time. In many chronic overuse problems, the compression wrap should be worn until the swelling is gone.

As is the case with ice, there is limited evidence that supports the use of compression.[29]

Elevation

Along with cold and compression, elevation reduces internal bleeding. The injured part, particularly an extremity, should be elevated to eliminate the effects of gravity on blood pooling in the extremities. Elevation assists the veins, which drain blood and other fluids from the injured area and return them to the central circulatory system. The greater the degree of elevation, the more effective the reduction in swelling. For example, in an ankle sprain, the leg should be placed so that the ankle is virtually straight up in the air against the wall. The injured part should be elevated as much as possible during the first 72 hours.

Clinical Decision-Making Exercise 1-5

A soccer player has been successfully managing Achilles tendinitis with POLICE, exercises, and anti-inflammatories. The athletic trainer has decided that the patient should begin playing again. What can the athletic trainer do to help the patient prevent further injury?

The appropriate technique for initial management of the acute injuries discussed in this chapter, regardless of where they occur, would be the following:

- Apply a compression wrap directly over the injury. Wrapping should be from distal to proximal. Tension should be firm and consistent. Wetting the elastic wrap to facilitate the passage of cold from ice packs might be helpful.
- Surround the injured area entirely with ice bags, and secure them in place. Ice bags should be left on for 45 minutes initially, then 1 hour off and 30 minutes on as much as possible over the next 24 hours. During the following 48-hour period, ice should be applied as often as possible.
- The injured part should be elevated as much as possible during the initial 72-hour period after injury. Keeping the injured part elevated while sleeping is particularly important.
- Allow the injured part to rest for about 24 hours after the injury.

Controlling Pain

When an injury occurs, the athletic trainer must realize that the patient will experience some degree of pain. The extent of the pain will be determined in part by the severity of the injury, by the patient's individual response to and perception of pain, and by the circumstances in which the injury occurred. The patient's pain is real. The athletic trainer can effectively modulate acute pain by using the POLICE technique immediately after injury.[26] A physician can also make use of various medications to help ease pain.

Persistent pain can make strengthening or flexibility exercises more difficult, thus interfering with the rehabilitation process. The athletic trainer should routinely address pain during each individual treatment session. Making use of appropriate therapeutic modalities—including various techniques of cryotherapy, thermotherapy, and electrical stimulating currents—will help modulate pain throughout the rehabilitation process[25] (Figure 1-2). To a great extent, pain will dictate the rate of progression. With initial injury, pain is intense and tends to decrease and eventually subside altogether as healing progresses. Any exacerbation of either pain, swelling, or other clinical symptoms during or following a particular exercise or activity indicates that the load is too great for the level of tissue repair or remodeling.

Establishing Core Stability

Core stability is absolutely essential to every aspect of the rehabilitation process (Figure 1-3). The core is considered to be the lumbo-pelvic-hip complex, which functions to dynamically stabilize the entire kinetic chain during functional movements. Without proximal or core stability, the distal movers cannot function optimally to efficiently use their strength and power. Chapter 5 will discuss the concept of core stabilization in great detail.[19,30]

Figure 1-2. Several modalities, including electrical stimulating currents, may be used to modulate pain. (Reprinted with permission from DJ Global.)

Figure 1-3. Core stability forms the basis for all aspects of a rehabilitation program.

Reestablishing Neuromuscular Control

Reestablishing neuromuscular control should be of prime concern to the athletic trainer in all rehabilitation programs[32] (see Chapter 6). The ability to sense the position of a joint in space is mediated by mechanoreceptors found in both muscles and joints, in addition to cutaneous, visual, and vestibular input. Neuromuscular control relies on the central nervous system to interpret and integrate proprioceptive and kinesthetic information and then to control individual muscles and joints to produce coordinated movement.[13]

Following injury and subsequent rest and immobilization, the central nervous system "forgets" how to put together information coming from muscle and joint mechanoreceptors, and from cutaneous, visual, and vestibular input. Regaining neuromuscular control means regaining the ability to follow some previously established sensory pattern.[32] Neuromuscular control is the mind's attempt to teach the body conscious control of a specific movement. Successful repetition of a patterned movement makes its performance progressively less difficult, thus requiring less concentration until the movement becomes automatic. This requires many repetitions of the same movement, progressing step-by-step from simple to more complex movements. Strengthening exercises, particularly those that tend to be more functional such as closed kinetic chain exercises, are essential for reestablishing neuromuscular control (see Chapter 12). Addressing neuromuscular control is critical throughout the recovery process, but it is perhaps most critical during the early stages of rehabilitation to avoid reinjury (see Chapter 6).[32]

Restoring Postural Control and Stability (Balance)

Postural stability involves the complex integration of muscular forces, neurological sensory information received from the mechanoreceptors, and biomechanical information.[16] The ability to maintain postural stability and balance is essential to acquiring or reacquiring complex motor skills.[13] Patients who show a decreased sense of balance or a lack of postural stability following injury might lack sufficient proprioceptive and kinesthetic information and/or might have muscular weakness, either of which can limit the ability to generate an effective correction response when there is not equilibrium. A rehabilitation program must include functional exercises that incorporate balance and proprioceptive training that prepares the patient for return to activity (Figure 1-4). Failure to address balance problems can predispose the patient to reinjury (see Chapter 7).

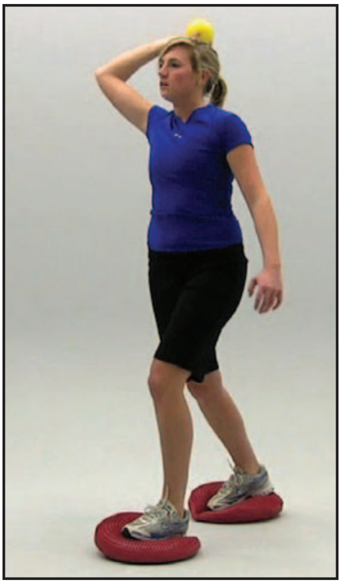

Figure 1-4. Reestablishing neuromuscular control and balance is critical to regaining functional performance capabilities.

Restoring Range of Motion

Following injury to a joint, there will always be some associated loss of motion. That loss of movement can usually be attributed to a number of pathological factors, including resistance of the musculotendinous unit (ie, muscle, tendon, fascia) to stretch; contracture of connective tissue (ie, ligaments, joint capsule); or some combination of the two. Muscle imbalances, postural imbalance, neural tension, and joint dysfunction can also lead to a loss in ROM.

It is critical for the athletic trainer to closely evaluate the injured joint to determine whether motion is limited due to physiological movement constraints involving musculotendinous units or due to limitation in accessory motion (joint arthrokinematics) involving the joint capsule and ligaments. If physiological movement is restricted, the patient should engage in stretching activities designed to improve flexibility (Figure 1-5; see Chapters 8 and 14). Stretching exercises should be used whenever there is musculotendinous resistance to stretch. If accessory motion is limited due to some restriction of the joint capsule or the ligaments, the athletic trainer should incorporate joint mobilization and traction techniques into the treatment program (Figure 1-6; see Chapter 14). Mobilization techniques should be used whenever there are tight articular structures.[19] Traditionally, rehabilitation programs tend to concentrate more on passive physiological movements without paying much attention to accessory motions.

Figure 1-5. Stretching techniques are used with tight musculotendinous structures to improve physiological ROM.

Figure 1-6. Joint mobilization techniques are used with tight ligamentous or capsular structures to improve accessory motion.

Restoring Muscular Strength, Endurance, and Power

Muscular strength, endurance, and power are among the most essential factors in restoring the function of a body part to preinjury status. Isometric, progressive resistive (isotonic), isokinetic, and plyometric exercises can benefit rehabilitation. A major goal in performing strengthening exercises is to work through a full, pain-free ROM.[26]

Most strength training programs involve single-plane force production using either free weights or exercise machines. A functional rehabilitative strengthening program should involve exercises in all 3 planes of motion,

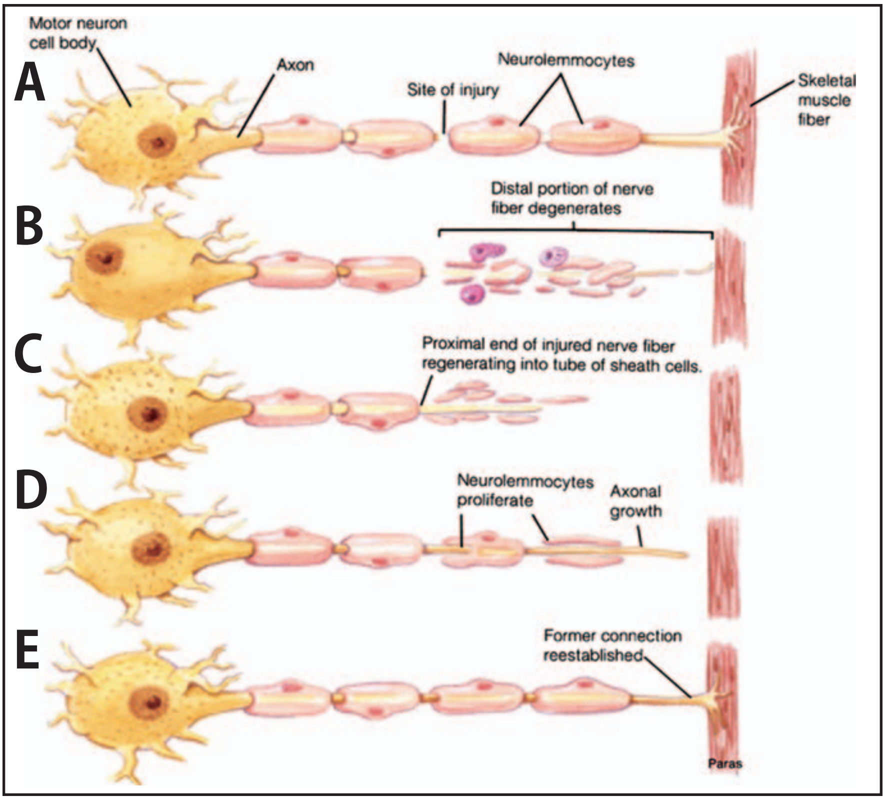

Figure 2-13. Neuron regeneration. (A) If a neuron is severed through a myelinated axon, the proximal portion may survive, but (B) the distal portion will degenerate through phagocytosis. (C) and (D) The myelin layer provides a pathway for regeneration of the axon, and (E) innervation is restored. (Reprinted with permission from Van De Graaff. *Human Anatomy*. Chicago, IL: McGraw-Hill Higher Education; 2002.)

The axon proximal to the cut has minimal degeneration initially and then begins the regenerative process with growth from the proximal axon. Bulbous enlargements and several axon sprouts form at the end of the proximal axon. Within about 2 weeks, these sprouts grow across the scar that has developed in the area of the cut and enter the column of Schwann cells. Only one of these sprouts will form the new axon, whereas the others will degenerate. Once the axon grows through the Schwann cell columns, remaining Schwann cells proliferate along the length of the degenerating fiber and form new myelin around the growing axon, which will eventually reinnervate distal structures.[56]

Regeneration is slow, at a rate of only 3 to 4 mm per day. Axon regeneration can be obstructed by scar formation caused by excessive fibroplasia. Damaged nerves within the central nervous system regenerate very poorly compared to nerves in the peripheral nervous system. Central nervous system axons lack connective tissue sheaths, and the myelin producing Schwann cells fail to proliferate.[56,70]

ADDITIONAL MUSCULOSKELETAL INJURIES

Dislocations and Subluxations

A dislocation occurs when at least one bone in an articulation is forced out of its normal and proper alignment and stays out until it is either manually or surgically put back into place or reduced.[39] Dislocations most commonly occur in the shoulder joint, elbow, and fingers, but they can occur wherever 2 bones articulate (Figure 2-14A).[53,55,69]

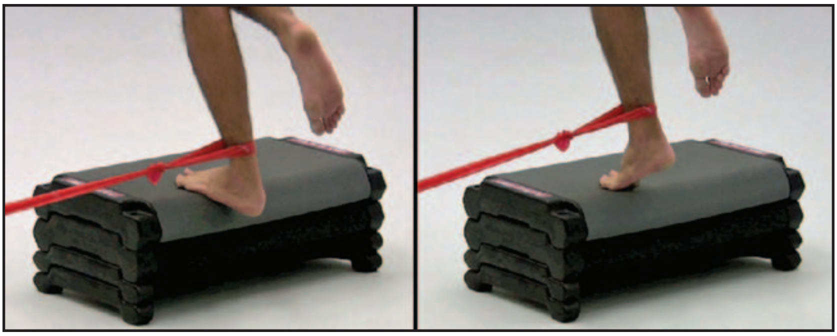

Figure 6-6. Balance and strength exercises are combined by incorporating light external forces and increasing the level of difficulty for balancing while strengthening the muscles required for dynamic stabilization.

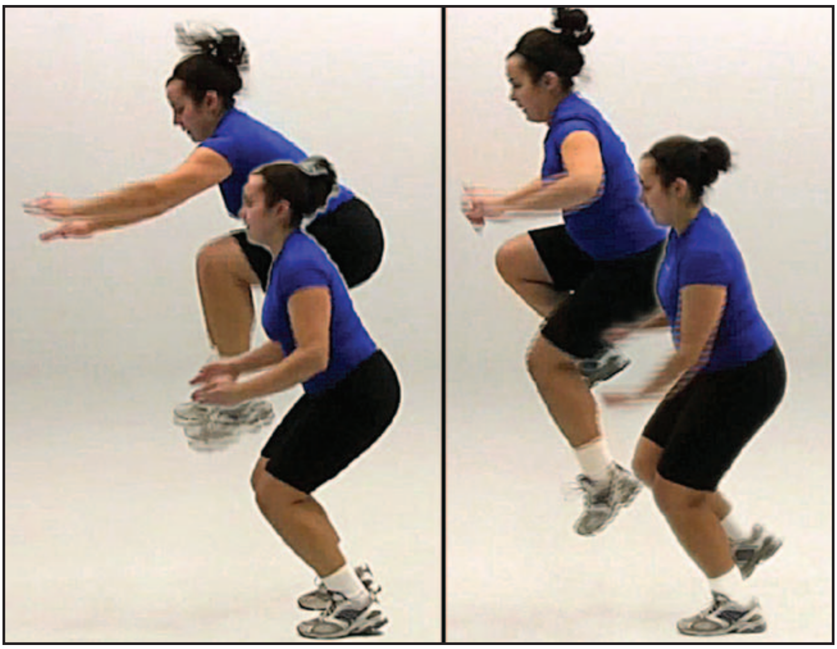

Figure 6-7. Plyometrics begin with double-leg hopping and progress to single-leg hopping.

along with the related changes in muscle stiffness. This preparatory muscle activation prior to eccentric loading is considered to be a combination of preprogrammed and reactive motor commands. Plyometric activities such as unweighted walking in a pool or low-impact hopping may commence once weightbearing is achieved (Figure 6-7). Double-leg bounding is an effective intermediate exercise because the uninvolved limb can be used for assistance. Stretch-shortening activities are made more difficult with alternate-leg bounding, then single-leg hopping. Subsequent activities such as hopping with rotation, lateral hopping, and hopping onto various surfaces are instituted as tolerated. Plyometric training requires preparatory muscle activation and facilitates reflexive pathways for reactive neuromuscular control.

Clinical Decision-Making Exercise 6-3

A female cross-country runner complains of chronic anterior knee pain. Your assessment reveals that she has patellofemoral pain and stiffness with associated hypertrophy of her vastus lateralis and atrophy in the vastus medialis oblique. What modalities would you use to correct this muscular imbalance? Discuss the rationale for each modality and how it relates to neuromuscular control.[66]

Although maintaining balance while standing may appear to be a simple motor skill for able-bodied athletes, this feat cannot be taken for granted as it is a complex process involving multiple systems and inputs. Muscular weakness, proprioceptive deficits, and range of motion (ROM) deficits may challenge a person's ability to maintain his or her center of gravity (COG) within the body's base of support, or, in other words, cause him or her to lose balance. Balance is the single most important element dictating movement strategies within the closed kinetic chain. Acquisition of effective strategies for maintaining balance is essential for athletic performance.

Although balance is often thought of as a static process, it is actually a highly integrative dynamic process involving multiple central and peripheral neurologic pathways. Although *balance* is the more commonly used term, *postural equilibrium* is a broader term that involves the alignment of joint segments in an effort to maintain the COG within an optimal range of the maximum limits of stability (LOS).

Despite often being classified at the end of the continuum of goals associated with therapeutic exercise,[50] maintenance of balance is a vital component in the rehabilitation of brain and joint injuries that should not be overlooked. Traditionally, orthopedic rehabilitation has placed the emphasis on isolated joint mechanics, such as improving ROM and flexibility, and increasing muscle strength and endurance, rather than on afferent information obtained by the joint(s) to be processed by the postural control system. Additionally, rehabilitation following traumatic brain injury/concussions has only recently been at the forefront of management options.[77]

Research in the area of proprioception and kinesthesia has emphasized the need to train the joint's neural system.[51-55] Joint position sense, proprioception, and kinesthesia are vital to all athletic performance requiring balance. Current rehabilitation protocols should therefore focus on a combination of open and closed kinetic chain exercises. The necessity for a combination of open and closed kinetic chain exercises can be seen during gait (walking or running), as the foot and ankle prepare for heel strike (open chain) and prepare to control the body's COG during midstance and toe off (closed chain). Concerning concussion, recent evidence suggests that balance training and vestibular specific training in individuals with these deficits can improve outcomes.[77] As such, these types of activities should be considered in the management of concussion.

This chapter focuses on the postural control system, various balance training techniques, and technologic advancements that are enabling athletic trainers to assess and treat balance deficits in physically active people.

POSTURAL CONTROL SYSTEM

To design effective rehabilitation programs, the athletic trainer must first have an understanding of the postural control system and its various components. The postural control system uses complex processes involving both sensory and motor components. Maintenance of postural equilibrium includes sensory detection of body motions, integration of sensorimotor information within the central nervous system (CNS), and execution of appropriate musculoskeletal responses. Most daily activities, such as walking, climbing stairs, reaching, or throwing a ball, require static foot placement with controlled balance shifts, especially if a favorable outcome is to be attained. So, balance should be considered both a dynamic and static process. The successful accomplishment of static and dynamic balance is based on the interaction between body and environment.[49] Figure 7-1 shows the complexity of this dynamic process.

From a clinical perspective, separating the sensory and motor processes of balance means that a person may have impaired balance for one or a combination of 2 reasons: the position of the COG relative to the base of support is not accurately sensed for either peripheral or central reasons, and/or the automatic movements required to bring the COG to a balanced position are not timely or effectively coordinated.[67] The position of the body in relation to gravity and its surroundings is sensed by combining visual, vestibular, and somatosensory inputs. Balance movements also involve motions of the ankle, knee, and hip joints, which are controlled by the coordinated actions along the

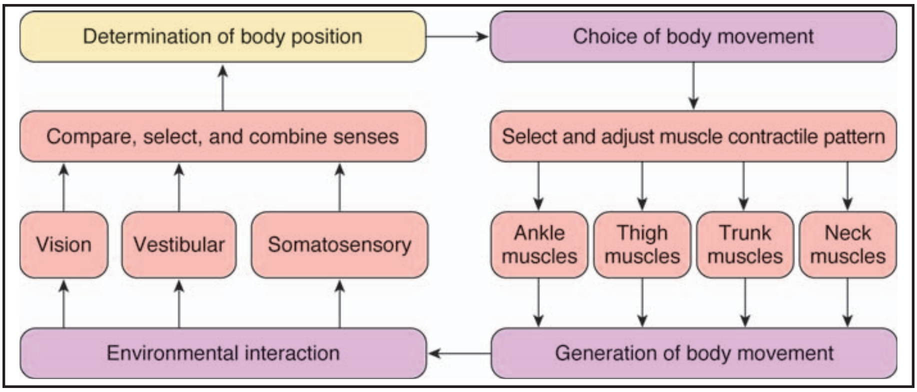

Figure 7-1. Dynamic equilibrium. (Adapted from Allison L, Fuller K, Hedenberg R, et al. *Contemporary Management of Balance Deficits*. Clackamas, OR: NeuroCom International; 1994. Reprinted with permission from Natus Medical Incorporated.)

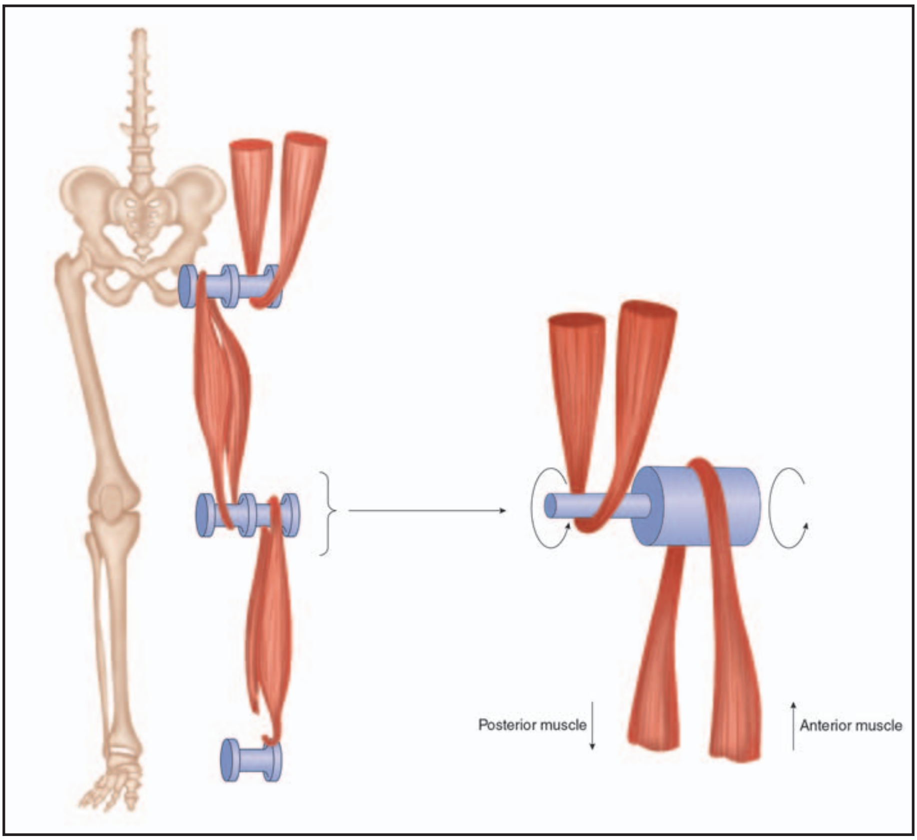

Figure 7-2. Paired relationships between major postural musculatures that execute coordinated actions along the kinetic chain to control the COG.

kinetic chain (Figure 7-2). These processes are all vital for producing both normal, everyday movements such as gait as well as fluid, sport-related movements.

CONTROL OF BALANCE

The human body is a very tall structure balanced on a relatively small base, and its COG is quite high, being just above the pelvis. Many factors enter into the task of controlling balance

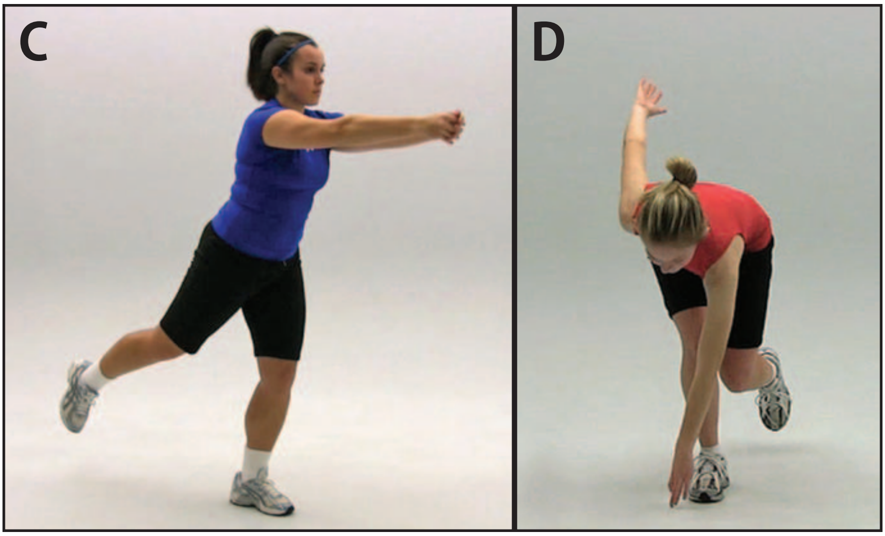

Figure 7-16 (continued). Single-leg balance dynamic (multiplane) movements on a stable surface. (C) Double-arm reach. (D) Romanian deadlift.

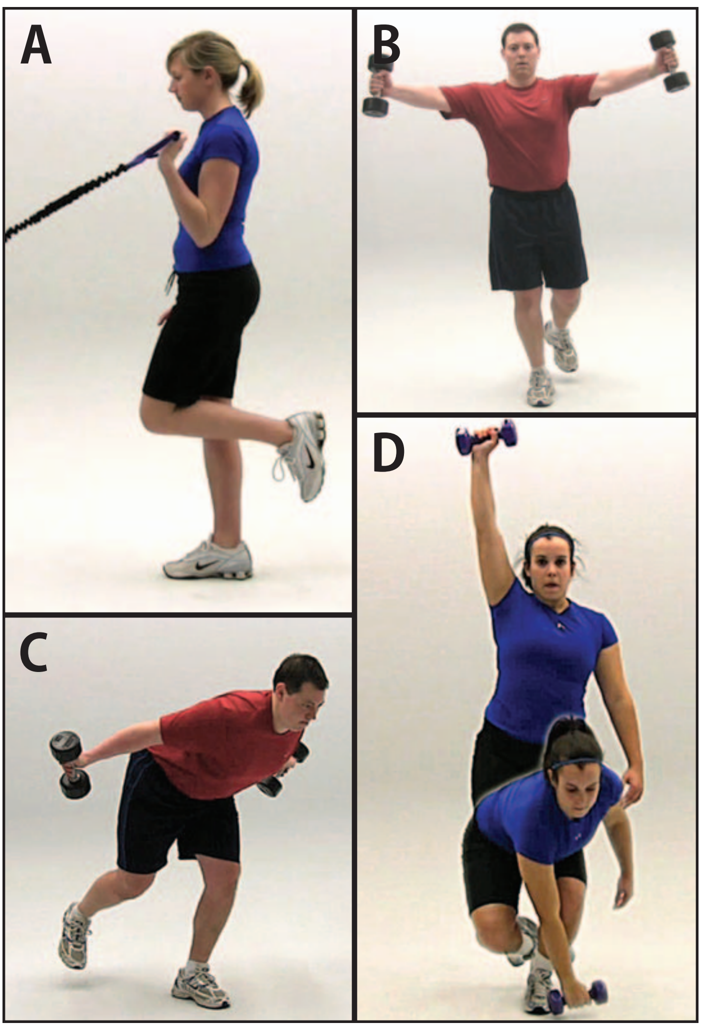

Figure 7-17. Single-leg balance resisted (multiplane) movements on a stable surface. (A) Biceps curls using cable or tubing. (B) Dumbbell scaption. (C) Dumbbell cobra. (D) Squat touchdown to overhead press.

Some specialized training is necessary for the athletic trainer to understand specific techniques of myofascial release.[78] It is also essential to have an in-depth understanding of the fascial system.

Fascia is a type of connective tissue that surrounds muscles, tendons, nerves, bones, and organs. It is essentially continuous from head to toe and is interconnected in various sheaths or planes. Fascia is composed primarily of collagen along with some elastic fibers. During movement, the fascia must stretch and move freely. If there is damage to the fascia owing to injury, disease, or inflammation, it will not only affect local adjacent structures, but may also affect areas far removed from the site of the injury.[51] Thus, it may be necessary to release tightness both in the area of injury and in distant areas. It will tend to soften and release in response to gentle pressure over a relatively long period.

Myofascial release has also been referred to as *soft tissue mobilization*. Soft tissue mobilization should not be confused with joint mobilization, although it must be emphasized that the two are closely related.[2] Joint mobilization is used to restore normal joint arthrokinematics, and specific rules exist regarding direction of movement and joint position based on the shape of the articulating surfaces (see Chapter 13). Myofascial restrictions are considerably more unpredictable and may occur in many different planes and directions.[26] Myofascial treatment is based on localizing the restriction and moving into the direction of the restriction, regardless of whether that follows the arthrokinematics of a nearby joint. Thus, myofascial manipulation is considerably more subjective and relies heavily on the experience of the therapist.[51] Myofascial manipulation focuses on large treatment areas, whereas joint mobilization focuses on a specific joint. Releasing myofascial restrictions over a large treatment area can have a significant impact on joint mobility.[54] The progression of the technique is to work from superficial fascial restrictions to deeper restriction. Once more superficial restrictions are released, the deep restrictions can be located and released without causing any damage to superficial tissue. Joint mobilization should follow myofascial release and will likely be more effective once soft tissue restrictions are eliminated.

As extensibility is improved in the myofascia, elongation and stretching of the musculotendinous unit should be incorporated. In addition, strengthening exercises are recommended to enhance neuromuscular reeducation, which helps promote new, more efficient movement patterns. As freedom of movement improves, postural reeducation may help ensure the maintenance of the less-restricted movement patterns.

Generally, acute cases tend to resolve in just a few treatments. The longer a condition has been present, the longer it will take to resolve. Occasionally, dramatic results will occur immediately after treatment. It is usually recommended that treatment be done at least 3 times per week.

Myofascial release can be done manually by an athletic trainer or by the patient stretching using a foam roller.[41,78,85] Foam rolling has been shown to be more effective than static and dynamic stretching in acutely increasing flexibility of the quadriceps and hamstrings without hampering muscle strength, and has been recommended as part of a warm-up in healthy young adults.[85] Figure 8-11 shows examples of stretching using the foam roller.

Strain-Counterstrain Technique

Strain-counterstrain is an approach to decreasing muscle tension and guarding that may be used to normalize muscle function. It is a passive technique that places the body in a position of greatest comfort, thereby relieving pain.[93]

In this technique, the athletic trainer locates "tender points" on the patient's body that correspond to areas of dysfunction in specific joints or muscles that are in need of treatment.[93] These tender points are not located in or just beneath the skin, as are many acupuncture points, but instead are deeper in muscle, tendon, ligament, or fascia. They are characterized by tense, tender, edematous spots on the body. They are 1 cm or less in diameter, with the most acute points being 3 mm in diameter, although they may be a few centimeters long within a muscle. There can be multiple points for one specific joint dysfunction. Points might be arranged in a chain, and they are often found in a painless area opposite the site of pain and/or weakness.[93]

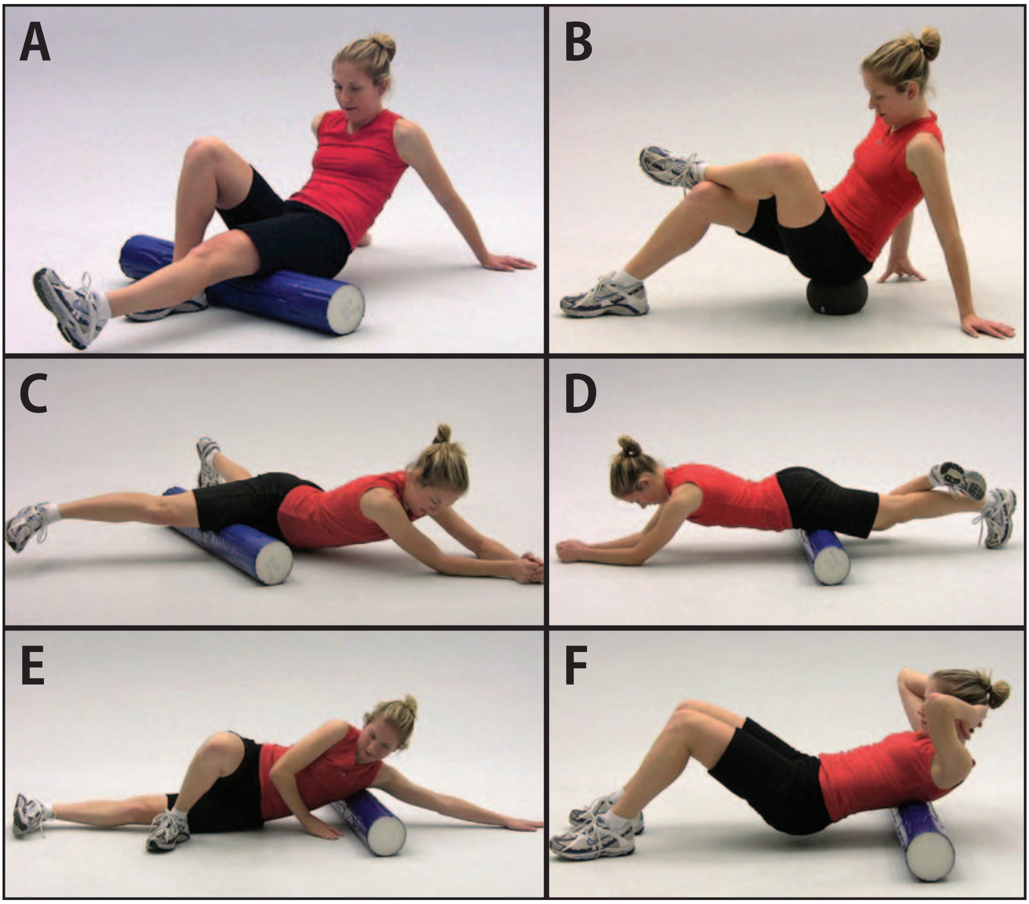

Figure 8-11. Myofascial release stretching using a foam roller or firm ball. (A) Hamstrings. (B) Piriformis. (C) Adductors. (D) Quadriceps. (E) Latissimus dorsi. (F) Rhomboids.

The athletic trainer monitors the tension and level of pain elicited by the tender point while moving the patient into a position of ease or comfort. This is accomplished by markedly shortening the muscle.[93] When this position of ease is found, the tender point is no longer tense or tender. When this position is maintained for a minimum of 90 seconds, the tension in the tender point and in the corresponding joint or muscle is reduced or cleared. By slowly returning to a neutral position, the tender point and the corresponding joint or muscle remains pain-free with normal tension. For example, with neck pain and/or tension headaches, the tender point may be found on either the front or back of the patient's neck and shoulders. The athletic trainer will have the patient lie on the his or her back and will gently and slowly bend the patient's neck until that tender point is no longer tender. After holding that position for 90 seconds, the athletic trainer gently and slowly returns the neck to its resting position. When that tender point is pressed again, the patient should notice a significant decrease in pain there (Figure 8-12).[93]

The physiologic rationale for the effectiveness of the strain-counterstrain technique can be explained by the stretch reflex.[21] When a muscle is placed in a stretched position, impulses from the muscle spindles create a reflex contraction of the muscle in response to stretch. With strain-counterstrain, the joint or muscle is placed not in a position of stretch, but instead in a slack position. Thus, muscle spindle input is reduced and the muscle is relaxed, allowing for a decrease in tension and pain.[38]