Chapter 8

Therapeutic Exercise

OUTCOMES

1. Explain the principles associated with the cognitive model that describes a patient's adjustment to injury.
2. Identify various psychological influences that can affect an injured individual, and describe strategies or intervention techniques used to overcome these influences.
3. Explain the importance of dealing with the psychological concerns of the patient that may arise during the therapeutic exercise program, and identify the referral process if warranted.
4. Describe key factors in the development of a therapeutic exercise program.
5. Explain the four phases of a therapeutic exercise program, including the goals of these phases and methodology of implementation.
6. List the criteria used to clear an individual to return to full participation in sport and physical activity.

The ultimate goal of therapeutic exercise is to return the injured participant to pain-free and fully functional activity. For this to be accomplished, attention must focus on modulating pain and restoring normal joint range of motion (ROM), kinematics, flexibility, muscular strength, endurance, coordination, and power. Furthermore, cardiovascular endurance and strength must be maintained in the unaffected limbs.

Psychological influences can inhibit or enhance the progress of the therapeutic exercise program. As such, an awareness of the physical, psychological, emotional, social, and performance factors that may affect the patient during rehabilitation is essential. Only then can each component be addressed within a well-organized, individualized exercise program.

In this chapter, several emotional and psychological factors that may affect the injured individual are presented. These factors may either inhibit or enhance progress through the rehabilitation program. Next, a therapeutic exercise program following the SOAP (Subjective evaluation, Objective evaluation, Assessment, and Plan) note format is explained. Phases of a therapeutic exercise program are presented, including criteria used to determine when an individual is ready to progress in the program, and ultimately to return to sport activity. Practical application of the material for the various body segments is included in Chapters 10 through 17. Because of the extensive nature of the material and the inability to provide in-depth information in a single chapter, students should enroll in a separate therapeutic exercise class to gain a more thorough understanding of the subject area, and to learn the clinical skills necessary to develop a total rehabilitation program.

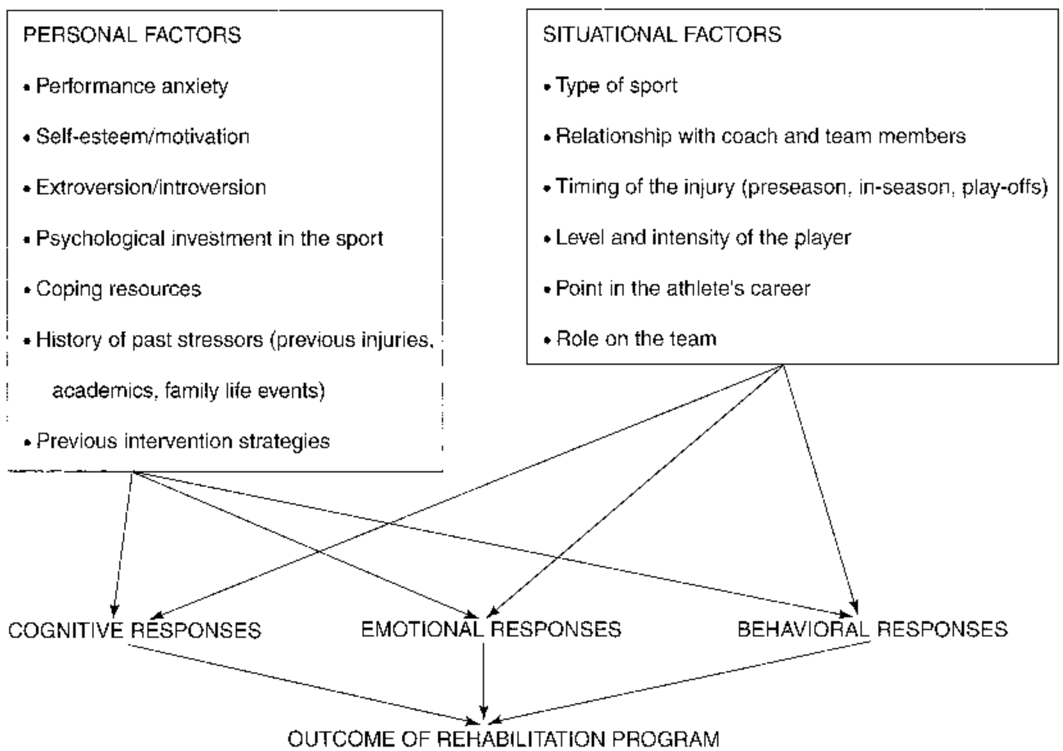
PSYCHOLOGICAL ASPECTS OF THE INJURED PARTICIPANT

Q A high school senior soccer player developed acute Achilles tendinitis 2 days before the post-season tournament, and just learned that he will be unable to participate for the remainder of the season. How might this athlete react to the inability to participate in sport? What impact will this reaction have on his motivation to improve? How can the athletic trainer help this person overcome the physical, psychological, and emotional effects that may hinder progress in the therapeutic exercise program?

To an individual who enjoys sport and physical activity, an injury can be devastating. For many, the development and maintenance of a physically fit body provides a focal point for social and economic success that is important for self-esteem. A therapeutic exercise program must address not only the physical needs, but also the emotional and psychological needs in returning the individual to activity.

In general, there are two models that categorize an individual's adjustment to injury, namely stage and cognitive models. The **stage model** is often linked to the Kübler-Ross emotional stages that an individual progresses through when confronted with grief. The stages include denial and isolation, anger, bargaining, depression, and acceptance. Although the model has some intuitive appeal, the stereotypical linear pattern of distinct emotional responses has not stood up to empirical scrutiny (1). Furthermore, if individuals react to injury in a linear manner, then the therapist should be able to predict the patient's progress during rehabilitation. This is rarely the case.

Each person reacts differently to an injury, depending on individual coping mechanisms that stem from the interaction of personal and situational factors **(Figure 8.1)**. As such, **cognitive models** were developed to account for the differences. Personal factors, such as performance anxiety, self-esteem/motivation, extroversion/introversion, psychological investment in the sport, coping resources, a history of past stressors (e.g., previous injuries, academics,



➤ **Figure 8.1. Cognitive model of an athletic injury.** Personal factors and situational factors interact with the cognitive, emotional, and behavioral responses of the patient to influence the success or failure of a therapeutic exercise program.

and family life events), and previous intervention strategies influence how a patient approaches the rehabilitation process. Situational factors may involve the type of sport, relationship with the coach and team members, characteristics of the injury (severity, history, and type), timing of the injury (preseason, in-season, playoffs), level and intensity of the player, point in the individual's career, and role on the team. Each of these factors interacts with the cognitive, emotional, and behavioral responses of the patient to influence the success or failure of a therapeutic exercise program. The cognitive appraisal asks: "What are you thinking in regard to this injury?" The emotional response refers to what one is feeling, and the behavioral response focuses on what the patient is going to do: "What are the behavioral rehabilitation consequences?" (1)

Goal Setting

Goal setting is a common practice used to motivate patients in the recovery program. This practice directs the individual's effort, provides a sense of control that may enhance motivation, persistence, and commitment, and facilitates the development of new strategies to improve performance. It has been found that patients who set specific personal goals in each training session exhibit an increase in self-efficacy, or the sense of having the power to produce intended outcomes, and have greater satisfaction with their performance (2-5).

The process begins by establishing a strong and supportive rapport between the therapist and patient, as they work in partnership to assist the individual back to preinjury status. In order to achieve success, the therapist must form a genuine relationship with the patient and listen intently for clues that indicate what the individual is or is not feeling. Goals should be realistic, objective, measurable, and attainable. Guidelines for goal setting for therapeutic exercise can be seen in **Box 8.1**. Long-term goals can reduce the patient's fears of the unknown, but do little to motivate the patient on a day-to-day basis. Therefore, short-term goals should be established to serve as daily motivators. Goals should be personalized and challenging, yet realistic. A timetable for completion should be established, and measured to monitor progress.

Plateaus and setbacks usually occur because something is blocking the patient's progress. These barriers fall under four general categories: lack of knowledge, lack of skill, lack of risk-taking ability, and lack of social support.

➤ *Lack of Knowledge*

It is imperative to inform the patient about the injury and recovery process. The use of a specific treatment, the intended goal, and any side effects or sensations that may be experienced should be explained to the patient. This helps the individual understand the process, avoids any surprises, and hopefully, reduces any anxiety the patient may be experiencing (6).

➤➤ BOX 8.1

Guide to Goal Setting for Therapeutic Exercise

Goals should be:

Specific and Measurable. The athlete must know exactly what to do, and be able to determine if gains are made.

Stated in Positive versus Negative Language. Knowing what to do guides behavior, whereas knowing what to avoid creates a focus on errors without providing a constructive alternative.

Challenging but Realistic. Overly difficult goals set up failure and pose a threat to the athlete. The lower the athlete's self-confidence, the more important success becomes, and the greater the importance of setting attainable goals.

Established on a Timetable for Completion. This allows for a check on progress, and evaluation of whether realistic goals have been set.

Integration of Short-, Intermediate-, and Long-Term Goals. A comprehensive program links daily activities with expectations for specific competitions, and for season and career goals.

Personalized and Internalized. The athlete must embrace goals as his or her own, not as something from the outside.

Monitored and Evaluated. Feedback must be provided to assess goals, and the goals should be modified based on progress.

Linked to Life Goals. This identifies sport and rehabilitation as learning experiences in life, and helps the athlete put sport in a broader perspective. This is especially important for athletes whose return to sport is doubtful.

➤ *Lack of Skill*

It is important to explain and demonstrate the various techniques that a patient will be performing. In some cases, a patient may indicate familiarity with an exercise, but the technique may not be correct. For example, a patient involved in knee rehabilitation states the ability to perform lateral step-ups. However, observation of the patient's actions reveals a pushing off with the plantar flexors to raise the body, rather than allowing only the heel to touch the floor and, in doing so, recruiting the quadriceps to raise the body. The exercise is ineffective if done improperly. Therefore, the therapist should always demonstrate the skill and watch the individual complete the exercise. Positive reinforcement and suggestions should be provided to correct any errors in technique.

➤ *Lack of Risk-Taking Ability*

Most individuals experience some level of fear and anxiety of the unknown. In a therapeutic exercise program, such emotions can block the individual's ability to push himself or herself to meet the challenges of the exercise program.

For example, fear of increased pain, discomfort, or reinjury during an exercise may limit the individual's motivation to exert full effort. Constant positive feedback from the therapist can help overcome many of these obstacles.

➤ Social Support

The injured patient needs to feel as important as noninjured individuals and not feel alone or isolated. Friends, colleagues, coaches, and the athletic trainer can provide emotional, challenging material and informational support to help the patient recognize his or her progress and value to the team. It is important to stress the individual's value as a person, and maintain connection to the team, friends, family, and any other supportive entities.

Psychological Influences

Five major factors can significantly influence the rehabilitation process: confidence, motivation, anxiety, focus, and the management of pain.

➤ Confidence

Confidence is perhaps the most critical factor to a complete and timely recovery. Low confidence can lead to a host of negative thinking and talk, which in turn can lead to increasing anxiety, negative emotions (e.g., bitterness, confusion, anger, or guilt), and low motivation, which can interfere with the individual's focus. Four main types of confidence can affect the patient's recovery: program, adherence, physical, and return-to-sport. *Program confidence* refers to the strength of the individual's belief that the rehabilitation program will enable recovery, and is significantly influenced by the therapist's confidence in the effectiveness of the program. *Adherence confidence* refers to the individual's belief that the prescribed exercise program can be completed. This factor can be enhanced by showing the individual that skills learned in sports, such as goal-setting and understanding the process of rehabilitation can heighten success in the rehabilitation program. *Physical confidence* is knowing that the individual's body is capable of handling the demands placed on it during rehabilitation and subsequent competition. Responding well to the rigors of the exercise program, maintaining a positive attitude about the ups and downs of rehabilitation, and using imagery can enhance this factor. *Return-to-sport confidence* relates to the individual's belief that his or her return to competition is at a level equal to or better than the preinjury status (7).

➤ Motivation

Motivation has the greatest influence on adherence in rehabilitation. Low motivation can result in poor attendance, incomplete exercises, low effort and intensity, lack of attentiveness to instructions, undefined goals, using unspecified pain to avoid exercise, and insupportable excuses. Motivation can be enhanced through goal setting by reminding the individual that rehabilitation is a type of athletic performance, improving commitment, providing clear direction and the means to achieve full recovery, and offering deliberate steps to recovery. High motivation builds confidence, reduces anxiety and the perception of pain, and refocuses the individual's attention on the positive rather than the negative aspects of rehabilitation (3, 5).

➤ Anxiety

Anxiety is the negative and threatening psychological and physical reaction to the injury, and produces a wide range of physical, cognitive, emotional, social, and performance problems. Many of these signs and symptoms can be seen in **Box 8.2**. Anxiety often is caused by a number of factors, such as pain, slow healing, low confidence, pressure from others, and a lack of familiarity, predictability, and control. Anxiety can restrict oxygen intake and blood flow, increase muscle tension and pain, reduce confidence and motivation, and lead the individual to focus on the negative rather than positive aspects of rehabilitation. Physically active individuals can control anxiety by using deep breathing, passive and active relaxation, soothing music, smiling, and therapeutic massage. A rehabilitation routine can benefit the patient's recovery by encompassing all the activities necessary for

➤➤ BOX 8.2

Signs and Symptoms of Anxiety in Rehabilitation

Physical	Muscle tension and bracing; short, choppy breathing; decreased coordination; fatigue; rushed speech; minor secondary injuries or nagging illness with recurrent physical complaints; and sleeping problems
Cognitive	Excessive negativity and overly self-critical, statements of low confidence in rehabilitation, extreme thinking and unrealistic expectations, and very narrow focus
Emotional	Anger, depression, irritability, moodiness, and impatience
Social	Decreased communication, social withdrawal, intolerance, and abruptness with others
Performance	Overall decline in motivation and enjoyment in rehabilitation, loss of interest in sports and other activities, nervousness and physical tension during therapy, trying too hard in therapy or "giving up" in response to obstacles and setbacks, and decrease in school or work performance

total preparation, including a review of the goals for that day, mental preparation to ensure prime confidence, motivation, intensity, and focus, and physical preparation such as stretching and warm-up (7).

➤ *Focus*

Often misunderstood and ignored, focus is critical in the rehabilitation process. In essence, **focus** is the ability to perceive and address various internal (e.g., thoughts, emotions, physical responses) and external (e.g., sights, sounds) cues and, when needed, to shift focus to other cues in a natural, effortless manner. Focus differs from concentration in that concentration is usually linked to the ability to attend to one thing for a long period of time. In contrast, focus is the ability to attend to various cues occurring simultaneously, and shift focus when the need arises. For example, a patient may be executing an exercise and have to shift focus externally to listen to the instructions for an exercise. The patient then needs to focus internally in order to consciously monitor the intensity and any pain being experienced. The ability to focus is often compared with the beam of a Mag-Lite flashlight in that the beam can be adjusted to illuminate a wide area or focused to brighten a narrow area (7).

Cues that interfere with rehabilitation include negative thoughts, anxiety, pain (as an inhibitor), preoccupation with the injury after returning to sport participation, peer pressure to recover quickly, any distraction during physical therapy, and comparisons to others upon return to sport. Facilitating cues may include pain (as information), proprioceptive responses, physical dimensions such as ROM and strength, information that the therapist provides, support from others, and feedback from the therapeutic exercise equipment. In order to maintain one's prime focus, the patient must balance the focus on short- and long-term goals, and pay attention to the four principles (Ps) of focus. In general, the patient should focus on the:

Positive attributes of the rehabilitation rather than the negative
Present time rather than the past
Process and what needs to be done on a day-to-day basis to enhance recovery
Progress while moving through the rehabilitation program

The patient also must avoid being distracted during the exercise session. Too often, distractions in the room (noise, talking, or music) can result in the individual redirecting his or her eyes and attention toward something else rather than internally focusing on the exercise. It is important to learn to control the eyes and only process beneficial information, such as instructions on how to complete the exercise. The use of keywords and rehabilitation imagery also may be helpful. For example, if muscle tension is present, a keyword might be *relax,* or the individual could imagine the muscle relaxing and elongating. Each of these cues helps focus the patient to the task at hand.

➤ *Pain Management*

Pain is the most debilitating obstacle to overcome in rehabilitation. It can have significant physical, psychological, and emotional effects on the individual. Physically active individuals must be able to differentiate between benign and harmful pain. **Benign pain** is usually characterized as dull, generalized, not long-lasting after exertion, and not associated with swelling, localized tenderness, or long-term soreness. In contrast, **harmful pain** is sharp, localized to the injury site, experienced during and persisting after exertion, and usually is associated with swelling, localized tenderness, and prolonged soreness.

Although pain can be controlled with medication, individuals can use nonpharmacologic means to control pain in two manners, namely pain reduction and pain focusing **(Box 8.3)**. Pain reduction techniques (e.g., muscle relaxation training, deep breathing, meditation, and therapeutic massage) directly affect the physiologic

➤➤ BOX 8.3

Pain Management Techniques

PAIN REDUCTION

Deep breathing	Emphasize slow, deep, rhythmical breathing
Muscle relaxation	Passive or progressive relaxation
Meditation	Repetitive focusing on mantra or breathing
Therapeutic massage	Manual manipulation of muscles, tendons, and ligaments (see Chapter 6)

PAIN FOCUSING

External focus	Listening to relaxing or inspiring music; watching a movie; playing chess
Soothing imagery	Generating calming images (lying on a beach, floating in space)
Neutral imaginings	Imagining playing chess or building a model airplane
Rhythmic cognitive activity	Saying the alphabet backward; meditation
Pain acknowledgment	Giving pain a "hot" color, such as red, then changing it to a less painful "cool" color, such as blue
Dramatic coping	Seeing pain as part of an epic challenge to overcome insurmountable odds
Situational assessment	Evaluating the causes of pain to take steps to reduce it

aspects of pain by decreasing the actual amount of pain that is present. Pain focusing directs attention onto (association) or away from (dissociation) the pain by reducing or altering the perception of pain. Strategies for focusing pain include external focus, such as emotionally powerful or intellectually absorbing activities, pleasant or neutral imaging, rhythmic cognitive activity, dramatic coping, and situational assessment (7).

Interventions

Knowing that an individual may be very concerned about the physical, psychological, social, and performance ramifications of his or her injury, the therapist can help the individual confront and overcome the concerns by using a variety of techniques. The more common techniques are discussed in the following.

➤ *Cognitive Restructuring*

The therapist should recognize when negative thinking creeps into the rehabilitation process. By restructuring the manner in which the patient views the process, the negative effects can be limited. For example, if a patient is distressed over the anticipated length of time the exercise program will continue, the therapist can point out ways that the injury can allow the individual time to rest and catch up with studies, complete other projects that have been neglected, or simply re-evaluate priorities and enjoy the absence of pressure from constant training and competition.

➤ *Concentration Skills*

Success upon return to sport can be enhanced by teaching the individual ways to focus on skills that help overcome negative progress. Eating correctly, getting plenty of rest, effectively managing time, and avoiding situations that may lead to reinjury can all help accomplish certain goals during the rehabilitation program.

➤ *Confidence Training*

The patient should be encouraged to direct his or her own course of action and "choose" to succeed. In doing so, the patient is made aware of the internal and external factors that affect confidence, and is taught to use those factors to personal benefit.

➤ *Coping Rehearsal*

Use of a performance-enhancing audiotape or videotape can prepare the patient for challenges. The information allows the patient to think about several issues that may arise when he or she returns to sport participation. This allows the individual to focus on the issues and develop strategies to overcome them prior to actually returning to sport participation.

➤ *Imagery*

Imagery has long been used in the training process as a way to enhance performance. Imagery involves the mental execution of a skill prior to actually performing the skill. In the rehabilitation process, imagery can be used to mentally practice the skills or processes that will expedite and promote a safe return to activity, such as envisioning healing, soothing (i.e., pain management), or performance (i.e., proper technique of an exercise). Imagery also can be enhanced by preceding it with relaxation exercises, such as passive or progressive relaxation. Relaxation can reduce anxiety and the physical manifestations of pain, and increase the vividness and control in imagery. Mental imagery can serve to motivate the patient to realize that this technique can facilitate the individual's performance upon return to sport activity.

➤ *Positive Self-Talk*

Injured individuals often express negative feelings about the injury, themselves, and occasionally their coaches and teammates. These negative feelings inhibit the individual and produce a self-defeating attitude. These thoughts and feelings can be redirected into positive, task-oriented thoughts that direct and motivate the individual to succeed in the rehabilitation process.

The Athletic Trainer's Role

The cognitive, or knowledge, appraisal and response to injury is influenced by the patient's recognition of the injury, understanding of the goal adjustments, and the individual's belief that he or she directly influences the success of the exercise program. However, the athletic trainer must not negate the emotional responses that will be exhibited throughout the exercise program. Seriously injured individuals may experience a variety of fears, social isolation, and loss of income or potential scholarships. This fear of the unknown may lead to increased tension, anger, and depression during the exercise period. If the patient does not perceive a gradual rate of recovery, frustration and boredom may deter a successful outcome. The athletic trainer should encourage the injured individual to develop a positive attitude by using social support networks and psychological skills to manage pain, and in doing so, direct the patient's energies into compliance with the treatment protocols. Positive encouragement may allow the patient to feel better about pushing himself or herself to a higher intensity despite discomfort, fatigue, or pain.

It is critical that the sports medicine team include the patient as an integral part of the rehabilitation process.

This is especially important when goals are established that direct the exercise program. The goals must be realistic and provide some means to measure progress so the patient can perceive a gradual rate of recovery. Whenever possible, the rehabilitation program should mirror the individual's regular training program, including the level of intensity, frequency, and duration. In some cases, activity modification and creativity may enable the physically active individual to do limited exercise or activity with the team. This may reduce the feeling of isolation and being left out of daily interaction with the coach and other players. Using graphs or charts to document progress also can help the individual see improvement. The athletic trainer must develop a positive professional relationship with the patient to assist the individual in recovering physically and psychologically from the injury.

Referral for Psychological Problems

Athletic trainers seldom have the extensive understanding or clinical training to handle psychological problems. In a recent survey of athletic trainers, 90% indicated that it was important to address the psychological aspects of an injury, but fewer than 25% had ever referred an athlete for counseling because of an injury, and only 8% had a standard procedure for referral (8). A clearly defined and well-organized procedural plan should be developed to guide the athletic trainer's actions and ensure confidentiality **(Box 8.4)**. Initially, criteria should be developed that establish when psychological distress or clinical issues are evident. During rehabilitation, several psychological factors can arise, including anxiety, depression, anger, pain, and treatment noncompliance.

As a general rule, any psychological difficulty that persists for more than a few days and interferes with the progress of rehabilitation should be referred to a licensed clinical psychologist or appropriate counseling center. Failure to address the issues can lead to an escalation in the distress and frustration of the patient. When a concern arises, the athletic trainer can telephone the clinical psychologist to discuss the symptoms and determine if the individual should be referred. If a decision is made to refer the individual, it should be discussed with the patient to facilitate the process. It should be pointed out that the referral is a positive step in helping the patient recover and return to sport participation. If possible, it may be advantageous to mention the previous use of a psychologist having helped other individuals recover. In this manner, the patient is likely to view the referral as a normal and positive aspect of the rehabilitation process (8,9).

Once referral has been made, it is important for the athletic trainer to follow-up with the clinical psychologist and provide any additional information about the patient's progress. It is important to remember that ethical considerations prohibit mental health professionals from discussing cases with third parties unless the patient gives explicit written permission. In cases involving athletes, it is beneficial to get this permission in advance, allowing the psychologist and athletic trainer to discuss the athlete's condition and develop strategies to facilitate the rehabilitation process.

Locating an individual with the qualifications and clinical experience of working in a sports rehabilitation setting can be difficult. It may be helpful to investigate the availability of personnel in college and university settings. Many schools may have a clinical psychologist on staff experienced in sports injury rehabilitation. Area hospitals also may be contacted, because many have a psychiatric or psychology department with a clinical psychologist specializing in various rehabilitation issues.

BOX 8.4

Psychological Distress Checklist for Possible Referral

Directions. Place a √ next to each behavior that you observe on a consistent basis in an athlete. The persistent presence of any of these behaviors may warrant a referral. The more items checked, the greater the need for a referral.

1. __ Not accepting injury
2. __ Denying seriousness or extent of injury
3. __ Displaying depression
4. __ Displaying anger
5. __ Displaying apprehension or anxiety
6. __ Failing to take responsibility for own rehabilitation
7. __ Not adhering to rehabilitation program
8. __ Missing appointments
9. __ Overdoing rehabilitation
10. __ Not cooperating with rehabilitation professional
11. __ Bargaining with rehabilitation professional over treatment or time out of competition
12. __ Frequent negative statements about injury and rehabilitation
13. __ Reduced effort in physical therapy
14. __ Poor focus and intensity in physical therapy
15. __ Unconfirmable reports of pain
16. __ Interfering behaviors outside of rehabilitation (e.g., using injured area)
17. __ Inappropriate emotions
18. __ Emotional swings

Reprinted with permission from Taylor (7), page 70.

A The soccer player is unable to participate for the remainder of the season. Clearly, his emotional and psychological state will have a direct impact on the success or failure of the therapeutic exercise program. Goal setting and intervention strategies can address many psychological influences that may inhibit the program. If progress is inhibited for several days because of suspected psychological issues, the athletic trainer should contact a specially trained clinical professional for referral.

DEVELOPING A THERAPEUTIC EXERCISE PROGRAM

Q A high school soccer player has Achilles tendinitis. The individual has increased pain with active plantar flexion and accompanying muscle weakness in plantar flexion. What short- and long-term goals might the athletic trainer and the athlete establish for the therapeutic exercise program? How will progress be measured?

In designing an individualized therapeutic exercise program, several sequential steps help identify the needs of the patient **(Box 8.5)**. First, the individual's level of function is assessed, including ROM, muscle strength, neurologic integrity, joint stability, and quality of functional activities. Second, the assessment is interpreted for the purpose of identifying primary and secondary structural or functional deficits. Based on the specific deficits, lists of short- and long-term goals are established to return the individual safely to participation. Subsequently, an exercise program is developed to address each problem. This process is ongoing throughout rehabilitation. As continued assessment of the exercise program occurs, alterations in short-term goals may result in changes in treatment or exercise progression. The process is dependent on the patient's progress and adaptation to the therapeutic exercise program.

Assess the Patient

The subjective evaluation (i.e., history of the injury) is recorded in the **Subjective,** or **S,** portion of the SOAP note. This information should include the primary complaint, mechanism of injury, characteristics of the symptoms, functional impairments, previous injuries to the area, and family history. The objective evaluation (i.e., observation and inspection, palpation, and physical examination tests) establishes a baseline of measurable information, and is recorded in the **Objective,** or **O,** portion of the SOAP note. This information documents the visual analysis of the injury site, symmetry and appearance, determines the presence of a possible fracture, identifies abnormal clinical findings in the bony and soft-tissue structures at the injury site, and measures functional testing (i.e., active, passive, and resisted range of motion), ligamentous and capsular integrity, neurologic testing, and sport-specific functional testing. In paired body segments, the dysfunction of the injured body part is always compared with the noninjured body part to establish standards for bilateral functional status.

➤➤ **BOX 8.5**

The Rehabilitation Process

1. Assess the present level of function and dysfunction from girth measurements, goniometric assessment, strength tests, neurologic assessment, stress tests, and functional activities.
2. Organize and interpret the assessment to identify factors outside normal limits.
3. Establish short- and long-term goals.
4. Develop and supervise the treatment plan, incorporating therapeutic exercise, therapeutic modalities, and medication.
5. Reassess the progress of the plan, and adjust as needed.

Interpret the Assessment

When assessment is completed, the data are interpreted to identify factors outside normal limits for an individual of the same age and fitness level. Primary deficits or weaknesses are identified. These deficits, along with secondary problems resulting from prolonged immobilization, extended inactivity, or lack of intervention, are organized into a priority list of concerns. Examples of major concerns may include decreased ROM, muscle weakness or stiffness, joint contractures, sensory changes, inability to walk without a limp, or increased pain with activity. Physical assets are then identified to determine the individual's present functional status. For example, normal gait and bilateral, equal ROM should be documented. From the two lists, specific problems are then recorded in a section called the *Problem List,* which is a part of the **Assessment**, or **A**, portion of the SOAP note.

Establish Goals

Long-term goals are then established for the individual's expected level of performance at the conclusion of the exercise program and typically focus on functional deficits in performing activities of daily living (ADLs). These goals might include bilateral, equal range of motion, flexibility, muscular strength, endurance, and power; relaxation training; and restoration of coordination and cardiovascular endurance. Next, short-term goals are developed to address the specific component skills needed to reach the long-term goals. The athletic trainer and patient should discuss and develop the goals. The individual must feel a part of the process, because this may educate and motivate the individual to work harder to attain the stated goals. Many sport-specific factors, such as the demands of the sport; position played; time remaining in the season; regular-season versus post-season or tournament play; game rules and regulations regarding prosthetic braces or safety equipment; the location, nature, and severity of injury; and the mental state of the individual, may affect goal development.

The short-term goals are developed in a graduated sequence to address the list of problems identified during the assessment. For example, a high-priority short-term goal is the control of pain, inflammation, and spasm.

Each short-term goal should be moderately difficult, yet realistic. Specific subgoals should include an estimated time table needed to attain that goal. These subgoals are time dependent, but not fixed, because it is important to take into consideration individual differences in preinjury fitness and functional status, severity of injury, motivation to complete the goals, and subsequent improvement. Constant reinforcement from the athletic trainer to achieve the subgoals can be an incentive to continually progress toward the long-term goals. Long- and short-term goals may be recorded in the Assessment, or A, portion of the note; however, many athletic trainers choose to begin the treatment plan, or P, portion of the note with the objectives. Possible short-term goals for the injured soccer player can be seen in **Box 8.6**.

➤➤ BOX 8.6

Short-Term Goals

Week	Goals
1	Control inflammation, pain, and swelling in the right Achilles tendon region. Restore bilateral active range of motion (ROM) and passive range of motion (PROM), as tolerated. Protect the involved area, and decrease activity level. Maintain strength at the knee, ankle, and foot. Maintain cardiovascular endurance with weight-bearing exercise.
2	Restore full bilateral AROM and PROM at the ankle. Initiate strengthening exercises for the affected lower leg. Restore bilateral strength at the knee, ankle, and foot. Maintain cardiovascular endurance and general body strength.
2-3	Improve strength of plantar flexors from fair to good. Maintain full ROM at the knee, ankle, and foot. Improve cardiovascular endurance. Begin sport-specific functional patterns with no resistance.
3-4	Increase muscle strength, endurance, and power in the lower leg. Improve cardiovascular endurance. Restore sport-specific functional patterns with moderate resistance. Begin functional return to activity with necessary modification.
4-5	Improve general body strength, endurance, and power. Improve cardiovascular endurance. Increase speed and resistance on sport-specific skills. Return to full functional activity as tolerated.

Develop and Supervise the Treatment Plan

Any therapeutic exercise and therapeutic modality used to achieve the goals is recorded in the **Plan**, or **P**, section of the note, along with any medications prescribed by the physician. In order to return the individual safely to participation, the therapeutic exercise program is divided into four phases. The termination of one phase and initiation of the next may overlap. However, each phase has a specific role. In phase one, the inflammatory response, pain, swelling, and ecchymosis are controlled. Phase two regains any deficits in ROM at the affected joint and begins to restore proprioception. Phase three regains muscle strength, endurance, and power in the affected limb. Phase four prepares the individual to return to activity and includes sport-specific skill training, regaining coordination, and improving cardiovascular conditioning. These phases and their expected outcomes are discussed in more detail later in the chapter. **Box 8.7** lists the various phases of a therapeutic exercise program.

Each phase of the exercise program is supervised and documented. In addition, progress notes are completed on a weekly or biweekly basis. In many health care settings, these records are also used for third-party reimbursement of services rendered. They also provide documentation of services provided to an individual should litigation occur.

Reassess the Progress of the Program

Short-term goals should be flexible enough to accommodate the progress of the individual. For example, if therapeutic modalities or medications are used, and the individual attains a short-term goal sooner than expected, a new short-term goal should be written. It is possible that some conditions, such as edema, hemorrhage, muscle spasm, atrophy, or infection, may impede the healing process and delay attaining a short-term goal. Periodic measurement of girth, ROM, muscle strength, endurance, power, and cardiovascular fitness determine whether progress occurs. If progress is not seen, the individual should be re-evaluated. The athletic trainer must determine if the delay is caused by physical problems, noncompliance, or psychological influences, necessitating referral to the appropriate specialist (e.g., physician or clinical psychologist). The individual then can continue to progress through the short-term goals until the long-term goals are attained, and the individual is cleared for full activity.

A Long-term goals for the soccer player might include: pain-free bilateral ROM, muscle strength, endurance, and power; maintenance of cardiovascular endurance; restoration of normal joint biomechanics; increased proprioception and coordination; restoration of bilateral function of ADLs; and pain-free, unlimited motion in sport-specific skills. Short-term goals are listed in Box 8.6.

➤➤ BOX 8.7

The Therapeutic Exercise Program

Phase One: Control Inflammation

- Control inflammatory stage and minimize scar tissue with cryotherapy using **PRICE** principles (protect, restrict activity, ice, compression, and elevation).
- Instruct patient on relaxation and coping techniques.
- Maintain range of motion (ROM), joint flexibility, strength, endurance, and power in the unaffected body parts.
- Maintain cardiovascular endurance.

Phase Two: Restore Motion

- Restore ROM to within 80% of normal in the unaffected limb.
- Restore joint flexibility as observed in the unaffected limb.
- Begin proprioceptive stimulation through closed isotonic chain exercises.
- Begin pain-free, isometric strengthening exercises on the affected limb.
- Begin unresisted, pain-free functional patterns of sport-specific motion.
- Maintain muscular strength, endurance, and power in unaffected muscles.
- Maintain cardiovascular endurance.

Phase Three: Develop Muscular Strength, Power, and Endurance

- Restore full ROM and proprioception in the affected limb.
- Restore muscular strength, endurance, and power using progressive resisted exercise.
- Maintain cardiovascular endurance.
- Initiate minimal-to-moderate resistance in sport-specific functional patterns.

Phase Four: Return to Sport Activity

- Analyze skill performance, and correct biomechanical inefficiencies in motion.
- Improve muscular strength, endurance, and power.
- Restore coordination and balance.
- Improve cardiovascular endurance.
- Increase sport-specific functional patterns, and return to protected activity as tolerated.

PHASE ONE: CONTROLLING INFLAMMATION

Q The soccer player has pain and tenderness over the distal portion of the Achilles tendon, and weakness in active plantar flexion. Consistent with acute care protocol, a crushed ice pack was applied to the area. Would it be appropriate to begin any rehabilitation exercises during this initial phase of injury management?

Phase one of the exercise program begins immediately after injury assessment. The primary goal is to control inflammation by limiting hemorrhage, edema, effusion, muscle spasm, and pain. The individual can move into phase two when the following criteria have been attained:

- Control of inflammation with minimal edema, swelling, muscle spasm, and pain
- Range of motion, joint flexibility, muscular strength, endurance, and power are maintained in the general body
- Cardiovascular fitness is maintained at the preinjury level

Collagenous scar formation, a natural component of the repair and regeneration of injured soft tissue, is less efficient and tolerant of tensile forces than the original mature tissue. The length of the inflammatory response is a key factor that influences the ultimate stability and function of scar tissue. The longer the inflammatory process progresses, the more likely the resulting scar tissue will be less dense and weaker in yielding to applied stress. Furthermore, immobilization for more than 2 or 3 weeks may lead to joint adhesions that inhibit muscle fiber regeneration. Therefore, all inflammatory symptoms need to be controlled as soon as possible. **PRICE**, a well-known acronym for protect, restrict activity, ice, compression, and elevation, is used to reduce acute symptoms at an injury site.

Control of Inflammation

Following trauma, hemorrhage and edema at the injury site lead to a pooling of tissue fluids and blood products that increases pain and muscle spasm. The increased pressure decreases blood flow to the injury site, leading to hypoxia (i.e., deficiency of oxygen). As pain continues, the threshold of pain is lowered. These events lead to the cyclical pattern of pain-spasm-hypoxia-pain. For this reason, cryotherapy (i.e., ice, compression, and elevation) is preferred during the acute inflammation to decrease circulation, cellular metabolism, the need for oxygen, and the conduction velocity of nerve impulses to break the pain-spasm cycle. An elastic compression wrap can de-

FIELD STRATEGY 8.1 **Acute Care of Soft-Tissue Injuries**

ICE APPLICATION

- Apply crushed ice for 30 minutes directly to the skin (40 minutes for a large muscle mass such as the quadriceps).
- Ice applications should be repeated every 2 hours when awake (every hour if the athlete is active), and may extend to 72+ hours postinjury.
- Skin temperature can indicate when acute swelling has subsided. For example, if the area (compared bilaterally) feels warm to the touch, swelling continues. If in doubt, it is better to extend the time of a cold application.

COMPRESSION

- On an extremity, apply the wrap in a distal-to-proximal direction to avoid forcing extracellular fluid into the distal digits.
- Take a distal pulse after applying the wrap to ensure the wrap is not overly tight.
- Felt horseshoe-pads placed around the malleolus may be combined with an elastic wrap or tape to limit ankle swelling.
- Maintain compression continuously on the injury for the first 24 hours.

ELEVATION

- Elevate the body part 6 to 10 inches above the level of the heart.
- While sleeping, place a hard suitcase between the mattress and box spring, or place the extremity on a series of pillows.

RESTRICT ACTIVITY AND PROTECT THE AREA

- If the individual is unable to walk without a limp, fit the person for crutches and apply an appropriate protective device to limit unnecessary movement of the injured joint.
- If the individual has an upper extremity injury and is unable to move the limb without pain, fit the person with an appropriate sling or brace.

crease hemorrhage and hematoma formation, yet still expand in cases of extreme swelling. Elevation uses gravity to reduce pooling of fluids and pressure inside the venous and lymphatic vessels, to prevent fluid from filtering into surrounding tissue spaces. The result is less tissue necrosis and local waste, leading to a shorter inflammatory phase. **Field Strategy 8.1** explains acute care of soft-tissue injuries using the PRICE principle.

Cryotherapy, intermittent compression, and electrical muscle stimulation (EMS) may be used to control hemorrhage and eliminate edema. Electrical therapy also has been shown to decrease pain and muscle spasm, strengthen weakened muscles, improve blood flow to an area, and enhance the healing rate of injured tendons. Transcutaneous electrical nerve stimulation (TENS) also might be used to limit pain (see Chapter 7). The modality of choice is determined by the size and location of the injured area, availability of the modality, and preference of the supervising health care provider. A decision to discontinue treatment and move to another modality should be based on the cessation of inflammation. Placing the back of the hand over the injured site shows any temperature change as compared with an uninjured area. Increased heat may indicate that inflammation and edema are still present. A cooler area may indicate diminished circulation in an area.

Effects of Immobilization

The effects of immobilization on the various tissues of the body have been extensively covered in the literature. It is well accepted that muscle tension, muscle and ligament atrophy, decreased circulation, and loss of motion prolong the repair and regeneration of damaged tissues.

➤ *Muscle*

Immobilization can lead to a loss of muscle strength within 24 hours. This is manifested with decreases in muscle fiber size, total muscle weight, mitochondria (energy source of the cell) size and number, muscle tension produced, and resting levels of glycogen and ATP (adenosine triphosphate), which reduces muscle endurance. Motor nerves become less efficient in recruiting and stimulating muscle fibers. Immobilization also increases muscle fatigability as a result of decreased oxidative capacity. The rate of loss appears to be more rapid during the initial days of immobilization; however, after 5 to 7 days, the loss of muscle mass diminishes (10). Although both slow-twitch (type I) and fast-twitch (type II) muscle fibers atrophy, it is generally accepted that there is a greater degeneration of slow-twitch fibers with immobilization. Muscles immobilized in a lengthened or neutral position maintain muscle weight and fiber cross-sectional area better than muscles immobilized in a shortened position. When shortened, the length of the fibers decreases, leading to increased connective tissue and reduced muscle extensibility. Muscles immobilized in a shortened position atrophy faster and have a greater loss of contractile function.

➤ *Articular Cartilage*

The greatest impact of immobilization occurs to the articular cartilage, with adverse changes appearing within 1 week of immobilization. The effects depend on the length of immobilization, position of the joint, and joint loading. Intermittent loading and unloading of synovial joints is necessary to ensure proper metabolic exchange necessary for normal function. Constant contact with opposing bone ends can lead to pressure necrosis and cartilage cell (chondrocyte) death. In contrast, noncontact between two surfaces promotes growth of connective tissue into the joint. Diminished weight bearing, and loading and unloading, also can increase bone resorption. In general, articular cartilage softens and decreases in thickness. Immobilization longer than 30 days can lead to progressive osteoarthritis.

➤ *Ligaments*

Similar to bone, ligaments adapt to normal stress by remodeling in response to the mechanical demands placed on them. Stress leads to a stiffer, stronger ligament, whereas immobilization leads to a weaker, more compliant structure. This causes a decrease in the tensile strength, thus reducing the ability of ligaments to provide joint stability.

➤ *Bone*

Mechanical strain on a bone affects the osteoblastic (bone cell formation) and osteoclastic (bone cell resorption) activity on the bone surface. The effects of immobilization on bone, accordingly, are similar to other connective tissues. Limited weight-bearing and muscle activity lead to bone loss, and can be detected as early as 2 weeks after immobilization (10). As immobilization time increases, bone resorption occurs, resulting in the bones becoming more brittle and highly susceptible to fracture. Disuse atrophy appears to increase bone loss at a rate five to 20 times greater than that resulting from metabolic disorders affecting bone (11). Therefore, non–weight-bearing immobilization should be limited to as short a time as possible.

Effects of Remobilization

Early controlled mobilization can speed the healing process. Bone and soft tissue respond to the physical demands placed on them, causing the formation of collagen to remodel or realign along the lines of stress, thus promoting healthy joint biomechanics **(Wolff's law)**. Continuous passive motion (CPM) can prevent joint adhesions and stiffness, and decrease joint hemarthrosis (blood in the joint) and pain. Early motion, and loading and unloading of joints, through partial weight-bearing exercise maintain joint lubrication to nourish articular cartilage, menisci, and ligaments. This leads to an optimal environment for proper collagen fibril formation. Tissues recover at different rates with mobilization; muscle recovers faster, and articular cartilage and bone respond least favorably.

➤ *Muscle*

Muscle regeneration begins within 3 to 5 days after mobilization. Both fast-twitch and slow-twitch muscle fibers can completely recover after 6 weeks. Muscle contractile activity rapidly increases protein synthesis. However, maximal isometric tension may not return to normal until 4 months after mobilized activity. The use of electrotherapy (i.e., EMS) may be helpful in re-educating muscles, limiting pain and spasm, and decreasing effusion through the pumping action of the contracting muscle. Unfortunately, neither EMS nor isometric exercise has been shown to prevent disuse atrophy.

➤ *Articular Cartilage*

The effects of immobilization, whether there is contact or loss of contact between joint surfaces, can adversely interfere with cartilage nutrition. Articular cartilage generally responds favorably to mechanical stimuli, with structural modifications noted after exercise. Soft-tissue changes are reversible if immobilization does not exceed 30 days. These structural changes may not be reversible if immobilization exceeds 30 days.

➤ *Ligaments*

The bone-ligament junction recovers slower than the mechanical properties in the midportion of the ligament. In addition, other nontraumatized ligaments weaken with disuse. Recovery depends on the duration of immobilization. Studies have shown that, following 12 weeks of immobilization, there was a recovery of 50% of normal strength in a healing ligament after 6 months, 80% after 1 year, and 100% after 1 to 3 years, depending on the type of stresses placed on the ligament and on the prevention of repeated injury (12). Although the properties of ligaments return to normal with remobilization, the bone-ligament junction takes longer to return to normal. This factor must be considered when planning a rehabilitation program.

➤ *Bone*

Although bone lost during immobilization may be regained, the period of recovery can be several times greater than the period of immobilization. In disuse osteoporosis, a condition involving reduced quantity of bone tissue, bone loss may not be reversible upon remobilization of the limb. Isotonic and isometric exercises during the immobilization period can decrease some bone loss and can hasten recovery after returning to a normal loading environment.

Protection After Injury

The type of protection selected and length of activity modification depend on injury severity, structures damaged, and the philosophy of the supervising health care provider. Several materials can be used to protect the area, including elastic wraps, tape, pads, slings, hinged braces, splints, casts, and crutches. Many of these items were discussed and illustrated in Chapter 4. If an individual cannot walk without pain or walks with a limp, crutches should be recommended. Proper crutch fitting and use are summarized in **Field Strategy 8.2**.

Restricted activity does not imply cessation of activity but simply means "relative rest," decreasing activity to a

FIELD STRATEGY 8.2 Fitting and Using Crutches and Canes

FITTING CRUTCHES

1. Have the individual stand erect in flat shoes with the feet close together.
2. Place the crutch tip 2 inches in front, and 6 inches from the outer sole, of the shoe.
3. Adjust crutch height to allow a space of about 2 finger widths between the crutch pad and the axillary skin fold, to avoid undue pressure on neurovascular structures.
4. Adjust the hand grip so the elbow is flexed 25 to 30°, and is at the level of the hip joint (greater trochanter).

FITTING FOR A CANE

1. Place the individual in the same position as above. Adjust the hand grip so the elbow is flexed at 25 to 30°, and is at the level of the hip joint (greater trochanter).

SWING THROUGH GAIT (NON–WEIGHT-BEARING)

1. Stand on the uninvolved leg. Lean forward and place both crutches and the involved leg approximately 12 to 24 inches in front of the body.
2. Body weight should rest on the hands, not the axillary pads.
3. With the good leg, step through the crutches as if taking a normal step. Repeat process.
4. If possible, the involved leg should be extended while swinging forward to prevent atrophy of the quadriceps muscles.

THREE-POINT GAIT (PARTIAL WEIGHT BEARING)

1. This is indicated when one extremity can support the body weight, and the injured extremity is to be touched down, or to bear weight partially.
2. As tolerated, place as much body weight as possible onto the involved leg, taking the rest of the weight on the hands.
3. Make sure a good heel-toe technique is used, whereby the heel strikes first, then the weight is shifted to the ball of the foot.
4. Increase the amount of weight bearing by decreasing the force transferred through the arms; mimic a normal gait.

GOING UP AND DOWN STAIRS

1. Place both crutches under the arm opposite the handrail.
2. To go **up** the stairs, step **up with the uninvolved leg** while leaning on the rail.
3. To go **down** the stairs, place the crutches down on the next step and step **down with the involved leg**.

USING ONE CRUTCH OR CANE

1. Place one crutch or cane on the uninvolved side and move it forward with the involved leg.
2. Do not lean heavily on the crutch or cane.

level below that required in sport, but tolerated by the recently injured tissue or joint. **Detraining**, or loss of the benefits gained in physical training, can occur after only 1 to 2 weeks of nonactivity, with significant decreases measured in both metabolic and working capacity (13). Strengthening exercises in a weight-lifting program can be alternated with cardiovascular exercises such as jogging or swimming, or use of a stationary bike, or upper body ergometer (UBE). These exercises can prevent the individual from experiencing depression as a result of inactivity, and can be done simultaneously with phase one exercises as long as the injured area is not irritated or inflamed.

A After following acute care protocol in treating the Achilles tendon injury, early controlled mobilization, pain-free range-of-motion exercises at the ankle, and general load-bearing, strengthening, and cardiovascular exercises may be completed as long as the injured area is not irritated.

PHASE TWO: RESTORATION OF MOTION

Q It is now 4 days postinjury. The acute inflammatory symptoms have subsided. What exercises can be used to increase flexibility and strength in the Achilles tendon? Are there any modalities that could be used to supplement the exercise program?

Phase two begins immediately after inflammation is controlled. This phase focuses on restoring ROM and flexibility at the injured site as well as continuing to maintain general body strength and cardiovascular endurance. The phase may begin as early as 4 days after the injury, when swelling has stopped, or may have to wait for several weeks. The injured site may still be tender to touch, but it is not as painful as in the earlier phase. Also, pain is much less evident on passive and active ROM. If the patient is in an immobilizer or splint, remove the splint for treatment and exercise. The splint then can be replaced to support and protect the injured site. The individual can move into phase three when the following criteria have been completed:

- Inflammation and pain are under control.
- Range of motion is within 80% of normal in the unaffected limb.
- Bilateral joint flexibility is restored and proprioception is regained.
- Cardiovascular endurance and general body strength are maintained at the preinjury level.

Assessment of normal ROM should be done with a goniometer on the paired, uninjured joint (see Chapter 5). Cryotherapy may be used prior to exercise, to decrease perceived pain, or EMS or thermotherapy may be used to warm the tissues and increase circulation to the region. When the tissue is warmed, friction massage or joint mobilization may be helpful to break up scar tissue to regain normal motion.

➤➤ BOX 8.8

Factors that Limit Joint Motion

- Bony block
- Joint adhesions
- Muscle tightness
- Tight skin or an inelastic dense scar tissue
- Swelling
- Pain
- Fat or other soft tissues that block normal motion

Progression in this phase begins gradually with restoration of ROM, proprioception, and total joint flexibility **(Box 8.8)**. Prolonged immobilization can lead to muscles losing their flexibility and assuming a shortened position, referred to as a **contracture**. Connective tissue around joints has no contractile properties. Connective tissue is supple and elongates slowly with a sustained stretch, However, similar to muscle tissue, it adaptively shortens if immobilized. Connective tissue and muscles may be lengthened through passive and active stretching, and proprioceptive neuromuscular facilitation (PNF) exercises.

Passive Range of Motion

Two types of movement must be present for normal motion to occur about a joint. Physiologic motion, measured by a goniometer, occurs in the cardinal movement planes of flexion-extension, abduction-adduction, and rotation. Accessory motion, also referred to as **arthrokinematics**, is involuntary joint motion that occurs simultaneously with physiologic motion, but cannot be measured precisely. Accessory movements involve the spinning, rolling, or gliding of one articular surface relative to another. Normal accessory movement must be present for full physiologic ROM to occur. If any accessory motion component is limited, normal physiologic motion will not occur.

Limited passive range of motion (PROM) is called **hypomobility**. These discrete limitations of motion prevent pain-free return to competition and predispose an individual to microtraumatic injuries that reinflame the original injury. Restoring PROM prevents degenerative joint changes and promotes healing.

➤ *Joint Mobilization*

Joint mobilization utilizes various oscillating forces applied in the open packed position to “free up” stiff joints. The oscillations produce several key benefits in the healing process, including:

- Breaking up adhesions and relieve capsular restrictions
- Distracting impacted tissues
- Increasing lubrication for normal articular cartilage

➤➤ BOX 8.9

Contraindications to Joint Mobilization

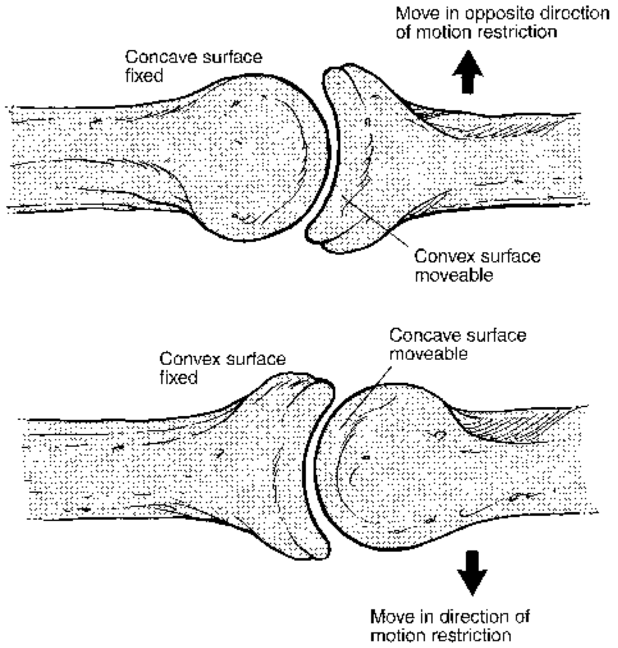
Acute inflammation
Advanced osteoarthritis
Congenital bone deformities
Fractures
Hypermobility
Infections
Malignancy
Neurologic signs
Osteoporosis
Premature stressing of surgical structures
Rheumatoid arthritis
Vascular disease

- Reducing pain and muscle tension
- Restoring full ROM and facilitate healing

However, joint mobilization is contraindicated in several instances **(Box 8.9)**. Maitland described five grades of mobilization (14):

- *Grade I:* A small-amplitude movement at the beginning of the ROM. Used when pain and spasm limit movement early in the ROM.
- *Grade II:* Large-amplitude movement within the mid-ROM. Used when spasm limits movement sooner with a quick oscillation than with a slow one, or when slowly increasing pain restricts movement halfway into the range.
- *Grade III:* A large-amplitude movement up to the pathologic limit in the ROM. Used when pain and resistance from spasm, inert tissue tension, or tissue compression limit movement near the end of the range.
- *Grade IV:* A small-amplitude movement at the very end of the ROM. Used when resistance limits movement in the absence of pain and spasm.
- *Grade V:* A small-amplitude, quick thrust delivered at the end of the ROM, usually accompanied by a popping sound called a manipulation. Used when minimal resistance limits the end of the range. Manipulation is most effectively accomplished by the velocity rather than the force of the thrust.

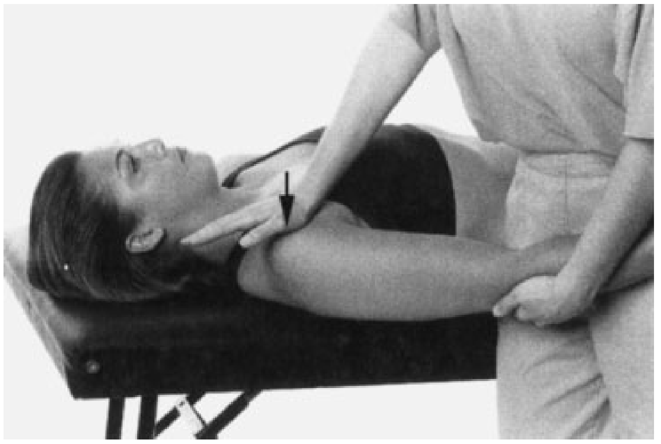
In performing joint mobilization, the individual is placed in a comfortable position with the joint placed in an open packed position. This allows the surrounding tissues to be as lax as possible and the intracapsular space to be at its greatest. The direction of force is dependent on the contour of the joint surface of the structure being mobilized. The concave-convex rule states that, when the concave surface is stationary and the convex surface is mobilized, a glide of the convex segment should be in the direction opposite to the restriction of joint movement. If the convex articular surface is stationary and the concave surface is mobilized, gliding of the concave segment should be in the same direction as the restriction of joint movement **(Figure 8.2)**. Typical treatment involves a series of three to six mobilizations lasting up to 30 seconds, with one to three oscillations per second (14). **Figure 8.3** demonstrates joint mobilization technique.



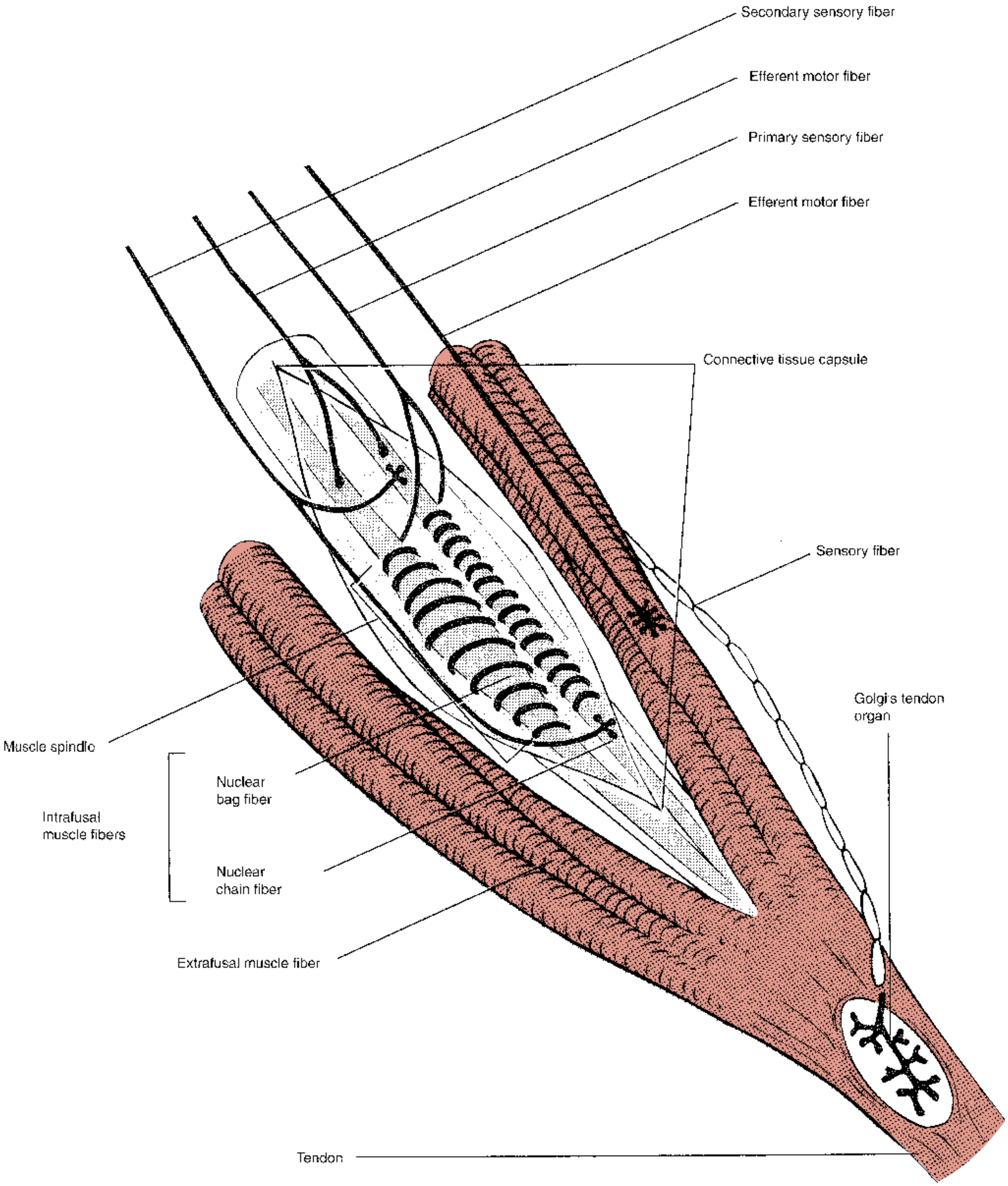
➤ **Figure 8.2. Concave-convex rule.** If the joint surface to be moved is convex, mobilize it opposite the direction of motion restriction. If the joint surface of the body segment being moved is concave, move it in the direction of motion restriction.

➤ *Flexibility*

Flexibility is the total ROM at a joint that occurs pain-free in each of the planes of motion. Joint flexibility is a combination of normal joint mechanics, mobility of soft tissues, and muscle extensibility. For example, the hip joint may have full passive ROM, but when doing active



➤ **Figure 8.3. Joint mobilization technique.** Posterior humeral glide uses one hand to stabilize the humerus at the elbow while the other hand glides the humeral head in a posterior direction (indicated by the arrow) to increase flexion and medial rotation at the joint.



➤ **Figure 8.4.** **Anatomy of the muscle spindle and Golgi tendon organ.**

hip flexion from a seated position, as in touching one's toes, resistance from tight hamstrings may limit full hip flexion. This type of resistance may be generated from tension in muscle fibers or connective tissue.

Muscles contain two primary proprioceptors that can be stimulated during stretching, namely the muscle spindles and Golgi tendon organs. Because muscle spindles lie parallel to muscle fibers, they stretch with the muscle **(Figure 8.4)**. When stimulated, the spindle sensory fibers discharge and through reflex action in the spinal cord initiate impulses to cause the muscle to contract reflexively, thus inhibiting the stretch. Muscles that perform the desired movement are called **agonists**. Unlike muscle spindles, Golgi tendon organs are connected in a series of fibers located in tendons and joint ligaments, and respond to muscle tension rather than length. If the stretch continues for an extended time (i.e., over 6 to 8 seconds), the Golgi tendons are stimulated. This stimulus, unlike the stimulus from muscle spindles, causes a reflex inhibition in the **antagonist** muscles. This sensory mechanism protects the musculotendinous unit from excessive tensile forces that could damage muscle fibers.

Flexibility can be increased through ballistic or static stretching techniques. **Ballistic stretching** uses repetitive bouncing motions at the end of the available ROM. Muscle spindles are repetitively stretched, but because the bouncing motions are of short duration, the Golgi tendon organs do not fire. As such, the muscles resist relaxation. Because generated momentum may carry the body part beyond normal ROM, the muscles being stretched often remain contracted to prevent overstretching, leading to microscopic tears in the musculotendinous unit. In a **static stretch**, movement is slow and deliberate **(Box 8.10)**. Golgi tendon organs are able to override impulses from the muscle spindles, leading to a safer, more effective muscle stretch. When the muscle is stretched to the point where a mild burn is felt, joint position is maintained statically for about 15 seconds and repeated several times. This technique is often used with vapo-coolant sprays to desensitize myofascial trigger points.

Proprioceptive neuromuscular facilitation (PNF) promotes and hastens the response of the neuromuscular system through stimulation of the proprioceptors. The patient is taught how to perform the exercise through cutaneous and auditory input. The individual often looks at the moving limb while the examiner moves the limb from the starting to terminal position. Verbal cues are used to coordinate voluntary effort with reflex responses. Words such as "push" or "pull" are commonly used to ask for an isotonic contraction. "Hold" may be used for an isometric or stabilizing contraction, followed by "relax." Manual (cutaneous contact) helps to influence the direction of motion and facilitate a maximal response, because reflex responses are greatly affected by pressure receptors.

These exercises increase flexibility in one muscle group (i.e., agonist), and simultaneously improve strength in another muscle group (i.e., antagonist). Furthermore, if instituted early in the exercise program, PNF stretches can aid in elongating scar tissue. As scar tissue matures and increases in density, it becomes less receptive to short-term stretches and may require prolonged stretching to achieve deformation changes in the tissue.

Proprioceptive neuromuscular facilitation technique recruits muscle contractions in a coordinated pattern as agonists and antagonists move through a ROM. One technique utilizes **active inhibition** whereby the muscle group reflexively relaxes prior to the stretching maneuver. Common methods include contract-relax, hold-relax, and slow reversal-hold-relax **(Box 8.11)**. The examiner stabilizes the limb to be exercised. Alternating contractions and passive stretching of a group of muscles are then performed **(Figure 8.5)**. Contractions may be held for 3, 6, or 10 seconds, with similar results obtained (15).

A second technique, known as **reciprocal inhibition**, uses active agonist contractions to relax a tight antagonist muscle. In this technique, the individual contracts the muscle opposite the tight muscle, against resistance. This causes a reciprocal inhibition of the tight muscle, leading to muscle lengthening. An advantage to PNF exercise is the ability to stretch a tight muscle that may be painful or in the early stages of healing. In addition, movement can occur in a single plane or diagonal pattern that mimics actual skill performance.

➤➤ BOX 8.10

Guidelines for Static Stretching to Improve Flexibility

1. Stretching is facilitated by warm body tissues; therefore, a brief warm-up period is recommended. If it is not possible to jog lightly, stretching could be performed after a superficial heat treatment.
2. In the designated stretch position, position yourself so a sensation of tension is felt.
3. Do not bounce; hold the stretch for 10 to 30 seconds until a sense of relaxation occurs. Be aware of the feeling of relaxation, or "letting go." Repeat the stretch six to eight times.
4. Breathe rhythmically and slowly. Exhale during the stretch.
5. Do not be overly aggressive in stretching. Increased flexibility may not be noticed for 4 to 6 weeks.
6. If an area is particularly resistant to stretching, partner stretching or proprioceptive neuromuscular facilitation may be used.
7. Avoid vigorous stretching of tissues in the following conditions:
   - After a recent fracture
   - After prolonged immobilization
   - With acute inflammation or infection in or around the joint
   - With a bony block that limits motion
   - With muscle contractures or when joint adhesions limit motion
   - With acute pain during stretching

Active Assisted Range of Motion

Frequently, PROM at the injured joint may be greater than active motion, perhaps because of muscle weakness. A person may be able to sit on top of a table and slide the leg across the tabletop away from the body to fully extend the knee. However, if the individual sits at the edge of the table with his or her legs hanging over the edge then attempts to straighten the knee, the individual

➤➤ BOX 8.11

Active Inhibition Techniques

To stretch the hamstring group on a single leg using the three separate proprioceptive neuromuscular facilitation techniques, do the following:

CONTRACT-RELAX

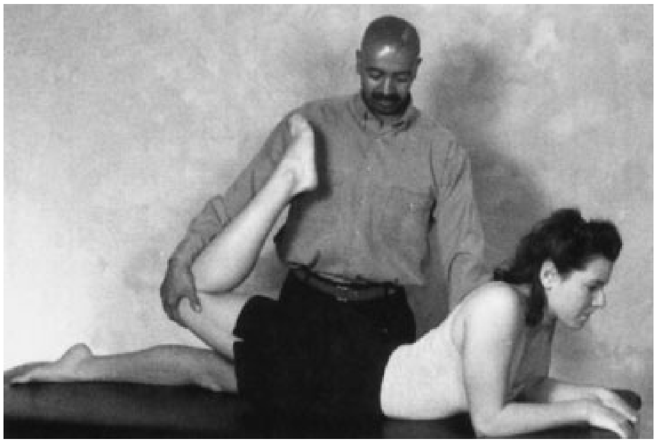
1. Stabilize the thigh and passively flex the hip into the agonist pattern until limitation is felt in the hamstrings.
2. The individual then performs an isotonic contraction with the hamstrings through the antagonist pattern.
3. Apply a passive stretch into the agonist pattern until limitation is felt; repeat the sequence.

HOLD-RELAX

1. Passively move the leg into the agonist pattern until resistance is felt in the hamstrings.
2. The individual then performs an isometric contraction to "hold" the position for about 10 seconds.
3. Allow the individual to relax for about 5 seconds.
4. Then apply a passive stretch into the agonist pattern until limitation is felt; repeat the sequence.

SLOW REVERSAL-HOLD-RELAX

1. The individual consciously relaxes the hamstring muscles while doing a concentric contraction of the quadriceps muscles into the agonist pattern.
2. The individual then performs an isometric contraction, against resistance, into the antagonist pattern for 10 seconds.
3. Allow the individual to relax for 10 seconds.
4. The individual then actively moves the body part further into the agonist pattern; repeat the sequence



➤ **Figure 8.5. Proprioceptive neuromuscular facilitation.** In performing proprioceptive neuromuscular facilitation stretching techniques, the athletic trainer passively stretches a muscle group. In this photo, the hip flexors are being stretched. When slight tension is felt, the individual isometrically contracts the muscle group against resistance for 3, 6, or 10 seconds. The muscle is then passively stretched again. This process is repeated four to five times.

may be unable to move the limb voluntarily into full extension. In this situation, normal joint mechanics exist and full PROM is present. However, in order to attain full active ROM the individual may require some assistance from an athletic trainer, a mechanical device, or the opposite limb (active assisted range of motion, AAROM). Working the limb through available pain-free motion with assistance restores normal active ROM more quickly than working the limb within limited voluntary motion.

Active Range of Motion

Active range of motion (AROM) exercises performed by the individual enhance circulation through a pumping action during muscular contraction and relaxation. Full, pain-free, AROM need not be achieved before strength exercises are initiated, but certain skills and drills requiring full functional motion, such as throwing, full squats, or certain agility drills, must wait until proper joint mechanics are restored. Active range of motion exercises should be relatively painless, and may be facilitated during certain stages of the program by completing the exercises in a whirlpool to provide an analgesic effect and relieve the stress of gravity on sensitive structures. Examples of AROM exercises include spelling out the letters of the alphabet with the ankle, and using a wand or cane with the upper extremity to improve joint mobility. **Field Strategy 8.3** illustrates selected ROM exercises.

Resisted Range of Motion

Resisted range of motion (RROM) may be either static or dynamic. Static movement is measured with an isometric muscle contraction, and can be used during phases 1 and 2 of the exercise program in a pain-free arc of motion. Dynamic resisted motion (dynamic strengthening) is discussed in the next section.

Isometric training measures a muscle's maximum potential to produce static force. The muscle is at a constant tension while muscle length and joint angle remain the same. For example, standing in a doorway and pushing outward against the door frame produces a maximal muscle contraction, but joints of the upper extremity do not appear to move. Isometric exercise is useful when motion: (1) is contraindicated by pathology or bracing; (2) is limited because of muscle weakness at a particular angle, called a **sticking point**; or (3) when a painful arc is present. Isometric strength exercises are the least effective training method because, although circumference and strength increase, strength gains are limited to a range of 10° on either side of the joint angle. An adverse, rapid increase in blood pressure occurs when the breath is held against a closed glottis, and is referred to as the **Valsalva effect**. This can be avoided with proper breathing. In performing an isometric contraction, a maximal force is generated against an object, such as the examiner's hand, for about 10 seconds and repeated 10 times per set. Contractions, performed every 20° throughout the available ROM, are called multiangle isometric exercises.

FIELD STRATEGY 8.3 Range of Motion Exercises for the Lower and Upper Extremity

A. **Ankle.** Write out the letters of the alphabet using sweeping capital letters. Do all letters three times.

B. **Achilles tendon.** In a seated position, wrap a towel around the forefoot and slowly stretch the Achilles tendon.

C. **Knee.** In a seated position with the knee slightly flexed, wrap a towel around the lower leg and slowly bring the ankle and foot toward the buttocks.

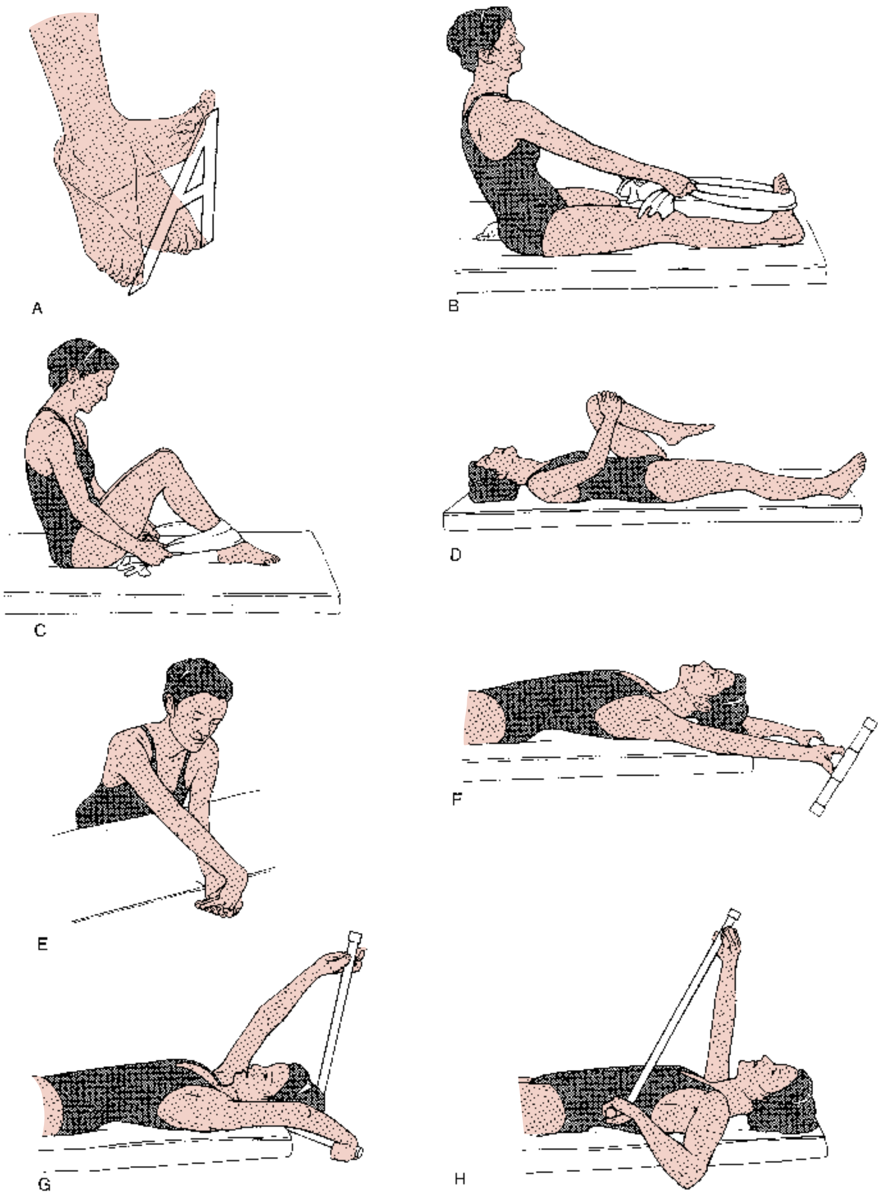
D. **Hip.** Lying down, bring one knee toward the chest. Repeat with the other knee.

E. **Wrist or elbow.** Using the unaffected hand, slowly stretch the affected hand or forearm in flexion and extension.

F. **Shoulder flexion.** With a wand or cane, use the unaffected arm to slowly raise the wand high above the head.

G. **Shoulder lateral (external) rotation.** With a wand or cane, use the unaffected arm to slowly do lateral (external) rotation of the glenohumeral joint.

H. **Shoulder medial (internal) rotation.** With a wand or cane, use the unaffected arm to slowly do medial (internal) rotation of the glenohumeral joint.



Proprioception

Proprioception is a specialized variation of the sensory modality of touch that encompasses the sensation of joint movement **(kinesthesia)** and joint position. Sensory receptors located in the skin, muscles, tendons, ligaments, and joints provide input into the central nervous system (CNS) relative to tissue deformation. Visual and vestibular centers also contribute afferent information to the CNS regarding body position and balance. The ability to sense body position is mediated by cutaneous, muscle, and joint mechanoreceptors.

➤ *Joint Mechanoreceptors*

Joint mechanoreceptors are found in the joint capsule, ligaments, menisci, labra, and fat pads, and include four types of nerve endings: Ruffini's corpuscles, Golgi receptors, pacinian corpuscles, and free nerve endings. Ruffini's corpuscles are sensitive to intra-articular pressure and stretching of the joint capsule. Golgi receptors are intraligamentous and become active when the ligaments are stressed at the end ranges of joint movement. Pacinian corpuscles are sensitive to high-frequency vibration and pressure, and the free nerve endings are sensitive to mechanical stress and the deformation and loading of soft tissues that comprise the joint.

➤ *Muscle Mechanoreceptors*

As mentioned, the receptors found in muscle and tendons are the muscle spindles and Golgi tendon organs. Muscle spindles are innervated by both afferent and efferent fibers, and can detect not only muscle length, but more importantly, the rate of change in muscle length. Golgi tendon organs respond to both contraction and stretch of the musculotendinous junction. If the stretch continues for an extended time (i.e., over 6 to 8 seconds), the Golgi tendons are stimulated, causing a reflex inhibition in the antagonist muscles. This sensory mechanism protects the musculotendinous unit from excessive tensile forces that could damage muscle fibers.

➤ *Regaining Proprioception*

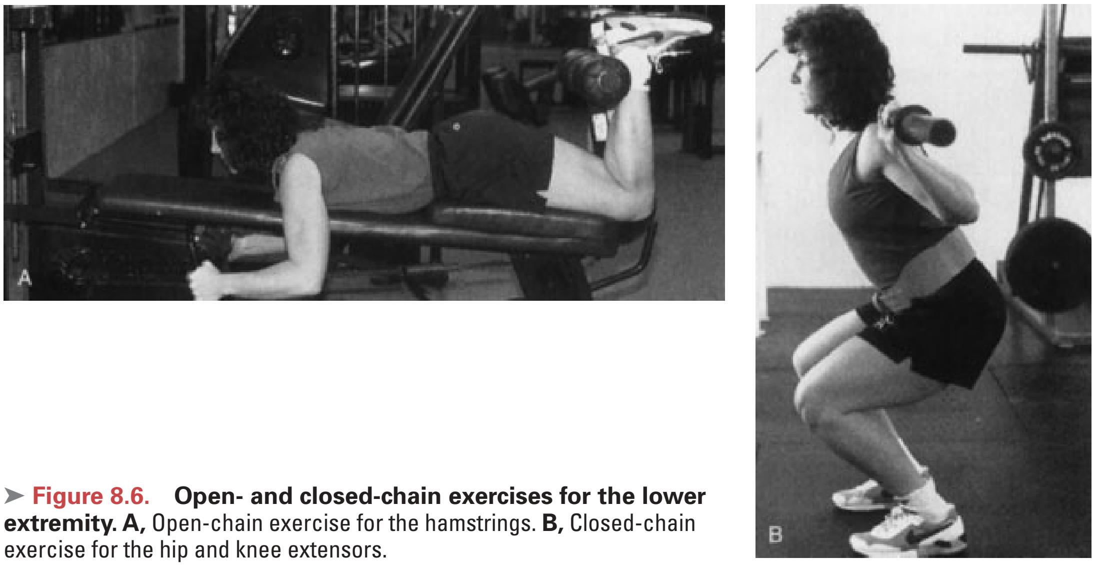
Balance involves positioning the body's center of gravity over a base of support through the integration of information received from the various proprioceptors within the body. Even when the body appears motionless, a constant postural sway is caused by a series of muscle contractions that correct and maintain dynamic equilibrium in an upright position. When balance is disrupted, as in falling forward or stumbling, the response is primarily automatic and reflexive. An injury or illness can interrupt the neuromuscular feedback mechanisms. Restoration of the proprioceptive feedback is necessary to promote dynamic joint and functional stability to prevent reinjury.

Proprioceptive exercises must be specific to the type of activity that the individual will encounter in sport participation. In general, the progression of activities to develop dynamic, reactive neuromuscular control is achieved through a progression that moves from slow speed to high speed, low force to high force, and controlled to uncontrolled activities. A patient might begin with Romberg's test, which requires the individual to stand with the feet together, arms at the sides, and eyes closed. The examiner looks for any tendency to sway or fall to one side. A single-leg stance test (e.g., stork stand) requires the individual to maintain balance while standing on one leg for a specified time with the eyes closed. In the next stage, with the eyes open, the patient can progress to playing catch with a ball. This exercise can be made more difficult by having the patient balance on a trampoline and playing catch with a ball. Use of a biomechanical ankle platform system (BAPS) board might begin with bilateral balancing and progress to one-legged balancing, dribbling a basketball, or playing catch with a ball. Many of these exercises can be adapted to the upper extremity. An individual can begin in a push-up position and shift his or her weight from one hand to another, or perform isometric or isotonic press-ups, balance on one hand, balance on a BAPS board or ball, or walk on the hands over material of different densities or heights.

Open versus Closed Kinetic Chain Exercises

A common error in developing an exercise program is failure to assess the proximal and distal segments of the entire extremity, or kinetic chain. A **kinematic chain** is a series of interrelated joints that constitute a complex motor unit, constructed so that motion at one joint will produce motion at the other joints in a predictable manner. Whereas kinematics describes the appearance of motion, **kinetics** involves the forces, whether internal (e.g., muscle contractions or connective tissue restraints) or external (e.g., gravity, inertia, or segmental masses) that affect motion. Initially, a closed kinetic chain (CKC) was characterized as the distal segment of the extremity in an erect, weight-bearing position, such as the lower extremity when a person is weight bearing. Subsequently, when the distal segment of the extremity is free to move without causing motion at another joint, such as when non–weight bearing, the system was referred to as an open kinetic chain (OKC). When force is applied, the distal segment may function independently or in unison with the other joints. Movements of the more proximal joints are affected by OKC and CKC positions. For example, the rotational components of the ankle, knee, and hip reverse direction when moving from an OKC to CKC position.

Because of incongruities between the lower and upper extremity, particularly in the shoulder region, several authors have challenged the traditional definition of OKC and CKC positions (16-18). Stabilizing muscles in the scapulothoracic region produces a joint compression



➤ **Figure 8.6. Open- and closed-chain exercises for the lower extremity. A,** Open-chain exercise for the hamstrings. **B,** Closed-chain exercise for the hip and knee extensors.

force that stabilizes the glenohumeral joint much in the same manner as a CKC in the lower extremity. Although debate continues on defining CKC and OKC relative to the upper extremity, there remains general agreement that both CKC and OKC exercises should be incorporated into an upper and lower extremity rehabilitation program.

Injury and subsequent immobilization can affect the proprioceptors in the skeletal muscles, tendons, and joints. In rehabilitation, it is critical that CKC activities be used to retrain joints and muscle proprioceptors to respond to sensory input. Closed kinetic chain exercises are recommended for several reasons **(Box 8.12)**. Closed kinetic chain exercises stimulate the proprioceptors, increase joint stability, increase muscle coactivation, allow better utilization of the SAID (Specific Adaptations to Imposed Demands) principle, and permit more functional patterns of movement and greater specificity for athletic activities.

In contrast, OKC exercises can isolate a specific muscle group for intense strength and endurance exercises. In addition, they can develop strength in very weak muscles that may not function properly in a CKC system because of muscle substitution. Although OKC exercises may produce great gains in peak force production, the exercises are usually limited to one joint in a single plane (uniplanar), have greater potential for joint shear, have limited functional application, and have limited eccentric and proprioceptive retraining. However, OKC exercises can assist in developing a patient-athletic trainer rapport through uniplanar and multiplanar manual therapeutic techniques. **Figure 8.6** illustrates open and closed kinetic chain exercises for the lower extremity.

When ROM has been achieved, repetition of motion through actual skill movements can improve coordination and joint mechanics as the individual progresses into phase three of the program. For example, a pitcher may begin throwing without resistance or force application in front of a mirror to visualize the action. This also can motivate the individual to continue to progress in the therapeutic exercise program.

A In phase two, passive stretching and AROM exercises should be conducted at the ankle. In particular, Achilles tendon stretching and strengthening of the plantar flexors should be major parts of the rehabilitation plan. Cryotherapy, thermotherapy, EMS, or massage can complement the exercise program, as needed. The soccer player should be able to continue many of the exercises at home to supplement the exercise program performed in the athletic training room.

➤➤ **BOX 8.12**

Advantages of Closed Kinetic Chain Exercises

- It provides greater joint compressive forces.
- Multiple joints are exercised through weight bearing and muscular contractions.
- Velocity and torque are more controlled.
- Shear forces are reduced.
- Joint congruity is enhanced.
- Proprioceptors are re-educated.
- Postural and dynamic stabilization mechanics are facilitated.
- Exercises can work in spiral or diagonal movement patterns.

PHASE THREE: DEVELOPING MUSCULAR STRENGTH, ENDURANCE, AND POWER

Q The soccer player has regained normal ROM at the ankle and wants to start playing on an indoor soccer team. Is this a good idea? Is reinjury likely to occur?

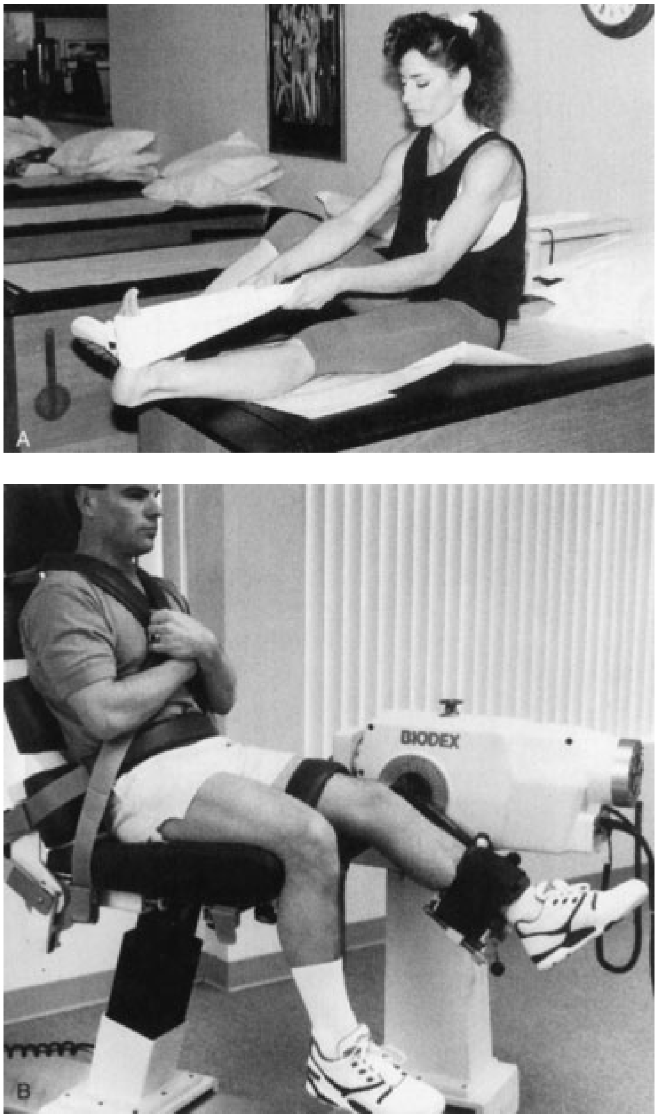
Phase three focuses on developing muscular strength, endurance, and power in the injured extremity as compared with the uninjured extremity. The individual can move into phase four when the following criteria have been completed:

- Bilateral ROM and joint flexibility are restored.
- Muscular strength, endurance, and power in the affected limb are equal or near equal to the unaffected limb.
- Cardiovascular endurance and general body strength are at or better than the preinjury level.
- Sport-specific functional patterns are completed using mild-to-moderate resistance.
- The individual is psychologically ready to return to protected activity.

Muscular Strength

Strength is the ability of a muscle or group of muscles to produce force in one maximal effort. Although static strength (isometric strengthening) is used during phases one and two in a pain-free arc of motion, dynamic strengthening is preferred in phase three of the program. Two types of contractions occur in dynamic strength: **concentric**, in which a shortening of muscle fibers decreases the angle of the associated joint, and **eccentric**, in which the muscle resists its own lengthening so that the joint angle increases during the contraction. Concentric and eccentric also may be referred to as positive and negative work, respectively. Concentric contractions work to accelerate a limb. For example, the gluteus maximus and quadriceps muscles concentrically contract to accelerate the body upward from a crouched position. In contrast, eccentric contractions work to decelerate a limb and provide shock absorption, especially during high-velocity dynamic activities. For example, the shoulder external rotators decelerate the shoulder during the follow-through phase of the overhead throw.

Eccentric contractions generate greater force than isometric contractions, and isometric contractions generate greater force than concentric contractions. In addition, less tension is required in an eccentric contraction. However, one major disadvantage of eccentric training is delayed-onset muscle soreness (DOMS). Delayed-onset muscle soreness is defined as muscular pain or discomfort 1 to 5 days following unusual muscular exertion. Delayed-onset muscle soreness is associated with joint swelling and weakness, which may last after the cessation of pain. This differs from acute-onset muscle soreness, where pain during exercise ceases after the exercise bout is completed. To prevent the onset of DOMS, eccentric exercises should progress gradually. Dynamic muscle strength is gained through isotonic or isokinetic exercise **(Figure 8.7)**.



➤ **Figure 8.7. Dynamic muscle strengthening.** Dynamic strength may be gained through **(A)** isotonic exercise, or **(B)** isokinetic exercise.

➤ *Isotonic Training (Variable Speed/Fixed Resistance)*

A more common method of strength training is isotonic exercise, or **progressive resistive exercise** (PRE) as it is sometimes called. In this technique, a maximal muscle contraction generates a force to move a constant load throughout the ROM at a variable speed. Both concentric and eccentric contractions are possible with free weights, elastic or rubber tubing, and weight machines. Free weights are inexpensive and can be used in diagonal patterns for sport-specific skills, but adding or removing weights from the bars can be troublesome. In addition, a spotter may be required for safety purposes to avoid dropping heavy weights. Thera-Band, or surgical tubing, is inexpensive and easy to set up, can be used in diagonal patterns for sport-specific skills, and can be adjusted to the patient's strength level by using bands of different tension. Weights on commercial machines can be changed quickly and easily. Utilizing several stations of free weights and commercial machines, an individual can perform circuit training to strengthen multiple muscle groups in a single exercise session. However, the machines are typically large and expensive, work only in a single plane of motion, and may not match the biomechanical makeup or body size of the individual.

Isotonic training permits exercise of multiple joints simultaneously, allows for both eccentric and concentric contractions, and permits weight-bearing, closed kinetic chain exercises. A disadvantage is that when a load is applied, the muscle can only move that load through the ROM with as much force as the muscle provides at its weakest point. Nautilus and Eagle equipment are examples of variable resistance machines with an elliptical cam. The cam system provides minimal resistance where the ability to produce force is comparatively lower (i.e., early and late in the ROM) and greatest resistance where the muscle is at its optimal length-tension and mechanical advantage (i.e., usually the midrange). The axis of rotation generates an isokinetic-like effect, but angular velocity cannot be controlled.

➤ *Isokinetic Training (Fixed Speed/Variable Resistance)*

Isokinetic training, or accommodating resistance, allows an individual to provide muscular overload and angular movement to rotate a lever arm at a controlled velocity or fixed speed. Theoretically, isokinetic training should activate the maximum number of motor units, which consistently overloads muscles and achieves maximum tension-developing or force output capacity at every point in the ROM, even at the relatively "weaker" joint angles. Cybex, Biodex, and Kin Com are examples of equipment that used this strength training method. Coupled with a computer and appropriate software, torque-motion curves, total work, average power, and torque-to-body weight measurements can be instantaneously calculated to provide immediate, objective measurement to the individual and examiner.

Two advantages of isokinetic training are that a muscle group can be exercised to its maximum potential throughout the full ROM, and the dynamometer's resistance mechanism essentially disengages if pain is experienced by the patient. However, as the muscles fatigue isokinetic resistance decreases. In contrast, with an isotonic contraction, because the resistance is constant, as the muscle fatigues, it must either recruit additional motor units, thus increasing muscle force, or fail to perform the complete repetition. It is hypothesized that during rehabilitation, isotonic training is more effective than isokinetic training in achieving rapid strength gains during training utilizing the daily adjusted progressive resistance exercise (DAPRE) technique (19). Two other disadvantages are the cost of the machine, computer, and software package (ranging from $25,000 to $60,000), and the fact that most available machines permit only open chain exercises. For this reason, isokinetic training should be used in conjunction with other modes of resistance training.

Muscular Endurance

Muscular endurance is the ability of muscle tissue to exert repetitive tension over an extended period. The rate of muscle fatigue is related to the endurance level of the muscle (i.e., the more rapidly the muscle fatigues, the less endurance it has). A direct relationship exists between muscle strength and endurance. As muscle endurance is developed, density in the capillary beds increases, providing a greater blood supply, and thus a greater oxygen supply, to the working muscle. Increases in muscle endurance may influence strength gains; however, strength development has not been shown to increase muscle endurance. Muscular endurance is gained by lifting low weights at a faster contractile velocity with more repetitions in the exercise session, or with use of stationary bikes or aquatic therapy, or Stair Master, Nordic Track, or a Slide Board.

Muscular Power

Muscular power is the ability of muscle to produce force in a given time. Power training is started after the injured limb has regained at least 80% of the muscle strength in the unaffected limb. Regaining power involves weight training at higher contractile velocities, or using plyometric exercises.

Plyometric training employs the inherent stretch-recoil characteristics of skeletal muscle through an initial rapid eccentric (loading) prestretching of a muscle, thereby activating the stretch reflex to produce tension prior to initiating an explosive concentric contraction of the muscle. This stretch produces a strong stimulus at the spinal cord level that causes an explosive reflex concentric contraction. The greater the stretch from the muscle's resting length immediately before the concentric contraction, the greater the load the muscle can lift or overcome. Injury can result if the individual does not have full ROM, flexibility, and near-normal strength before beginning these exercises. Examples of plyometric exercises include a standing jump, multiple jumps, box jumps or drop jumping from a height, single- or double-leg hops, bounding, leaps, and skips. In the upper extremity, a medicine ball, surgical tubing, plyoback, and boxes can be used. Performing jumping and skipping exercises on grass reduces impact on the lower extremity during landing. These exercises should be performed every 3 days to allow the muscles to recover from fatigue.

Functional Application of Exercise

Strength, endurance, and power can only be increased by using the **overload principle**, which states that physiologic improvements occur only when an individual physically demands more of the muscles than is normally required. This philosophy is based on the SAID principle, which states that the body responds to a given demand with a specific and predictable adaptation. Overload is achieved by manipulating intensity, duration, frequency, specificity, speed, and progression in the exercise program.

➤ Intensity

Intensity reflects both the caloric cost of the work and the specific energy systems activated. Strength gains depend primarily on the intensity of the overload and not the specific training method used to improve strength. Knight's DAPRE is an objective method of increasing resistance as the individual's strength increases or decreases (20). A fixed percentage of the maximum weight for a single repetition is lifted during the first and second sets. Maximum repetitions of the resistance maximum (RM) are lifted in the third set. Adaptations to the amount of weight lifted are then increased or decreased accordingly in the fourth set and in the first set of the next session. The DAPRE guidelines, listed in **Table 8.1**, are based on the concept that if the working weight is ideal, the individual can perform six repetitions when told to perform as many as possible. If the individual can perform more than six repetitions, the weight is too light. Conversely, if the individual cannot lift six repetitions, the weight is too heavy.

For individuals with chronic injuries or early postoperative rehabilitation, the DAPRE method may not be appropriate. Instead, a high-repetition, low-weight exercise may be more productive, particularly in the early phases. High weights potentially can cause a breakdown of the supporting soft-tissue structures and exacerbate the condition. Use of smaller weights and submaximal intensities can stimulate blood flow and limit tissue damage. To gain strength and endurance, higher repetitions are required.

TABLE 8.1 Daily Adjusted Progressive Resistance Exercise Program

Set	Weight	Repetitions
1	50% of RM	10
2	75% of RM	6
3	100% of RM	Maximum
4	Adjusted*	Maximum
Number of Repetitions During Set 3	**Adjusted Working Weight During Set 4**	**Weight During Set 4 Day's Exercise Session**
0–2	Decrease by 5–10 lb and repeat set	Keep the same
3–4	Decrease by 0–5 lb	Keep the same
5–7	Keep the same	Increase by 5–10 lb
8–12	Increase by 5–10 lb	Increase by 5–15 lb

* Adjusted work weight is gauged on individual differences completed in Set 3.
Adjusted work weight for the next day is gauged on individual differences completed in Set 4.

The individual begins with two or three sets of 10 repetitions, progressing to five sets of 10 repetitions, as tolerated. When the individual can perform 50 repetitions, 1 pound may be added, and the repetitions reduced to three sets of 10 repetitions. All exercises should be performed slowly, concentrating on proper technique. As strength increases, the DAPRE method or other type of progressive resistance exercise schedule may be used.

➤ Duration

Duration refers to the estimated time it will take to return the individual to full (100%) activity, or more commonly to the length of a single exercise session. This time can shorten if pain, swelling, or muscle soreness occur. In general, the individual must participate in at least 20 minutes of continuous activity with the heart elevated to at least 70% of maximal heart rate. This is particularly important when increasing cardiovascular endurance, which will be explained later in the chapter.

➤ Frequency

Frequency refers to the number of exercise sessions per day or week. Although exercise performed twice daily yields greater improvement than exercise done once, the exercise program should be conducted three to four times per week in most cases. It is critical not to work the same muscle groups on successive days, in order to allow recovery from fatigue and muscle soreness. If daily bouts are planned, strength and power exercises may be alternated with cardiovascular conditioning, or exercises for the lower extremity may alternate with exercises for the upper extremity.

➤ Specificity

An exercise program must address the specific needs of the patient. For example, exercises that mimic the throwing action will benefit a baseball pitcher, but are not applicable to a football lineman. If exercises simulate actual skills in the individual's sport, the patient is more likely to be motivated and compliant with the exercise program. The type of exercise (e.g., isometric, isotonic, or isokinetic) is also important. Individuals who rely upon eccentric loading must also include eccentric training in their rehabilitation program. Rhythm, or velocity, also has been shown to be specific to that required for the sport skill, with greatest strength gains consistently occurring at training speeds (21).

➤ Speed

Speed refers to the rate at which the exercise is performed. Initially, exercises should be performed in a slow, deliberate manner at a rate of about 60° per second,

FIELD STRATEGY 8.4 **Power and Strength Exercises**

STAIRS
- Use a "low" walking stance and vigorously swing the arms.
- Triple stairs: Walk only. One repetition is a round trip from the bottom of the stairwell to the top and back down. Use the walk down as recovery.
- Double stairs: Emphasize technique.
- Single stairs: Emphasize speed.

BOUNDING
- Involves one-foot takeoff and landing for 30 to 40 yards. Swing the arms vigorously to provide a strong movement.
- Run-Run-Bound: Establish the number of bounds (repetitions) and the number of sets.
- Distance: Establish the number of bounds in a given distance.

HOPS (CAN BE PERFORMED ONE- OR TWO-LEGGED)
- Single goal: 40 to 50 yards.
- Double goal: Sequence of 10 hops in each of three sets.

UPHILL RUNNING
- Decrease the stride length and make sure foot strike is underneath the body rather than in front.
- Land on the forefoot/toes, not on the heels.

BENCH STEPS WITH BARBELLS
- Step up, up, down, down. Begin with a light weight and add 1 minute daily until consecutive step-ups can be done for a preset period of time.

with emphasis placed on concentric and eccentric contractions. The individual should exercise throughout the full ROM, pausing at the end of the exercise. Large muscle groups should be exercised first, followed by the smaller groups. In addition, the exercise speed should be varied. As strength, endurance, and power increase, functional movements should increase in speed. Surgical tubing can be used to develop a high-speed regimen to produce concentric and eccentric synergist patterns, and isokinetic units also may be used at the highest speeds.

➤ *Progression*

In an effort to maintain motivation and compliance, an objective improvement should occur each day, whether this is an increase in repetitions or intensity. Muscular strength is improved with a minimum 3 days per week of training that includes 12 to 15 repetitions per bout of 8 to 10 exercises for the major muscle groups (13). If the individual complains of pain, swelling, or residual muscle soreness, the program may need to be decreased or varied in intensity. However, an orderly progression should move from ROM exercises to isometric, isotonic, isokinetic, and functional activities progressing from low to high intensity with ever-increasing demands on the patient as the healing process allows. **Field Strategy 8.4** lists exercises for developing muscular power and strength.

A The soccer player asked to play on an indoor soccer team after full ROM was achieved at the ankle. However, muscle strength, endurance, and power need to be developed in the affected limb at or near the level of the unaffected limb to prevent reinjury.

PHASE FOUR: RETURN TO SPORT ACTIVITY

Q The soccer player has regained near- normal strength in the affected limb as compared with the unaffected limb, and maintained cardiovascular endurance by riding a stationary bike. What additional factors need to be considered to prepare this individual for return to full activity?

The individual can return to his or her sport activity as soon as muscle strength, endurance, and power are restored. During phase four, the individual also should correct any biomechanical inefficiency in motion; restore coordination and muscle strength, endurance, and power in sport-specific skills; and improve cardiovascular endurance. The individual may be returned to activity if the following goals are attained:

- Coordination and balance are normal.
- Sport-specific functional patterns are restored in the injured extremity.
- Muscle strength, endurance, and power in the affected limb are equal to that of the unaffected limb.

FIELD STRATEGY 8.5 **Lower Extremity Exercises to Improve Balance and Proprioception**

FLAT FOOT BALANCE EXERCISES

1. Stand on one foot (stork stand) and maintain balance for 3 to 5 minutes.
2. Stand on one foot with the toes off the floor and maintain balance for 3 to 5 minutes.
3. Stand on one foot while dribbling a basketball.

BALANCING ON THE TOES

1. Balance on the toes/forefoot using both feet for 3 to 5 minutes, then use only one foot.
2. Balance on the toes while dribbling a basketball.

PROFITTER EXERCISES

1. In a location with a sturdy hand rail, stand on the ProFitter with the feet perpendicular to the long axis of the rails. Gently slide side-to-side, placing pressure first on the toes, then on the heels.
2. Progress to more rapid movement. When you feel comfortable, do the sliding motion without hand support. Document repetitions and sets.

BAPS BOARD EXERCISES

1. Begin in a seated position by rotating the foot clockwise and counterclockwise.
2. Stand with both feet on board (bilateral balancing) with support, and move the platform clockwise and counterclockwise; progress to one foot with support.
3. Do bilateral balancing with no support; progress to one foot with no support.
4. Add dribbling a basketball or catching a basketball to any of these activities.

- Cardiovascular endurance is equal to, or greater than, the preinjury level.
- The individual receives clearance to return to participation by the supervising physician.

Coordination

Coordination refers to the body's ability to execute smooth, fluid, accurate, and controlled movements. Simple movement, such as combing hair, involves a complex muscular interaction using the appropriate speed, distance, direction, rhythm, and muscle tension to execute the task. Coordination may be divided into two categories: gross motor movements involving large muscle groups, and fine motor movements using small groups. Gross motor movements involve activities such as standing, walking, skipping, and running. Fine motor movements are seen in precise actions, particularly with fingers, such as picking up a coin off a table, clutching an opponent's jersey, or picking up a ground ball with a glove. Coordination and proprioception are directly linked. When an injury occurs and the limb is immobilized, sensory input from proprioceptors and motor commands are disrupted, resulting in an alteration of coordination.

Performing closed kinetic chain activities in phase two of the exercise program can help restore proprioceptive input and improve coordination. Constant repetition of motor activities, using sensory cues (i.e., tactile, visual, or proprioceptive) or increasing the speed of the activity over time, can continue to develop coordination in phases three and four. A wobble board, teeter board, ProFitter, or BAPS board is often used to improve sensory cues and balance in the lower extremity. Proprioceptive neuromuscular facilitation patterns and the ProFitter also may be used to improve sensory cues in the upper and lower extremities. **Field Strategy 8.5** lists several lower extremity exercises used to improve coordination and balance.

Sport-Specific Skill Conditioning

Because sports require different skills, therapeutic exercise should progress to the load and speed expected for the individual's sport. For example, a baseball player performs skills at different speeds and intensities than a football lineman. Therefore, exercises must be coupled with functional training, or specificity of training related to the physical demands of the sport.

As ROM, muscular strength, and coordination are restored, the individual should work the affected extremity through functional diagonal and sport-specific patterns. For example, in phase three, a baseball pitcher may have been moving the injured arm through the throwing pattern with mild to moderate resistance. In phase four, the individual should increase resistance and speed of motion. Working with a ball attached to surgical tubing, the individual can develop a kinesthetic awareness in a functional pattern. When controlled motion is done without pain, actual throwing can begin. Initially, short throws with low intensity can be used, progressing to longer throws and low intensity. As the player feels more comfortable and is pain free with the action, the number of throws and their intensity are increased. Similar programs can be developed for other sports. Other sport-specific skills that can be performed at this level include

FIELD STRATEGY 8.6 Cardiovascular Conditioning Exercises

Jumping rope. The rope should pass from one armpit, under the feet, to the other armpit. Jump with the forearms near the ribs at a 45° angle. Rotation occurs at the hand and wrist. Jump with minimal ground clearance.

Two-footed jumps
- Bounce on the balls of the feet.
- Tap heel of one foot to toe of other foot on one jump. Variation: Tap toe of same foot to heel of other foot.
- Pepper.
- Arm and foot crossovers.

One-footed jumps
- One foot hop.
- Rocker step. Rock forward/backward with feet in a forward straddle.
- Heel strikes and toe taps.
- Jogging steps.

Stair Master. Twenty minutes of exercise is recommended three to four times a week.

Beginner level
- Manual or Pike's Peak mode at Level 2 or 3 for 5 minutes.
- Increase time to 8, 10, 15, and 20 minutes.

Advanced level
- When 20 minutes is comfortable, decrease time to 5 to 8 minutes and increase level intensity, then increase time again. As intensity increases, include a warm-up and cool-down period.

Treadmill

Beginner level
- Begin with a manual mode with a ground level (0° incline) for 5 minutes at approximately 2.5 mph.
- Increase time to 8, 10, 15, and 20 minutes.

Intermediate level
- When 20 minutes is comfortable, increase speed to 3 to 5 mph, and progress to 8, 10, 15, and 20 minutes.
- Allow for warm-up and cool-down periods.
- For example: Warm-up at 2.5 mph for 5 minutes
  increase speed to 4.0 to 5.0 mph for 10 minutes
  cool down at 2.5 mph for 5 minutes
  total workout = 20 minutes

Advanced level
- Increase incline during warm-up and decrease incline during cool-down.

Upper Body Ergometer

Beginner level
- Start at 120 rpm for 4 minutes, alternating directions: 2 minutes forward, 2 minutes backward.

Intermediate level
- Progress to 90 rpm and increase time to 6, 8, and 10 minutes.

Advanced level
- Alternate directions as tolerated. Duration should not exceed 12 minutes.
- For example: warm-up at 90 rpm for 2.5 minutes
  workout at 60 rpm for 5 minutes
  cool down at 120 rpm for 2.5 minutes

sprint work, agility runs, figure eights, side stepping, shuttle runs, and interval training (alternating periods of intense work and active recovery).

Cardiovascular Endurance

Cardiovascular endurance, commonly called aerobic capacity, is the body's ability to sustain submaximal exercise over an extended period, and depends on the efficiency of the pulmonary and cardiovascular systems. When an injured individual is unable to continue, or chooses to stop aerobic training, detraining occurs within 1 to 2 weeks (13). If the individual returns to activity without a high cardiovascular endurance level, fatigue sets in quickly and places the individual at risk for reinjury.

Similar to strength training, maintaining and improving cardiovascular endurance is influenced by an interaction of frequency, duration, and intensity. The American College of Sports Medicine recommends that aerobic training include activity 3 to 5 days per week lasting more than 20 minutes at an intensity of 60 to 90% of maximal heart rate (HRmax) (22). Targeted heart rate can be calculated in two manners:

1. An estimated HRmax for both men and women is about 220 beats/minute. Heart rate is related to age, with maximal heart rate decreasing as an individual ages. A relatively simple calculation is:

   $$\text{HRmax} = 220 - \text{Age}$$

   [With a 20-year-old individual working at 80% maximum, the calculation is: $.8 \times (220 - 20)$ or 160 beats per minute]
2. Another commonly used formula (Karvonen formula) assumes that the targeted heart rate range is between 60 and 90%. The calculation is:

   $$\text{Target HR range} = [(\text{HRmax} - \text{HRrest}) \times 0.60 \text{ and } 0.90] + \text{HRrest}$$

   [If an individual's HRmax is 180 beats/minute and the HRrest is 60 beats/minute, this method yields a target HR range of between 132 and 168 beats/minute.]

Non–weight-bearing exercises, such as swimming, rowing, biking, or use of the UBE can be helpful early in the therapeutic program, particularly if the individual has a lower extremity injury. Walking, cross-country skiing, jumping rope, or running can be performed as the condition improves. **Field Strategy 8.6** lists cardiovascular conditioning exercises.

A The documentation needed to clear the soccer player for return to full activity includes successful completion of the goals listed in phase four and a doctor's medical clearance. The individual should also agree to wear any appropriate taping or protective device to ensure safe return. It is important to remember that all written documentation of the exercise program and written medical clearance should be placed in the individual's file and stored in a safe, secure location for a minimum of 3 to 5 years.

Summary

1. A therapeutic exercise program must address not only the physical needs of the patient, but also the emotional and psychological needs.
2. Several factors can affect how an individual reacts to the rehabilitation process, including:
   - Performance anxiety
   - Self-esteem/motivation
   - Extroversion/introversion
   - Psychological investment in the sport
   - Coping resources
   - History of past stressors (previous injuries, academic, family, life events)
   - Previous intervention strategies
3. Goal setting is a common practice used by athletic trainers to motivate patients in the recovery program.
4. Psychological influences that may affect an individual's success in the rehabilitation process include confidence, motivation, anxiety, focus, and management of pain.
5. As a general rule, any psychological difficulty that persists for more than a few days and interferes with the progress of rehabilitation should be referred to a licensed clinical psychologist or an appropriate counseling center.
6. Rehabilitation begins immediately after injury assessment:
   - The level of function and dysfunction is assessed.
   - Results are organized and interpreted.
   - A list of patient problems is formulated.
   - Long- and short-term goals are established.
   - A treatment plan is developed, including therapeutic exercises, modalities, and medications.
   - The program is then supervised and periodically reassessed with appropriate changes made.
7. Phase one of the therapeutic exercise program should focus on patient education and control of inflammation, muscle spasm, and pain.
8. Phase two should regain any deficits in ROM and proprioception at the affected joint as compared with the unaffected joint.
9. Phase three should regain muscular strength, endurance, and power in the affected limb.
10. Phase four prepares the individual to return to activity and includes analysis of motion, sport-specific skill training, regaining coordination, and cardiovascular conditioning.
11. At the conclusion of the rehabilitation program, the supervising physician determines if the individual is ready to return to full activity. This decision should be based on review of the individual's:
    - ROM and flexibility
    - Muscular strength, endurance, and power
    - Biomechanical skill analysis
    - Proprioception and coordination
    - Cardiovascular endurance

12. If additional protective bracing, padding, or taping is necessary to enable the individual to return safely to activity, this should be documented in the individual's file. In addition, it should be stressed that use of any protective device should not replace a maintenance program of conditioning exercises.
13. The athletic trainer should keep a watchful eye on the individual as the person returns to activity. If the individual begins to show signs of pain, swelling, discomfort, or skill performance deteriorates, the individual should be re-evaluated to determine if activity should continue or the therapeutic exercise program needs to be reinstituted.

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