Lieber RL. Anti-inflammatory medication after muscle injury: A treatment resulting in short-term improvement but subsequent loss of muscle function. *J Bone Joint Surg Am*. 1995;77:1510–1519.
101. Baumert PW Jr. Acute inflammation after injury. Quick control speeds rehabilitation. *Postgrad Med*. 1995;97:35–36,39,42 passim.