PART

Injury Assessment and Rehabilitation

2

CHAPTER

5 Injury Assessment

STUDENT OUTCOMES

1. Differentiate between the history of the injury, observation and inspection, palpation, and special tests (HOPS) injury assessment format and the subjective evaluation, objective evaluation, assessment, and plan (SOAP) note format used to assess and manage musculoskeletal injuries.
2. Explain the general components of the history portion of an injury assessment.
3. Describe the processes involved in the visual observation and inspection of an injury.
4. Describe the basic principles that direct the palpation component of an injury assessment.
5. Identify the various types of tests included in the physical examination of an injury.
6. Develop an emergency medical services plan for an athletic training facility.
7. Identify the responsibilities of an emergency response team.
8. List supplies and equipment that should be on-site in case of a medical emergency.
9. Explain the procedures used during an on-site injury assessment.
10. Identify emergency conditions that warrant immediate activation of the emergency medical services system.
11. Demonstrate proper procedures for transporting an injured individual.
12. Describe testing techniques used by medical specialists in diagnosing an injury.

ROLE DELINEATION COMPETENCIES

The following Performance Domains and Tasks defined in the National Athletic Trainers' Association Board of Certification *Role Delineation Study*, 5th Edition are addressed in this chapter:

BOC COMPETENCIES

I. Prevention

F. Maintain clinical and treatment areas by complying with safety and sanitation standards to minimize the risk of injury and illness.

II. Clinical Evaluation and Diagnosis

A. Obtain a history through observation, interview, and/or review of relevant records to assess current or potential injury, illness, or condition.
B. Inspect the involved area(s) visually to assess the injury, illness, or health-related condition.
C. Palpate the involved area(s) using standard techniques to assess the injury, illness, or health-related condition.
D. Perform specific tests in accordance with accepted procedures to assess the injury, illness, or health-related condition.
E. Formulate a clinical impression by interpreting the signs, symptoms, and predisposing factors of the injury, illness, or condition to determine the appropriate course of action.
F. Educate the appropriate individual(s) regarding the assessment by communicating information about the current or potential injury, illness, or health-related condition to encourage compliance with recommended care.
G. Share assessment findings with other health care professionals using effective means of communication to coordinate appropriate care.

III. Immediate Care

A. Employ life-saving techniques through the use of standard emergency procedures in order to reduce morbidity and the incidence of mortality.
B. Prevent exacerbation of non–life threatening condition(s) through the use of standard procedures in order to reduce morbidity.
C. Facilitate the timely transfer of care for conditions beyond the scope of practice of the athletic trainer by implementing appropriate referral strategies to stabilize and/or prevent exacerbation of the condition(s).
D. Direct the appropriate individual(s) in standard immediate care procedures using formal and informal methods to facilitate immediate care.
E. Execute the established emergency action plan using effective communication and administrative practices to facilitate efficient immediate care.

IV. Treatment, Rehabilitation, and Reconditioning

E. Reassess the status of injuries, illnesses, and/or conditions using standard techniques and documentation strategies in order to determine appropriate treatment, rehabilitation, and/or reconditioning and to evaluate readiness to return to a desired level of activity.

V. Organization and Administration

A. Establish action plans for response to injury or illness using available resources to provide the required range of health care services for individuals, athletic activities, and events.
B. Establish policies and procedures for the delivery of health care services following accepted guidelines to promote safe participation, timely care, and legal compliance.
C. Establish policies and procedures for the management of health care facilities and activity areas by referring to accepted guidelines, standards, and regulations to promote safety and legal compliance.
E. Maintain records using an appropriate system to document services rendered, provide for continuity of care, facilitate communication, and meet legal standards.
F. Develop professional relationships with appropriate individuals and entities by applying effective communication techniques to enhance the delivery of health care.

One of the major performance domains for the athletic trainer is clinical assessment and diagnosis. Using standardized clinical practices, the athletic trainer makes decisions relative to the nature and severity of an injury or illness. Because the injury assessment process involves searching for atypical or dysfunctional anatomy, physiology, or biomechanics, a strong understanding of both these areas and the appropriate execution of evaluation techniques is essential to accurate injury assessment. Poor assessment can have a devastating effect on proper treatment and development of appropriate rehabilitation protocols.

This chapter begins with a description of two popular methods of injury assessment—namely, the history of the injury, observation and inspection, palpation, and special tests (HOPS) injury assessment format and the subjective evaluation, objective evaluation, assessment, and plan (SOAP) note format. Information is then presented regarding the various components of the injury assessment process. Next, the principles for developing and implementing an emergency medical plan are discussed, and the components of an "on-site" emergency assessment are presented, with a list of conditions that warrant activation of the emergency medical plan. Details of transporting an injured person from the scene are followed by information concerning several tests and procedures used by medical specialists to diagnose an injury.

Basic first-aid techniques are not included in this book. Rather, the authors assume that students have already completed a basic athletic training or first-aid course and hold current certification in advanced first aid and emergency cardiac care.

THE INJURY EVALUATION PROCESS

Regardless of the type of injury assessment selected by a health care provider, documentation of information on a medical report must be consistent with accepted standards. Abbreviations often are used in writing medical reports. As such, an athletic trainer must have the ability to both write and interpret abbreviations for common medical terms. Apply your knowledge of medical terminology by interpreting the following physician note: Athlete complained of mod knee pain, H/O patella tendonitis, Px revealed, B swelling B AROM painful, Dx B patella tendonitis. NSAID and cryotherapy AOAP.

When evaluating any injury or condition, diagnostic signs and symptoms are obtained and interpreted to determine the type and extent of injury. A diagnostic **sign** is an objective, measurable, physical finding regarding an individual's condition. A sign is what the evaluator hears, feels, sees, or smells when assessing the patient. A **symptom** is information provided by the injured individual regarding his or her perception of the problem. Examples of these subjective feelings include blurred vision, ringing in the ears, fatigue, dizziness, nausea, headache, pain, weakness, and inability to move a body part. Obtaining information about symptoms can determine if the individual has an **acute injury,** resulting from a specific event (**macrotrauma**) leading to a sudden onset of symptoms, or a **chronic injury,** characterized by a slow, insidious onset of symptoms (**microtrauma**) that culminates in a painful inflammatory condition.

Before assessing any injury, the opposite, or noninjured, body part should be assessed. This preliminary step in the injury evaluation process helps to determine the relative dysfunction of the injured body part. If an injury occurs to one of the extremities, the results of individual tests performed on the noninjured body part can be compared with those for the injured body part. Differences can indicate the level and severity of injury. The baseline of information gathered on the noninjured body part also can be used as a reference point to determine when the injured body part has been rehabilitated and, as such, when to allow return to full participation in an activity. Under most circumstances, assessment of the noninjured body part should precede assessment of the injured body part. In some acute injuries, such as fractures or dislocations, assessment of the noninjured body part is not necessary.

The injury evaluation process must include several key components—namely, taking a history of the current condition, visually inspecting the area for noticeable abnormalities, physically palpating the region for abnormalities, and completing functional and stress tests. Although several evaluation models may be used, each follows a consistent, sequential order to ensure that an essential component is not omitted without sufficient reason to do so. Two popular evaluation methods are the HOPS format and the SOAP note format. Each has its advantages, but the SOAP note format is much more inclusive of the entire injury management process.

The HOPS Format

The HOPS format uses both subjective information (i.e., history of the injury) and objective information (i.e., observation and inspection, palpation, and special testing) to recognize and identify problems contributing to the condition. This format is easy to use and follows a basic, consistent format. The HOPS format focuses on the evaluation component of injury management and excludes the rehabilitation process.

The subjective evaluation (i.e., history of the injury) includes the primary complaint, mechanism of injury, characteristics of the symptoms, and related medical history. This information comes from the individual and reflects his or her attitude, mental condition, and perceived physical state.

The objective evaluation (i.e., observation and inspection, palpation, and special tests) provides appropriate, measurable documentation relative to the individual's condition. Measurable factors may include edema, ecchymosis, atrophy, range of motion (ROM), strength, joint instability, functional disability, motor and sensory function, and cardiovascular endurance. This information can be measured repeatedly to track progress from the initial evaluation through final clearance for discharge and return to participation in a sport or other physical activity. A detailed postural assessment and gait analysis also may be documented during the objective evaluation.

The SOAP Note Format

The SOAP note format provides a more detailed and advanced structure for decision making and problem solving in injury management. Used in many physical therapy clinics, sports medicine clinics, and athletic training facilities, these notes document patient care and serve as a vehicle of communication between the on-site clinicians and other health care professionals. These notes are intended to provide information concerning the ongoing status and tolerance of a patient and, in doing so, to avoid duplication of services by health care providers.

The subjective and objective evaluations are identical to those used in the HOPS format; however, two additional components are added to the documentation: assessment, and planning. It is common practice to use abbreviations throughout the notes.

A listing of commonly used abbreviations is available on the companion website at thePoint.

Assessment

Following the objective evaluation, the examiner analyzes and assesses the individual's status and prognosis. Although a definitive diagnosis may not be known, the suspected site of injury, involved structures, and severity of injury are documented. Subsequently, both long-term and short-term goals are established. Long-term goals should reflect the anticipated status of the individual after a period of rehabilitation and might include pain-free ROM; bilateral strength, power, and muscular endurance; cardiovascular endurance; and return to full functional status. Short-term goals are developed to outline the expected progress within days of the initial injury and might include immediate protection of the injured area and control of inflammation, hemorrhage, muscle spasm, or pain. Short-term goals are updated with each progress note. Progress notes may be written daily, weekly, or biweekly to document progress.

A sample progress report format is available on the companion website at thePoint.

Plan

The final section of the note lists the therapeutic modalities and exercises, educational consultations, and functional activities used to achieve the documented goals. The action plan should include the following information:

- The immediate treatment given to the injured individual
- The frequency and duration of treatments, therapeutic modalities, and exercises
- Evaluation standards to determine progress toward the goals
- Ongoing patient education
- Criteria for discharge

As the short-term goals are achieved and updated, periodic "in-house review" of the individual's records permits health care providers to evaluate joint ROM; flexibility; muscular strength, power, and endurance; balance or proprioception; and functional status. In addition, these reviews allow health care providers to discuss the continuity of documentation, efficacy of treatment, average time to discharge, and other parameters that may reflect quality of care. When it is determined that the individual can be discharged and cleared for participation, a discharge note should be written to close the file. All information included within the file is confidential and cannot be released to anyone without written approval from the patient.

In a clinical setting, SOAP notes are the sole means of documenting the services provided to the patient. All clinicians have an ethical responsibility to keep accurate and factual records. This information verifies specific services rendered and evaluates the progress of the patient as well as the efficacy of the treatment plan. Insurance companies use this information to determine if services are being appropriately rendered and qualify for reimbursement. More important, this comprehensive record-keeping system can minimize the ever-present threat of malpractice and litigation. In general, the primary error in writing SOAP notes is the error of omission, whereby clinicians fail to adequately document the nature and extent of care provided to the patient. Formal documentation and regular review of records can reduce this threat and minimize the likelihood that inappropriate or inadequate care is being rendered to a patient.

Each component of the subjective and objective assessments are described in detail in the following sections and are repeated throughout each chapter on the various body regions. A brief outline of the steps can be seen in Field Strategy 5.1.

The physician note states the following: The athlete complains of moderate knee pain and has a history of patella tendonitis. Physical examination reveals bilateral swelling and bilateral painful active range of motion. Diagnosis is bilateral patella tendonitis. Begin non-steroidal anti-inflammatory therapy, and apply cryotherapy as often as possible.

HISTORY OF THE INJURY

A female high school long jumper sustains an ankle injury during practice and immediately reports to the athletic training room. What questions should be asked to identify the cause and extent of this injury?

Identifying the history of the injury can be the most important step of injury assessment. A complete history includes information regarding the primary complaint, cause or mechanism of the injury, characteristics of the symptoms, and any related medical history that may have a bearing on the specific condition. This information can provide potential reasons for the symptoms and identify injured structures before initiating the physical examination. An individual's medical history file can be an excellent resource for identifying past injuries, subsequent rehabilitation programs, and any factors that may predispose the individual to further injury. Specific to collegiate athletes, the National Collegiate Athletic Association (NCAA) has identified primary components that should be in an intercollegiate athlete's medical record and readily accessible to the athletic trainer (Box 5.1) (1).

History taking involves asking appropriate questions, but it also requires establishing a professional and comfortable atmosphere. When taking a history, the athletic trainer should present a competent manner, listen attentively, and maintain eye contact in an effort to establish rapport with the injured individual. Ideally, this encourages the individual to respond more accurately to questions and instructions.

Often, an unacknowledged obstacle to the evaluation process is the sociocultural dynamics that may exist between the patient and clinician that can hinder communication. It is important for all clinicians to understand and respect each cultural group's attitudes, beliefs, and values as related to health and illness. If English is a second language to the patient, it may be necessary to locate an interpreter. If an interpreter is used, it is important to speak to the client, not to the interpreter. It also may be necessary to speak slower, not louder, and to refrain from using slang terms or jargon. To ensure understanding, the patient should be asked to repeat the instructions.

FIELD STRATEGY 5.1

Injury Assessment Protocol

History of the Injury

1. Primary complaint
   - Current nature, location, and onset of the condition
2. Mechanism of injury
   - Cause of stress, position of limb, and direction of force
   - Changes in running surface, shoes, equipment, techniques, or conditioning modes
3. Characteristics of the symptoms
   - Presence of unusual sensation (i.e., pain, sounds, and feelings)
   - Evolution of the onset, nature, location, severity, and duration of symptoms
4. Disability resulting from the injury
   - Immediate limitations
   - Limitations in occupation and activities of daily living
5. Related medical history
   - Past musculoskeletal injuries, congenital abnormalities, family history, childhood diseases, allergies, or cardiac, respiratory, vascular, or neurologic problems

Observation and Inspection

1. Observation involves analysis of:
   - Overall appearance
   - Body symmetry
   - General motor function
   - Posture and gait
2. Inspection involves observing the injury site for:
   - Deformity, swelling, discoloration, scars, and general skin condition

Palpation

1. Bony structures
   - Determine a possible fracture first
2. Soft-tissue structures:
   - Skin temperature, swelling, point tenderness, crepitus, deformity, muscle spasm, cutaneous sensation, and pulse

Functional Tests

1. Active movement
2. Passive movement and end feel
3. Resisted manual muscle testing

Stress Tests

1. Ligamentous instability tests

Special Tests

Neurologic Tests

1. Dermatomes
2. Myotomes
3. Reflexes
4. Peripheral nerve testing

Activity/Sport-Specific Functional Testing

1. Proprioception and motor coordination

Activity/Sport-Specific Skill Performance

Box 5.1 National Collegiate Athletic Association (NCAA) Guideline 1b: Medical Evaluations, Immunizations, and Records

The following primary components should be included in the athlete's medical record:

1. History of injuries, illnesses, new medications or allergies, pregnancies, and operations, whether sustained during the competitive season or off-season

2. Referrals for and feedback from consultation, treatment, or rehabilitation with subsequent care and clearances

3. Comprehensive entry-year health-status questionnaires and an updated health-status questionnaire each year thereafter, including information on:
   - Illnesses suffered (acute and chronic); athletic and nonathletic hospitalization
   - Surgery
   - Allergies, including hypersensitivity to drugs, foods, and insect bites/stings
   - Medications taken on a regular basis
   - Conditioning status
   - Musculoskeletal injuries (previous and current)
   - Cerebral concussions or episodes involving loss of consciousness
   - Syncope or near-syncope with exercise
   - Exercise-induced asthma or bronchospasm
   - Loss of paired organs
   - Heat-related illness
   - Cardiac conditions and family history of cardiac disease, including sudden death in a family member younger than 50 years and Marfan's syndrome
   - Menstrual history
   - Exposure to tuberculosis

4. Immunization records, including:
   - Measles, mumps, rubella (MMR)
   - Hepatitis B
   - Diphtheria, tetanus, and boosters when appropriate
   - Meningitis

5. Written permission signed by the student-athlete, or by the parent if the athlete is younger than 18 years, that authorizes the release of medical information to others, specifically what information may be released and to whom.

Adapted from Klossner D, ed. NCAA Sports Medicine Handbook: 2005–06. Indianapolis: National Collegiate Athletic Association, 2005; with permission.

When communicating with older clients, a skilled interviewer must consider other issues that may impact the effectiveness of history taking. The client's education and socioeconomic status may affect his or her vocabulary, self-expression, ability to comprehend, and ability to conceptualize questions asked by the interviewer (2). Elderly individuals tend to view the world concretely, think in absolute terms, and may be confused by complicated questions. These individuals also may present with some anxiety if they perceive that the examiner is dismissing the magnitude of their complaints or becoming impatient with the length of time that patients take to answer a question. In addition, patients who may have a hearing loss might feel uncomfortable asking the interviewer to repeat information (2). A skilled examiner takes note of the patient's comfort level by recognizing not only verbal expression but also any emotion behind the expression, such as hidden fears, beliefs, or expectations. Patience, respect, rapport, structure, and reflecting on important information are all useful in conducting a comprehensive medical history.

The history begins by gathering general information, such as the individual's name, sex, age, date of birth, occupation, and activity in which the individual was participating when the injury occurred. Notes regarding body size, body type, and general physical condition also are appropriate.

Although information provided by the individual is subjective, it should still be gathered and recorded as quantitatively as possible. This can be accomplished by recording a number correlating with the described symptoms. For example, the individual can rate the severity of pain using a scale from 1 to 10. The patient also can be asked to quantify the length of time the pain lasts. In using such measures, the progress of the injury can be determined. If the individual reports that pain begins immediately after activity and lasts for 3 or 4 hours, a baseline of information has been established. As the individual undergoes treatment and rehabilitation for the injury, a comparison with the baseline information can determine if the condition is getting better, worse, or remains the same.

Although the intent of taking a history is to narrow the possibilities of conditions causing the injury, the history should always be taken with an open mind. If too few factors are considered, the athletic trainer may reach premature conclusions and fail to adequately address the severity of the injury. It is essential to document in writing the information obtained during the history.

Primary Complaint

The primary complaint focuses on the injured individual's perception of the current injury. Questions should be phrased to allow the individual to describe the current nature, location, and onset of the condition. The following questions could be asked:

- What is the problem?
- What hurts?
- When did the injury occur?
- What activities or motions are weak or painful?

It is important to realize that the individual may not wish to carry on a lengthy discussion about the injury or may trivialize the extent of pain or disability. The examiner must be patient and keep the questions simple and open-ended. It is advantageous to pay close attention to words and gestures used by the patient to describe the condition, because these may provide clues to the quality and intensity of the symptoms.

Mechanism of Injury

After identifying the primary complaint, the next step is to determine the mechanism of injury. This is probably the most important information gained in the history. For an acute injury, questions that might be asked include:

- How did the injury occur? What did you do? How did you do it?
- Did you fall? If so, how did you land?
- Were you struck by an object or another individual? If so, in what position was the involved body part, and in what direction was the force?

For a chronic nature, potential questions include:

- How long has the injury been a problem?
- Do you remember a specific incident that initiated or provoked the current problem?
- Have there been recent changes in running surface, shoes, equipment, techniques, or conditioning modes?
- What activities make the condition feel better? What activities make the condition feel worse?

It is important to visualize the manner in which the injury occurred as a way to identify possible injured structures. The information obtained pertaining to the mechanism of injury directs the objective evaluation.

Characteristics of the Symptoms

The primary complaint must be explored in detail to discover the evolution of symptoms, including the location, onset, severity, frequency, duration, and limitations caused by the pain or disability. The individual's pain perception can indicate which structures may be injured. There are two categories of pain: somatic, and visceral.

Somatic pain arises from the skin, ligaments, muscles, bones, and joints and is the most common type of pain encountered in musculoskeletal injuries. It is classified into two major types: deep, and superficial. Deep somatic pain is described as diffuse or nagging, as if intense pressure is being exerted on the structures, and may be complicated by stabbing pain. Deep somatic pain is longer lasting and usually indicates significant tissue damage to bone, internal joint structures, or muscles. Superficial somatic pain results from injury to the epidermis or dermis and usually is a sharp, prickly type of pain that tends to be brief.

Visceral pain results from disease or injury to an organ in the thoracic or abdominal cavity, such as compression, tension, or distention of the viscera. Similar to deep somatic pain, it is perceived as deeply located, nagging, and pressing, and it often is accompanied by nausea and vomiting. **Referred pain** is a type of visceral pain that travels along the same nerve pathways as somatic pain. It is perceived by the brain as being somatic in origin. In other words, the injury is in one region, but the brain considers it in another. For example, referred pain occurs when an individual has a heart attack and feels pain in the chest, left arm, and sometimes, the neck. Figure 5.1 illustrates cutaneous areas where pain from visceral organs can be referred.

Pain can travel up or down the length of any nerve and be referred to another region. An individual with a low back problem may feel the pain down the gluteal region and into the back of the leg. If a nerve is injured, pain or a change in sensation, such as a numbing or burning sensation, can be felt along the length of the nerve.

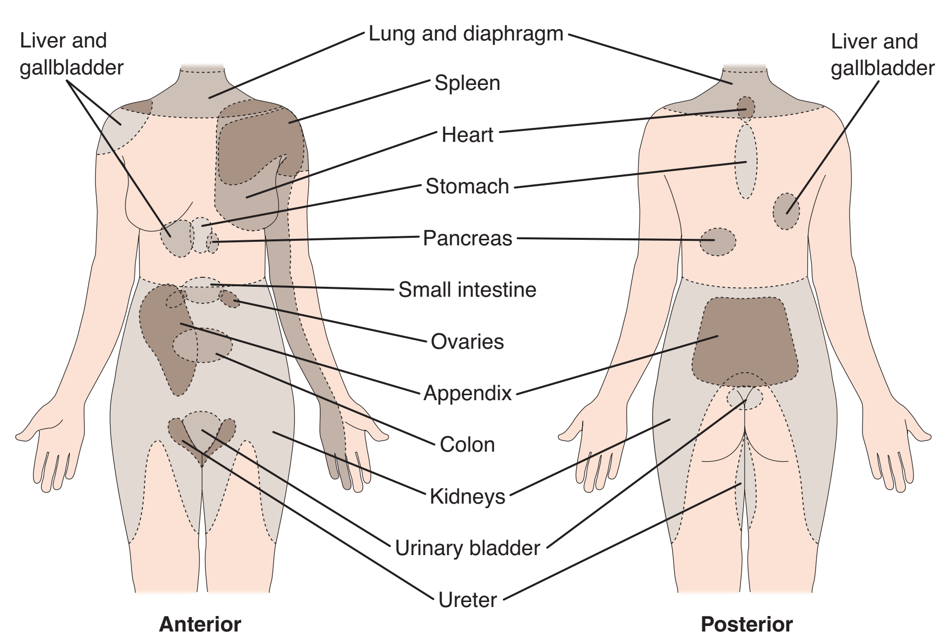


FIGURE 5.1 Referred pain. Certain visceral organs can refer pain to specific cutaneous areas. If all special tests are negative yet the individual continues to feel pain at a specific site, it may be referred pain.

In assessing the injury, the examiner should ask detailed questions about the location, onset, nature, severity, frequency, and duration of the pain. For example, the following questions should be asked:

- Where is the pain?
- Can you point to a specific painful spot?
- Is the pain limited to that area, or does it radiate into other parts of the leg or foot?
- How bad is the pain on a scale from 1 to 10, with 10 being most severe?
- Can you describe the pain (e.g., dull, sharp, or aching)?

In chronic conditions, the following questions should be asked:

- When does the pain begin (e.g., when you get out of bed, while sitting, while walking, during exercise, or at night)?
- How long does the pain last?
- Is the pain worse before, during, or after activity?
- What activities aggravate or alleviate the symptoms?
- Does the pain wake you up at night?
- How long has the condition been present?
- Has the pain changed or stayed the same?
- In the past, what medications, treatments, or exercise programs have improved the situation?

If pain is localized, it suggests that limited bony or soft-tissue structures may be involved. Diffuse pain around the entire joint may indicate inflammation of the joint capsule or injury to several structures. If pain radiates into other areas of the limb or body, it may be traveling up or down the length of a nerve. These responses also can determine if the condition is disabling enough to require referral to a physician. Table 5.1 provides more detailed information regarding pain characteristics and probable causes.

TABLE 5.1 Pain Characteristics and Possible Causes

CHARACTERISTICS	POSSIBLE CAUSES
Morning pain with stiffness that improves with activity	Chronic inflammation with edema, or arthritis
Pain increasing as the day progresses	Increased congestion in a joint
Sharp, stabbing pain during activity	Acute injury, such as ligament sprain or muscular strain
Dull, aching pain aggravated by muscle contraction	Chronic muscular strain
Pain that subsides during activity	Chronic condition or inflammation
Pain on activity relieved by rest	Soft-tissue damage
Pain not affected by rest or activity	Injury to bone
Night pain	Compression of a nerve or bursa
Dull, aching, and hard to localize; aggravated by passive stretching of the muscle and resisted muscle contractions	Muscular pain
Deeply located, nagging, and very localized	Bone pain
Sharp, burning, or numbing sensation that may run the length of the nerve	Nerve pain
Aching over a large area that may be referred to another area of the body	Vascular pain

In assessing the primary complaint of an acute injury, it also is important to determine if the individual experienced other unusual sensations at the time of injury. Specifically, the following questions should be asked:

- Did you hear anything?
- Did you feel anything?

The report of particular sounds and feelings at the time of injury can provide valuable input regarding the type of injury and the structures involved. Hearing a "pop" is characteristic of a rupture to a ligament or tendon, and hearing a snapping or cracking sound may suggest a fracture. Unusual feelings can be presented in a variety of ways. For example, having sustained a tear to the anterior cruciate ligament, an individual may report a feeling of the knee giving way. Following a rupture of the Achilles tendon, an individual may report a feeling of being shot or kicked in the lower leg.

Disability Resulting from the Injury

The examiner should attempt to determine the limitations experienced by the individual because of pain, weakness, or disability from the injury. Questions should not be limited to sport and physical activity but, rather, should determine if the injury has affected the individual's job, school, or daily activities. **Activities of daily living** are actions that most people perform without thinking, such as combing hair, brushing teeth, and walking up or down stairs.

Related Medical History

Information should be obtained regarding other problems or conditions that might have affected the current injury. If a preparticipation examination was conducted, it can be used to verify past childhood diseases; allergies; cardiac, respiratory, vascular, musculoskeletal, or neurologic problems; use of contact lenses, dentures, or prosthetic devices; and past episodes of infectious diseases, loss of consciousness, recurrent headaches, heat stroke, seizures, eating disorders, or chronic medical problems. Previous musculoskeletal injuries or congenital abnormalities may place additional stress on joints and predispose the individual to certain injuries. In some situations, it may be appropriate to ask if the individual is taking any medication. The type, frequency, dosage, and effect of a medication may mask some injury symptoms.

A *In attempting to determine the cause and extent of injury, the female long jumper should be asked questions pertaining to the following: primary complaint (i.e., what, when, and how questions), mechanism of injury (i.e., position of the ankle at the time of injury and the direction of force), characteristics of symptoms (i.e., nature, location, severity, and disability), unusual sensation (i.e., sounds and feelings), related medical history, and past injuries/treatment.*

OBSERVATION AND INSPECTION

Q *A detailed history of the injury has been gathered from the long jumper. The information suggests an inversion sprain of her right ankle. In the continued assessment of this individual, observation and inspection should be performed. What observable factors might indicate the seriousness of injury?*

The objective evaluation during an injury assessment begins with observation and inspection. Although explained as a separate step, observation begins the moment the injured person is seen, and it continues throughout the assessment. **Observation** refers to the visual analysis of overall appearance, symmetry, general motor function, posture, and gait. **Inspection** refers to factors seen at the actual injury site, such as swelling, redness, ecchymosis, cuts, or scars.

Observation

Occasionally, the athletic trainer observes an individual sustain an injury. In many instances, however, the individual comes to the sideline, office, athletic training room, or clinic complaining of pain or discomfort. The athletic trainer should immediately assess the individual's state of consciousness and body language, which may indicate pain, disability, fracture, dislocation, or other conditions. It also is important to note the individual's general posture, willingness and ability to move, ease of motion, and overall attitude.

General observations may focus on the patient's estimated age, physical condition, and personal hygiene. Potential questions to address in the observation include:

- Does the individual appear to be healthy?
- Is the individual's weight appropriate for height, or is the individual underweight or overweight? Is the individual's weight appropriate for the type and level of sport/physical activity participation? Could this be a contributing factor in their injury?
- Is the individual's speech slurred, hoarse, loud, soft, incoherent, slow, fast, or hesitant?
- Is the individual hearing impaired? Is the individual's hearing better through one ear?
- Is the individual oriented to the surroundings or disoriented and unaware of time or place?
- Does the individual seem to be hesitant or avoid eye contact?

By observing these factors, the skilled clinician can more accurately document the patient's characteristics both quickly and accurately (3).

Symmetry and Appearance

The body should be scanned visually to detect **congenital** (i.e., existing at birth) or functional problems that may be a contributing factor. This includes observing any abnormalities in the spinal curves, general symmetry of the various body parts, and general posture of the body from anterior, lateral, and posterior views.

If it is not **contraindicated**, the examiner should observe the normal swing of the individual's arms and legs during walking. By standing behind, in front, and to the side of the individual, observation from all angles is permitted. A shoulder injury may be evident in a limited arm swing or by holding the arm close to the body in a splinted position. A lower extremity injury may produce a noticeable limp, or **antalgic gait**. Running on a treadmill can show functional problems that may have contributed to a lower extremity injury.

Field Strategy: Postural Assessment, a detailed outline of what to look for during this assessment, is available on the companion website at thePoint.

Motor Function

Many clinicians begin observation using a scan examination to assess general motor function. This examination rules out injury at other joints that may be overlooked because of intense pain or discomfort at the primary site of injury. In addition, pain in one area can be referred from another area. Observe the injured person performing gross motor movements of the neck, trunk, and extremities by asking the individual to:

- Extend, flex, laterally flex, and rotate the neck
- Bend forward to touch the toes
- Stand and rotate the trunk to the right and left
- Bring the palms together above the head and then behind the back
- Perform straight leg raises in hip flexion, extension, and abduction
- Flex the knees
- Walk on the heels and toes

Any hesitation by the patient to move a body part or favoring one side over the other should be noted.

Inspection of the Injury Site

Using discretion in safeguarding the person's privacy, the injured area should be fully exposed. This may require the removal of protective equipment and clothing.

The localized injury site should be inspected for any deformity, swelling (i.e., edema or joint effusion), discoloration (e.g., redness, pallor, or ecchymosis), signs of infection (i.e., redness, swelling, pus, red streaks, or swollen **lymph nodes**), scars that might indicate previous surgery, and general skin condition (e.g., oily, dry, blotchy with red spots, sores, or hives). Swelling inside the joint is called localized intra-articular swelling, or joint **effusion**, and this swelling makes the joint appear enlarged, red, and puffy. The amount of swelling should be measured in a quantifiable manner using girth measurements (Field Strategy 5.2). **Ecchymosis** is superficial discoloration of tissue indicative of injury. **Keloids**, which are scars that form at a wound but grow beyond its boundaries, may indicate previous injury. This condition is more common in individuals with dark skin, and it is particularly important to note if surgery may be indicated.

The injured area should be compared to the opposite side if possible. This bilateral comparison helps to establish normal parameters for the individual.

A *Observable factors relative to the injured sight that might indicate the seriousness of the injury sustained by the female long jumper include deformity, swelling, discoloration, and signs of previous injury. It is important to perform a bilateral inspection of the injury site as well*

FIELD STRATEGY 5.2

Taking Girth Measurements

1. Identify the joint line using prominent bony landmarks. The individual should be non–weight bearing.
2. Using a marked tongue depressor or tape measure, make incremental marks (e.g., 2, 4, and 6 inches) from the joint line. (Do not use a cloth tape measure, because they tend to stretch.)
3. Encircle the body part with the measuring tape, making sure not to fold or twist the tape (Fig. A). If measuring ankle girth, use a figure eight technique by positioning the tape across the malleoli proximally and around the navicular and base of the fifth metatarsal distally (Fig. B).
4. Take three measurements, and record the average.
5. Repeat these steps for the noninjured body part, and record all findings.
6. Increased girth at the joint line indicates joint swelling. Increased girth over a muscle mass indicates hypertrophy; decreased girth indicates atrophy.

Figure A

Figure B

as of the surrounding area. In addition, observation of general presentation, including the presence of guarding or antalgic gait, will provide important information concerning the nature of the injury.

PALPATION

Inspection of the long jumper's injury revealed mild swelling on the anterolateral aspect of the ankle. Otherwise, no abnormal findings were evident. Observation of the athlete, however, suggests guarding and hesitation to walk. Based on the information provided concerning the long jumper's condition, explain palpation to determine the extent and severity of the injury.

Informed consent must be granted before making physical contact with a patient. If the patient is younger than 18 years, permission must be granted by the parent or guardian. In some cultures and religions, the act of physically touching an exposed body part may present certain moral and ethical issues. Likewise, some patients may feel uncomfortable being touched by a health care provider of the opposite gender. If a same-gender clinician is not available, the evaluation should be observed by a third party (e.g., another clinician, parent, or guardian).

Bilateral palpation of paired anatomic structures can detect eight physical findings:

1. Temperature
2. Swelling
3. Point tenderness
4. Crepitus
5. Deformity
6. Muscle spasm
7. Cutaneous sensation
8. Pulse

The examiner should have clean, warm hands. Latex examination gloves should be worn as a precaution against disease and infection. Palpation should begin with gentle, circular pressure, followed by gradual, deeper pressure, and it should be initiated on structures away from the site of injury and progress toward the injured area. Palpating the most painful area last avoids any carryover of pain into noninjured areas.

Skin temperature should be noted when the fingers first touch the skin. Increased temperature at the injury site could indicate inflammation or infection, whereas decreased temperature could indicate a reduction in circulation.

The presence of localized or diffuse swelling can be determined through palpation of the injured area. In addition, palpation should assess differences in the density or "feel" of soft tissues that may indicate muscle spasm, hemorrhage, scarring, myositis ossificans, or other conditions.

Point tenderness and crepitus may indicate inflammation when felt over a tendon, bursa, or joint capsule. It is important to note any trigger points that may be found in muscle and, when palpated, refer pain to another site.

Palpation of the bones and bony landmarks can determine the possibility of fractures, crepitus, or loose bony or cartilaginous fragments. Possible fractures can be assessed with percussion, vibrations through use of a tuning fork, compression, and distraction (Fig. 5.2). The region should be immobilized if test results indicate a possible fracture.

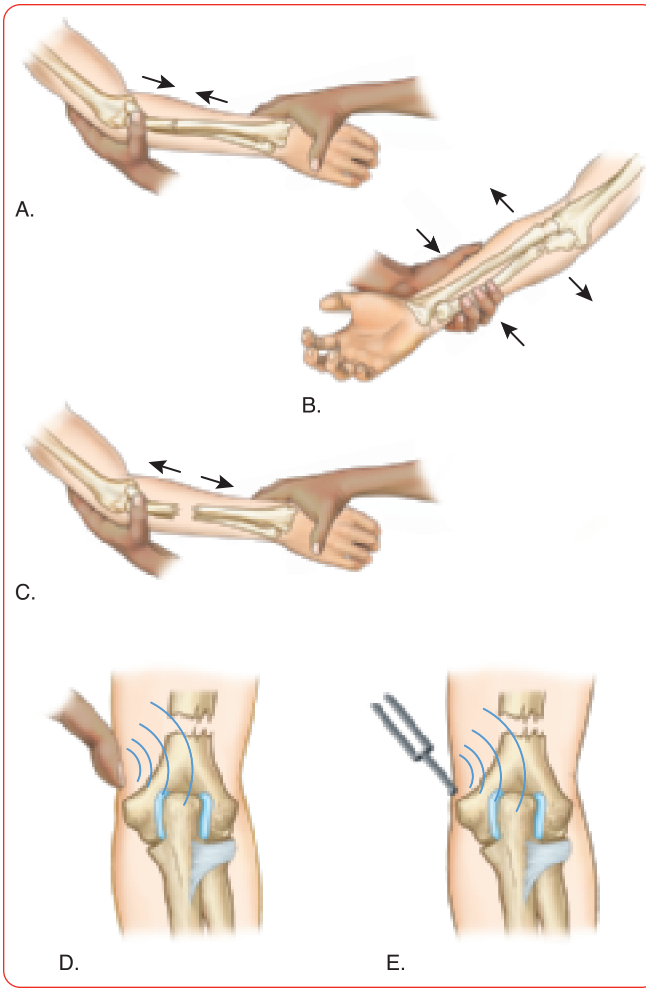


FIGURE 5.2 Determining a possible fracture. **A,** Compression (axial and circular). **B,** Distraction. **C,** Percussion. **D** and **E,** Vibration.

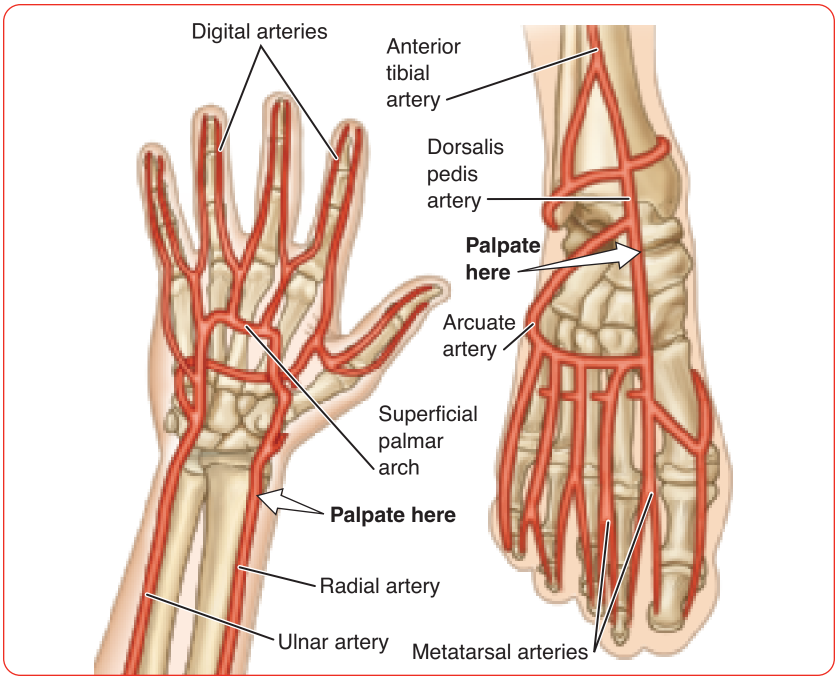


FIGURE 5.3 Peripheral pulses. Pulse can be taken at the radial pulse in the wrist (**A**) or the dorsalis pedis on the dorsum of the foot (**B**).

Cutaneous sensation can be tested by running the fingers along both sides of the body part and asking the patient if it feels the same on both sides. This technique can determine possible nerve involvement, particularly if the individual has numbness or tingling in the limb.

Peripheral pulses should be taken distal to an injury to rule out damage to a major artery. Common sites are the radial pulse at the wrist and the dorsalis pedis pulse on the dorsum of the foot (Fig. 5.3).

A *Palpation of bony and soft-tissue structures will provide information pertaining to several physical findings, including temperature, swelling, point tenderness, crepitus, deformity, muscle spasm, cutaneous sensation, and pulse. In the case of the long jumper, it is important to perform a bilateral palpation of key anatomic structures of the foot, ankle, and lower leg.*

PHYSICAL EXAMINATION TESTS

Q *The palpation component of the assessment of the long jumper confirms the presence of swelling over the anterolateral aspect of the ankle. It also reveals point tenderness in the area of the anterior talofibular ligament. Otherwise, no abnormal findings were present. How should testing proceed to determine the integrity of the soft-tissue structures and the extent and severity of injury?*

Once fractures and/or dislocations have been ruled out, soft-tissue structures, such as muscles, ligaments, the joint capsule, and bursae, are assessed using a variety of tests. This examination includes functional tests (i.e., active, passive, and resisted ROM), stress tests, special tests, neurologic testing, and sport- or activity-specific functional testing. General principles regarding physical examination are discussed in this chapter; more extensive explanations are provided in the individual joint chapters.

Functional Tests

Functional tests identify the patient's ability to move a body part through the ROM actively, passively, and against resistance. As with all tests, the noninjured side should be evaluated first to establish **normative data**. All motions common to each joint should be tested. Occasionally, it also may be necessary to test the joints proximal and distal to the injury to rule out any referred pain. The available active and passive ROM can be measured objectively using a **goniometer** (Fig. 5.4). The goniometer is a protractor with two rigid arms that intersect at a hinge joint. It is used to measure both joint position and available joint motion, and it can determine when the individual has regained normal motion at a joint.

The arms of the goniometer measure 0° to 180° of motion, or 0° to 360° of motion. Measurements are obtained by placing the goniometer's stationary arm parallel to the proximal bone. The axis of the goniometer should coincide with the joint axis of motion. The goniometer's moving arm is then placed parallel to the distal bone using specific anatomic landmarks as points of reference.

The normal ROM for selected joints is listed in Table 5.2 and in the individual joint chapters. Age and gender may influence ROM. Women in their teens and early twenties tend to have a greater ROM in all planes compared with men. Range of motion decreases after 20 years in both genders, with the decrease occurring to a greater extent in women.

Active Range of Motion

Active range of motion (**AROM**) is joint motion performed voluntarily by the individual through muscular contraction. Unless contraindicated, AROM should always be performed before **passive range of motion** (**PROM**). The AROM indicates the individual's willingness and ability to move the injured body part. Active movement determines possible damage to contractile tissue (i.e., muscle, muscle–tendon junction, tendon, and tendon–periosteal union) and measures muscle strength and movement coordination.

Measurement of all motions, except rotation, starts with the body in anatomic position. For rotation, the starting body position is midway between internal (medial) and external (lateral) rotation. The starting position is measured as 0°. The maximal movement away from the 0° point is the total available ROM. For example, subjective measurement of plantar flexion against gravity involves placing the individual prone on a table with the knees flexed. Next, both thighs are stabilized against the table, and the individual is instructed to plantar flex both ankles. Comparison of movement in both legs indicates if plantar flexion is equal bilaterally.

FIGURE 5.4 Goniometry measurement at the elbow. In anatomic position, the elbow is flexed. The goniometer axis is placed over the lateral epicondyle of the humerus. To accommodate using a goniometer that ranges from 0° to 180°, the stationary arm is held parallel to the longitudinal axis of the radius, pointing toward the styloid process of the radius. The moving arm is held parallel to the longitudinal axis of the humerus, pointing toward the tip of the acromion process. Range of motion is measured at the site where the pointer intersects the scale.

It is important to assess the individual's willingness to perform a movement, the fluidity of movement, and the extent of movement (joint ROM). If symptoms are present, their location in the arc of movement should be noted. Any increase in intensity or quality of symptoms also should be noted. Limitation in motion may result from pain, swelling, muscle spasm, muscle tightness, joint contractures, nerve damage, or mechanical blocks, such as a loose body. If the individual has pain or other symptoms with movement, it can be difficult to determine if the joint, muscle, or both are injured. It is important to assess the following:

- The point during the motion at which pain begins
- The presence of pain in a limited ROM (i.e., painful arc)
- The type of pain and if it is associated with the primary complaint

Anticipated painful movements should be performed last to avoid any carryover of pain from testing one motion to the next.

Passive Range of Motion

If the individual is unable to perform active movements at the injured joint because of pain or spasm, passive movement can be performed. In **passive movement**, the injured limb or body part is moved through the ROM with no assistance from the injured individual (Fig. 5.5). As PROM is performed, the individual should be positioned to allow the muscles to be in a relaxed state. The PROM distinguishes injury to contractile tissues from injury to noncontractile or inert tissues (i.e., bone, ligament, bursae, joint capsule, fascia, dura mater, and nerve roots). If no pain is present during passive motion but is present during active motion, injury to contractile tissue is involved. If noncontractile tissue is injured, passive movement is painful and limitation of movement may be

TABLE 5.2 Normal Ranges of Motion at Selected Joints (No Changes)

JOINT	MOTION	RANGE OF MOTION	JOINT	MOTION	RANGE OF MOTION
Cervical	Flexion	0–80°	Digits 2–5		
	Extension	0–70°	MCP	Flexion	0–90°
	Lateral flexion	0–45°		Extension	0–45°
	Rotation	0–80°		Abduction	0–20°
Lumbar	Forward flexion	0–60°	PIP	Flexion	0–100°
	Extension	0–35°	DIP	Flexion	0–90°
	Lateral flexion	0–20°	Hip	Flexion	0–120
	Rotation	0–50°		Extension	0–30°
Shoulder	Flexion	0–180°		Abduction	0–40°
	Extension	0–60°		Adduction	0–30°
	Abduction	0–180°		Internal rotation	0–40°
	Internal rotation	0–70°		External rotation	0–50°
	External rotation	0–90°	Knee	Flexion	0–135°
	Horizontal abduction/ adduction	0–130°		Extension	0–15°
Elbow	Flexion	0–150°		Medial rotation with knee flexed	0–25°
	Extension	0–10°		Lateral rotation with knee flexed	0–35°
Forearm	Pronation	0–80°	Ankle	Dorsiflexion	0–20°
	Supination	0–80°		Plantar flexion	0–50°
Wrist	Flexion	0–80°		Pronation	0–30°
	Extension	0–70°		Supination	0–50°
	Ulnar deviation	0–30°	Subtalar	Inversion	0–5°
	Radial deviation	0–20°		Eversion	0–5°
Thumb			Toes		
CMC	Abduction	0–70°	1st MTP	Flexion	0–45°
	Flexion	0–15°		Extension	0–75°
	Extension	0–20°	1st IP	Flexion	0–90°
	Opposition	Tip of thumb to tip of 5th finger	2nd to 5th MTP	Flexion	0–40°
MCP	Flexion	0–50°		Extension	0–40°
IP	Flexion	0–80°	PIP	Flexion	0–35°
			DIP	Flexion	0–30°
				Extension	0–60°

CMC, carpometacarpal; DIP, distal interphalangeal; IP, interphalangeal; MCP, metacarpophalangeal; MTP, metatarsophalangeal; PIP, posterior interphalangeal.

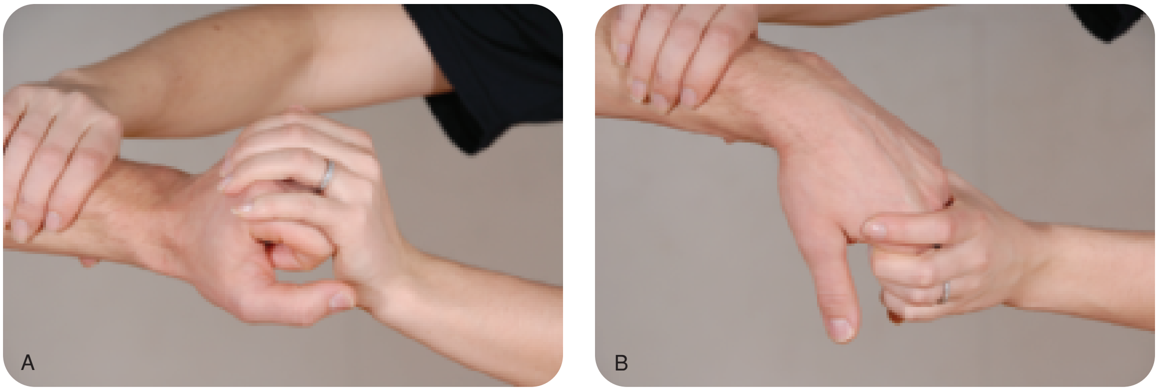


FIGURE 5.5 Passive movement. The body part is moved through the range of motion with no assistance from the injured individual. Any limitation of movement or presence of pain is documented. **A,** Starting position. **B,** End position.

present. Again, any potentially painful motions should be performed last to avoid any carryover of pain from one motion to the next.

A gentle overpressure should be applied at the end of the ROM to determine **end feel**. Overpressure is repeated several times to determine whether an increase in pain occurs, which could signify damage to noncontractile joint structures. The end feel can determine the type of disorder. Three normal end feel sensations (i.e., soft, firm, and hard) and four abnormal end feel sensations (i.e., soft, firm, hard, and empty) exist (Table 5.3).

Differences in ROM between active and passive movements can result from muscle spasm, muscle deficiency, neurologic deficit, contractures, or pain. If pain occurs before the end of the available ROM, it may indicate an acute injury. Stretching and manipulation of the joint are contraindicated. If pain occurs simultaneously at the end of the ROM, a subacute injury may be present, and a mild stretching program may be started cautiously. If no pain is felt as the available ROM is stretched, a chronic injury is present. An appropriate treatment and rehabilitation program should be initiated immediately.

Accessory movements are movements within the joint that accompany traditional active and PROM but cannot be performed voluntarily by the individual. Joint play motions occur within the joint, but only as a response to an outside force and not as a result of any voluntary movement. Joint play motions allow the joint capsule to "give" so that bones can move to absorb an external force. These movements include distraction, sliding, compression, rolling, and spinning of joint surfaces. Joint play movements aid the healing process, relieve pain, reduce disability, and restore full normal ROM. If joint play movement is absent or decreased, this movement must be restored before functional voluntary movement can be accomplished fully (5).

The presence of accessory movement can be determined by manipulating the joint in a position of least strain, called the **loose packed** or **resting position.** The resting position is the position in the ROM in which the joint is under the least amount of stress. It also is the position in which the joint capsule has its greatest capacity. The advantage of testing accessory movements in the loose packed position is that the joint surface contact areas are reduced, proper joint lubrication is enhanced, and friction and erosion in the joints are decreased.

See *Loose Packed Positions of Selected Joints* on the companion website at thePoint.

In contrast, a **close packed position** is the position in which two joint surfaces fit precisely together. In this position, the ligaments and joint capsule are maximally taut. The joint surfaces are maximally compressed and cannot be separated by distractive forces, nor can accessory movements occur. Therefore, if a bone or ligament is injured, pain increases as the joint moves into the close packed position. If swelling is present within the joint, the close packed position cannot be achieved.

See *Closed Packed Positions of Selected Joints* on the companion website at thePoint.

TABLE 5.3 Normal and Abnormal Joint End Feels

END FEEL	STRUCTURE	EXAMPLE
Normal End Feel Sensations		
Soft	Soft-tissue approximation	Elbow flexion (contact between soft tissue of the forearm and anterior arm)
Firm	Muscular stretch	Hip extension (passive stretch of iliopsoas muscle)
	Capsular stretch	External rotation at the shoulder (passive stretch of anterior glenohumeral joint capsule)
	Ligamentous stretch	Forearm supination (tension in the palmar radioulnar ligament of the inferior radioulnar joint, interosseous membrane, oblique cord)
Hard	Bone to bone	Elbow extension (contact between olecranon process and olecranon fossa)
Abnormal End Feel Sensations		
Soft	Occurs sooner or later in the ROM than is usual or in a joint that normally has a firm or hard end feel; feels boggy	Soft-tissue edema Synovitis Ligamentous stretch or tear
Firm	Occurs sooner or later in the ROM than is usual, or in a joint that normally has a soft or hard end feel	Increased muscular tonus Capsular, muscular, ligamentous shortening
Hard	Occurs sooner or later in the ROM than is usual, or in a joint that normally has a soft or firm end feel; a bony grating or bony block is felt	Chondromalacia Osteoarthritis Loose bodies in joint Myositis ossificans Fracture
Empty	No end feel, because the end of the ROM is never reached because of pain; no resistance is felt except for the patient's protective muscle splinting or muscle spasm	Acute joint inflammation Bursitis Fracture Psychogenic in origin

ROM, range of motion.

Resisted Manual Muscle Testing

Resisted manual muscle testing can assess muscle strength and detect injury to the nervous system. Resistance testing is performed by applying an overload pressure in a stationary or static position (sometimes referred to as a **break test**) or throughout the full ROM. Muscle weakness and pain indicate a muscle strain. Muscle weakness in the absence of pain may indicate nerve damage.

In performing a break test, overload pressure is applied with the joint in a neutral position to relax joint structures and reduce joint stress. The muscles are more effectively stressed in this position. When performing a break test, the limb is stabilized proximal to the joint to prevent other motions from compensating for weakness in the involved muscle. Resistance is provided distally on the bone to which the muscle or muscle group attaches; resistance should not be distal to a second joint. In a fixed position, the individual is asked to elicit a maximal contraction while the body part is stabilized to prevent little or no joint movement. For example, when testing the strength of the elbow flexors, the patient's elbow should be positioned at 90°, with the upper arm stabilized against

TABLE 5.4 Grading System for Manual Muscle Testing

NUMERIC	VERBAL	CLINICAL FINDINGS
5	Normal	Complete ROM against gravity with maximal overload
4	Good	Complete ROM against gravity with moderate overload
3+	Fair +	Complete ROM against gravity with minimal overload
3	Fair	Complete ROM against gravity with no overload
3–	Fair –	Some, but not complete, ROM against gravity
2+	Poor +	Initiates motion against gravity
2	Poor	Complete ROM with some assistance and gravity eliminated
2–	Poor –	Initiates motion if gravity is eliminated
1	Trace	Evidence of slight muscular contraction; no joint motion
0	Zero	No muscle contraction palpated

ROM, range of motion.

the body. While the patient maintains the arm in that position, the examiner applies downward overpressure on the distal forearm (Fig. 5.6). Pressure should be held for at least 5 seconds and be repeated five or six times to indicate muscle weakening and the presence or absence of pain. A standardized grading system can be used to measure muscle contraction, but the results are negated if the contraction causes pain (Table 5.4).

Testing resistance throughout the full ROM offers two advantages: First, a better overall assessment of weakness can be determined, and second, a **painful arc** of motion can be located which might otherwise go undetected if the test is only performed in the midrange. When performing resisted testing, the body segment is placed in a specific position to isolate the muscle or muscle group. The muscle or muscle group to be tested is placed in a stretched or elongated position. This position prevents other muscles in the area from performing the movement. Manual pressure is exerted throughout the full ROM and is repeated several times to reveal weakness or pain. The presence of pain during motion should be noted. In this manner, both subjective information (i.e., what the individual feels) and objective information (i.e., weakness) are gathered.

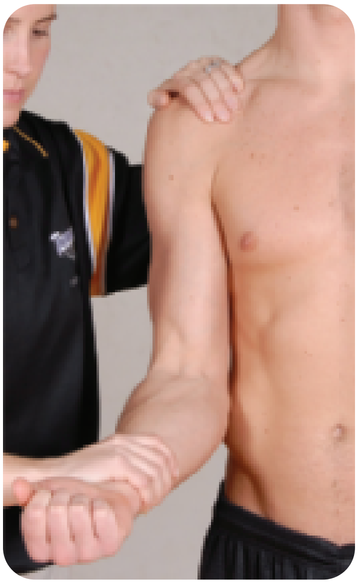


FIGURE 5.6 Resisted manual muscle testing in a static position. The arm is stabilized against the body. The individual is asked to prevent any movement while downward pressure is applied on the distal forearm.

Stress Tests

Each body segment has a series of tests to assess joint function and integrity of joint structures. These tests assess the integrity of noncontractile tissues (e.g., ligaments, intra-articular structures, and joint capsule). Stress tests occur in a single plane and are graded according to severity. Specifically, sprains of ligamentous tissue generally are graded on a three-degree scale after a specific stress is applied to a ligament to test its laxity (Table 5.5). **Laxity** describes the amount of "give" within a joint's supportive tissue. **Instability** refers to a joint's inability to function under the stresses encountered during functional activities.

Ligamentous testing should be done bilaterally and compared with baseline measures. It is essential to perform a test at the proper angle, because a seemingly minor change in the joint angle can significantly alter the laxity of the tissue being stressed. In some instances, it may be appropriate to perform ligamentous stress testing before any other testing. During a stress test, it is important that the patient be able to relax the involved area, because muscle guarding could interfere with the

TABLE 5.5 Grading System for Ligamentous Laxity

GRADE	LIGAMENTOUS END FEEL	DAMAGE
I	Firm (normal)	Slight stretching of the ligament with little or no tearing of the fibers. Pain is present, but the degree of stability roughly compares with that of the opposite extremity.
II	Soft	Partial tearing of the fibers. The joint line "opens up" significantly when compared with the opposite side.
III	Empty	Complete tearing of the ligament. The motion is restricted by other joint structures, such as tendons.

effectiveness of testing. If functional testing causes pain, the patient may find it more difficult to maintain a relaxed position. As such, if a ligamentous injury is suspected, initiating testing with stress tests may be advantageous.

Figure 5.7 demonstrates a **valgus** stress test on the elbow joint to assess the integrity of the joint medial collateral ligaments. During an on-site assessment, tests to determine a possible fracture and major ligament damage at a joint should always be performed before moving an individual who is injured. Only the specific tests deemed to be necessary for the specific injury should be used. Because of the wide variety of stress tests, each is discussed within subsequent chapters.

Special Tests

Special tests have been developed for specific body parts or areas as a means of detecting injury or related pathology. In general, special tests occur across planes and are not graded. For example, Speed's test is used as a technique for assessing pathology related to bicipital tendonitis, and Thompson's test is used to assess potential rupture of the Achilles tendon.

Neurologic Testing

A segmental nerve is the portion of a nerve that originates in the spinal cord and is referred to as a nerve root. Most nerve roots share two components:

1. A somatic portion, which innervates a series of skeletal muscles and provides sensory input from the skin, fascia, muscles, and joints.
2. A visceral component, which is part of the autonomic nervous system.

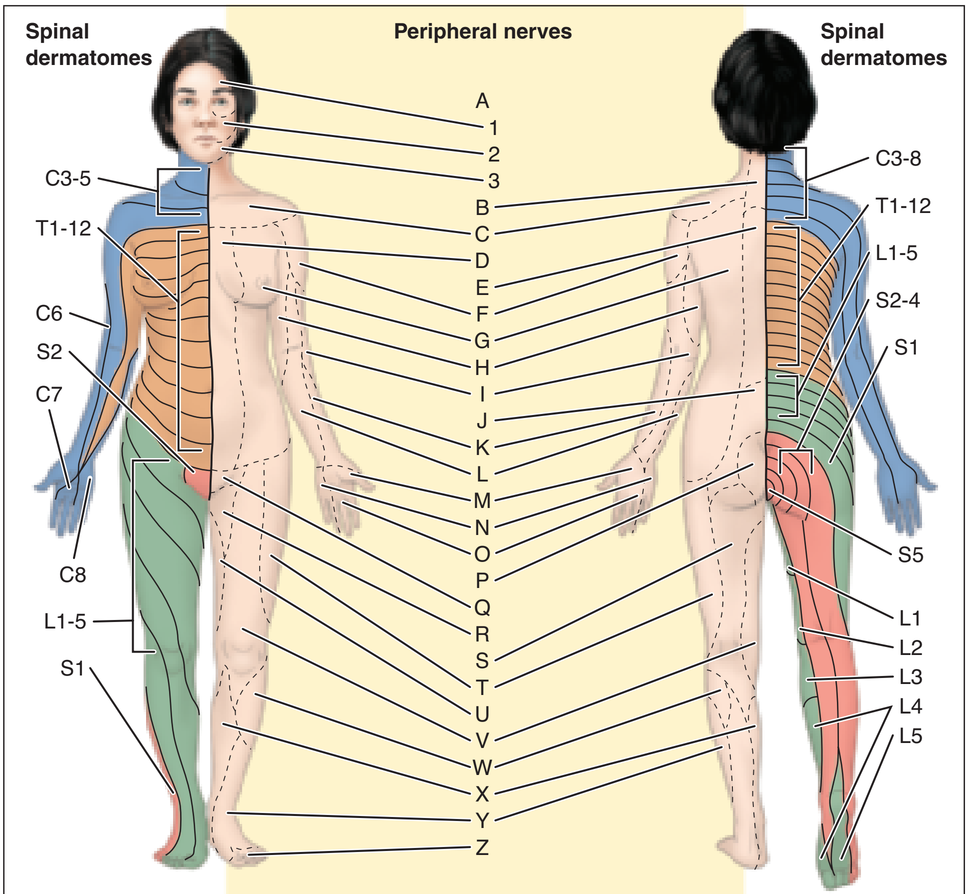
The autonomic system supplies the blood vessels, dura mater, periosteum, ligaments, and intervertebral disks, among many other structures.

Nerves commonly are injured by tensile or compressive forces, and these injuries are reflected in both motor and sensory deficits. The motor component of a segmental nerve is tested using a **myotome**, a group of muscles primarily innervated by a single nerve root. The sensory component is tested using a **dermatome**, an area of skin supplied by a single nerve root. An injury to a segmental nerve root often affects more than one peripheral nerve and does not demonstrate the same motor loss or sensory deficit as an injury to a single peripheral nerve. Dermatomes, myotomes, and reflexes are used to assess the integrity of the central nervous system (CNS). Peripheral nerves are assessed using manual muscle testing and noting cutaneous sensory changes in peripheral nerve patterns. Neurologic testing is only necessary in orthopaedic injuries when an individual complains of numbness, tingling, or a burning sensation or suffers from unexplained muscular weakness.

FIGURE 5.7 Stress tests. The application of a valgus stress on the elbow joint can assess the integrity of the joint medial collateral ligaments.

Dermatomes

The sensitivity of a dermatome can be assessed by touching a patient with a cotton ball, paper clip, pads of the fingers, or fingernails. In doing so, the examiner should ask the individual about the sensations being experienced. It is important to determine the nature of the sensation (e.g., a sharp or dull sensation) and to assess whether the same sensation was experienced in testing the uninjured body segment. Abnormal responses may be decreased tactile sensation (**hypoesthesia**), excessive tactile sensation (**hyperesthesia**), or loss of sensation (**anesthesia**). **Paresthesia** is another abnormal sensation characterized by a numb, tingling, or burning sensation. Figure 5.8 illustrates dermatome patterns for the segmental nerves.



A Divisions of trigeminal 1 Opthalmic 2 Maxillary 3 Mandibular	L Median antebrachial cutaneous
B Posterior cervical rami	M Radial
C Branches from cervical plexus	N Ulnar
D Anterior thoracic rami	O Median
E Posterior thoracic rami	P Posterior sacral rami
F Axillary	Q Iliohypogastric
G Lateral thoracic rami	R Ilioinguinal
H Branches from medial cord of brachial plexus	S Posterior femoral cutaneous
I Radial	T Lateral femoral cutaneous
J Posterior lumbar rami	U Obturator
K Lateral antebrachial cutaneous	V Anterior femoral cutaneous
	W Common peroneal
	X Saphenous
	Y Superficial peroneal
	Z Deep peroneal

FIGURE 5.8 **Cutaneous sensation.** The cutaneous sensation patterns of the spinal nerves dermatomes differ from the patterns innervated by the peripheral nerves.

Myotomes

The majority of muscles receive segmental innervation from two or more nerve roots. Selected motions, however, may be innervated predominantly by a single nerve root (myotome). Resisted muscle testing of a selected motion can determine the status of the nerve root that supplies that myotome (Table 5.6). In assessing nerve integrity, muscle contractions must be held for at least 5 seconds. A normal response is a strong muscle contraction. Weakness in the myotome indicates a possible injury to the spinal cord nerve root. A weakened muscle contraction may indicate partial paralysis (**paresis**) of the muscles innervated by the nerve root being tested. In a peripheral nerve injury, complete paralysis of the muscles supplied by that nerve occurs. For example, the L3 myotome is tested with knee extension. If the L3 nerve root is damaged at its origin in the spine, a weak muscle contraction occurs. This weakness results because the quadriceps receive innervation from L2 and L4 segmental nerves. If, however, the peripheral femoral nerve, which contains segments of L2, L3, and L4, is damaged proximal to the quadriceps muscle, the muscle cannot receive any nerve impulses; therefore, it is unable to contract and execute knee extension.

Reflexes

Damage to the CNS can be detected by stimulation of the deep tendon reflexes (DTRs) (Table 5.7). Reflex testing is limited, however, because not all nerve roots have a DTR. The most familiar DTR is the patellar, or knee-jerk, reflex elicited by striking the patellar tendon with a reflex hammer, causing a rapid contraction of the quadriceps muscle (Fig. 5.9). Deep tendon reflexes tend to be diminished or absent if the specific nerve root being tested is damaged. Exaggerated, distorted, or absent reflexes indicate degeneration or injury in specific regions of the nervous system. This may be demonstrated before other signs are apparent. Abnormal DTRs are not clinically relevant, however, unless they are found with sensory or motor abnormalities.

Superficial reflexes are reflexes provoked by superficial stroking, usually with a moderately sharp object that does not break the skin. This action produces a reflex muscle contraction. For

TABLE 5.6 Myotomes Used to Test Selected Nerve Root Segments

NERVE ROOT SEGMENT	ACTION TESTED
C1–C2	Neck flexion[a]
C3	Neck lateral flexion[a]
C4	Shoulder elevation
C5	Shoulder abduction
C6	Elbow flexion and wrist extension
C7	Elbow extension and wrist flexion
C8	Thumb extension and ulnar deviation
T1	Intrinsic muscles of the hand (finer abduction and adduction)
L1–L2	Hip flexion
L3	Knee extension
L4	Ankle dorsiflexion
L5	Toe extension
S1	Ankle plantar flexion, foot eversion, hip extension
S2	Knee flexion

[a]These myotomes should not be performed in an individual with a suspected cervical fracture or dislocation, because they may cause serious damage or possibly death.

TABLE 5.7 Deep Tendon Reflexes

REFLEX	STIMULATION SITE	NORMAL RESPONSE	SEGMENTAL LEVEL
Jaw	Mandible	Mouth closes	Cranial nerve V
Biceps	Biceps tendon	Biceps contraction	C5–C6
Brachioradialis	Brachioradialis tendon or just distal to the musculotendinous junction	Flexion of elbow and/or pronation of forearm	C5–C6
Triceps	Distal triceps tendon just superior to olecranon process	Elbow extension/muscle contraction	C7–C8
Patella	Patellar tendon	Leg extension	L3–L4
Medial hamstrings	Semimembranosus tendon	Knee flexion/muscle contraction	L5, S1
Lateral hamstrings	Biceps femoris tendon	Knee flexion/muscle contraction	S1–S2
Tibialis posterior	Tibialis posterior tendon behind medial malleolus	Plantar flexion of foot with inversion	L4–L5
Achilles	Achilles tendon	Plantar flexion of foot	S1–S2

example, the normal response when testing the upper abdominal reflex is for the umbilicus to move up and toward the areas being stroked; this reflex represents segmental level T7–T9. An absence of a superficial reflex indicates a lesion in the cerebral cortex of the brain (upper motor neuron lesion).

Additional examples of superficial reflexes can be found on the companion website at thePoint.

Pathologic reflexes (Table 5.8) can indicate upper motor neuron lesions if bilateral or lower motor neuron lesions if unilateral. The presence of the reflex often serves as a sign of some pathologic condition.

TABLE 5.8 Pathologic Reflexes[a]

REFLEX	ELICITATION	POSITIVE RESPONSE	PATHOLOGY
Babinski's[b]	Stroke lateral aspect of sole of foot	Extension of big toe; fanning of four small toes	Pyramidal tract lesion
		Test is normal in newborns	Organic hemiplegia
Chaddock's	Stroke lateral side of foot beneath lateral malleolus	Same response as above	Pyramidal tract lesion
Oppenheim's	Stroke anteromedial tibial surface	Same response as above	Pyramidal tract lesion
Gordon's	Squeeze calf muscle firmly	Same response as above	Pyramidal tract lesion
Brudzinski's	Passive flexion of one lower limb	Similar movement occurs in opposite limb	Meningitis
Hoffman's (digital)[c]	"Flicking" of terminal phalanx of index, middle, or ring finger	Reflex flexion of distal phalanx of thumb and of distal phalanx of index or middle finger (whichever one was not "flicked")	Increased irritability of sensory nerve in tetany Pyramidal tract lesion

[a]Bilateral positive response indicates an upper motor neuron lesion. Unilateral positive response may indicate a lower motor neuron lesion.

[b]Test is most commonly performed in the lower limb.

[c]Test is most commonly performed in the upper limb.

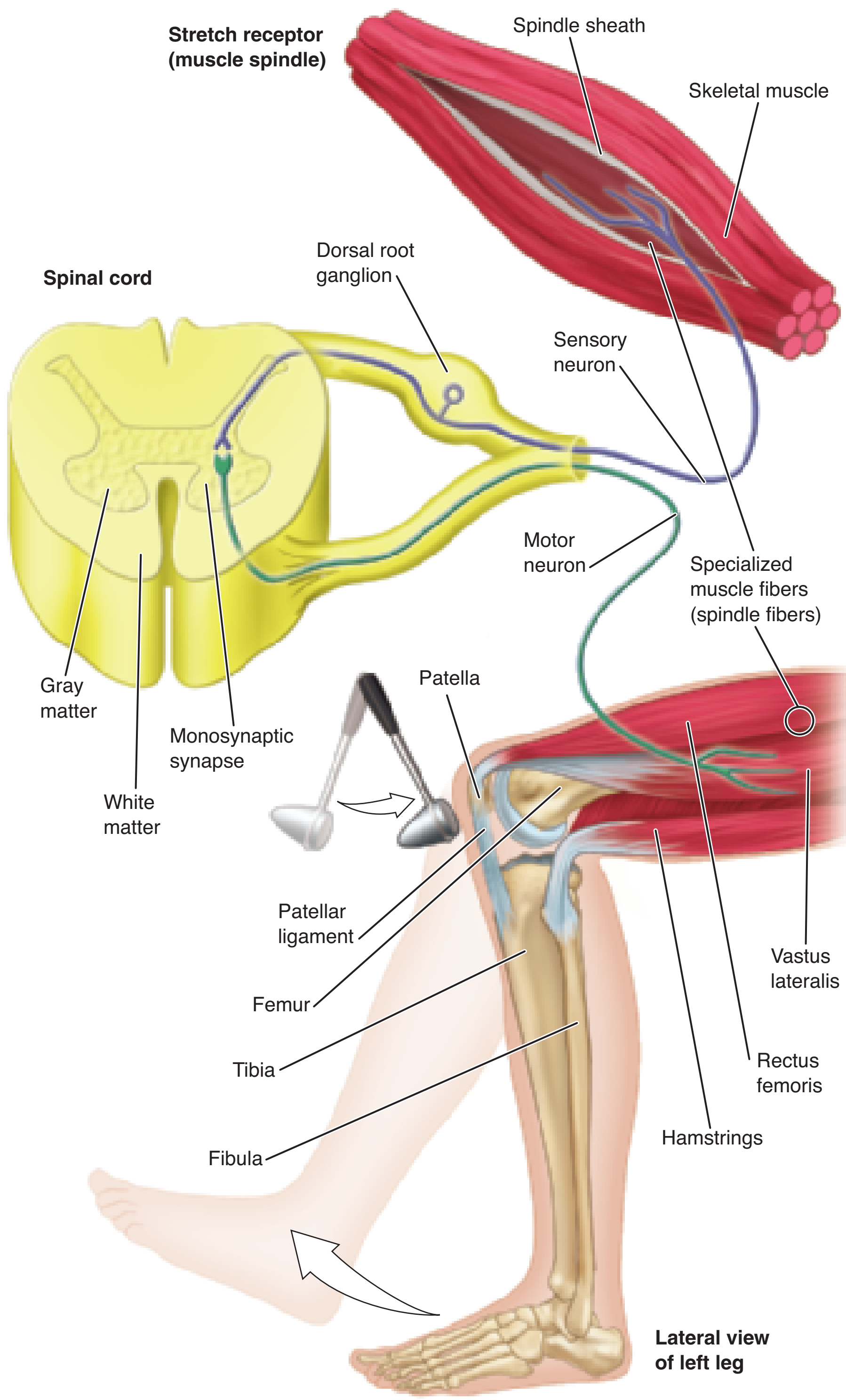


FIGURE 5.9 Reflexes. Reflexes can indicate the presence of nerve root damage. The most familiar stretch reflex is the knee jerk, or patellar reflex, performed by tapping the patellar tendon with a reflex hammer, causing involuntary knee extension.

Peripheral Nerve Testing

Motor function in peripheral nerves is assessed by resisted manual muscle testing throughout the full ROM. Sensory deficits are assessed in a manner identical to that of dermatome testing, except the cutaneous patterns differ (Fig. 5.8). Special compression tests also may be used on nerves close to the skin surface, such as the ulnar and median nerves. For example, the "Tinel sign" test is performed by tapping the skin directly over a superficial nerve (see Fig. 14.16). A positive sign, indicating irritation or compression of the nerve, results in a tingling sensation traveling into the muscles and skin supplied by the nerve.

Activity-Specific Functional Testing

Before permitting an individual to return to sport and physical activity after an injury, the individual's condition must be fully evaluated so that the risk of reinjury is minimal. Activity-specific tests involve the performance of active movements typical of those executed by the individual during sport or activity participation. These movements should assess strength, agility, flexibility, joint stability, endurance, coordination, balance, and activity-specific skill performance. In the rehabilitation process, the individual initially performs these skills at low intensity, then gradually increases the intensity as his or her condition improves. For example, in a lower leg injury, testing should begin by assessing walking, jogging, and then running forward and backward. If these skills are performed pain-free and without a limp, the individual might then be asked to run in a figure-eight or zigzag pattern. Again, each test must be performed pain-free and without a limp. An individual's balance can be tested by performing tasks with the eyes closed (e.g., walking a straight line on the toes and heels, balancing on a wobble board, or walking sideways on the hands while in a push-up position). Any individual who has been discharged from rehabilitation also should be cleared by a physician for participation.

A *The testing component of an assessment should include functional testing, stress testing, special tests, neurologic testing, and activity-specific functional testing. Given the findings (i.e., history, observation, inspection, and palpation) pertaining to the long jumper, a ligamentous injury should be suspected. As such, it would be appropriate to begin testing by stress testing the ligaments of the ankle. This should be followed by functional testing and neurologic testing. Based on those findings, activity-specific functional testing may or may not be appropriate.*

THE EMERGENCY MEDICAL SERVICES SYSTEM

Q *A gymnast slipped off the springboard on an approach to a vault and collided full force into the horse. As the on-site athletic trainer, you observe the gymnast lying motionless on the floor. Based on this information, is it appropriate to activate the institution's emergency medical plan?*

Serious injuries can be frightening, particularly if breathing or circulation is impaired. As the first responder on the scene, the athletic trainer is expected to evaluate the situation, assess the severity of injury, recognize life-threatening conditions, provide immediate emergency care, and initiate any emergency procedures to ensure the individual is transported to the nearest medical facility without delay. An **emergency medical services** (**EMS**) system is a well-developed process that activates the emergency health care services of the athletic training facility and community to provide immediate care to an injured individual. Every athletic training facility should develop a plan that details the activation of their EMS system. The emergency medical plan should be a written document that is comprehensive yet flexible enough to adapt to any emergency situation at any activity venue. The plan should identify the following general principles (6):

- The personnel, with their qualifications, needed to perform responsibilities in executing the plan.
- Equipment needed to carry out the tasks required in the event of an emergency.

- Mechanism of communication to the emergency care providers, and the mode of transportation for the patient.
- The facilities to which the patient will be taken, including how and when those facilities will be notified in advance of the scheduled event or contest.
- Documentation verifying the implementation and evaluation of the emergency plan, actions taken during the emergency, evaluation of the emergency response, and institutional personnel training.
- Documentation of an annual review and rehearsal of the emergency plan, and notations indicating whether the emergency plan was modified and, if so, how the plan was changed.

Every institution/facility should have an emergency response team. The designated emergency response team should meet with representatives from local EMS agencies to discuss, develop, and evaluate the facility's emergency plan. As part of this process, individual responsibilities and protocols for an emergency situation should be determined. In developing the emergency medical plan, it is important to recognize that in any given situation, the members of the emergency response team can vary. For example, a physician may or may not be on-site, the athletic trainer may be working alone or part of an on-site staff, and emergency medical technicians may be present at an event or available only if summoned. The following questions should be addressed relative to each event:

- What emergency equipment must be available?
- What equipment will be provided by the local EMS agency (e.g., spine board and splints) if in attendance at an event?
- Who will be responsible for ensuring that the emergency equipment is operational?
- What type of communication will be used to contact emergency personnel? Who will activate the facility's emergency medical plan?
- Who will assess the injured individual on-site, and under what circumstances will a local EMS agency be called to the site?
- If a physician is present, what are the responsibilities of other medical personnel (e.g., athletic trainer and emergency medical technician)?
- If a physician is not present and the athletic trainer is evaluating the situation, what are the responsibilities of emergency medical technicians responding to the situation?
- If it becomes necessary to stabilize and transport an individual to a medical facility, who will direct the stabilization, and what protocol will be followed for the removal of protective equipment?
- Who will supervise other participants if the athletic trainer is assessing and providing care to an injured individual?
- Who will be responsible for the proper disposal of items and equipment exposed to blood or other bodily fluids?

A written emergency plan should be developed for each activity site to address these questions.

The emergency response team should practice the emergency plan through regular educational workshops and training exercises. The use of interactive or simulation practice exercises can better prepare individuals to assume their roles in rendering emergency care.

Field Strategy: Developing an Emergency Care Plan, available on the companion website at thePoint, summarizes several important issues in developing an emergency medical plan. You also will find a checklist for materials and supplies that should be included in an athletic training medical kit and in the emergency crash kit.

While the condition of the gymnast may eventually warrant activation of the institution's emergency medical plan, there is not sufficient information at this point to activate the plan. It is important that the athletic trainer assess the athlete's condition to determine whether activation of the emergency medical plan is necessary.

EMERGENCY INJURY ASSESSMENT

In assessing the condition of the injured gymnast, what sequential process can be used to determine if the CNS and/or cardiorespiratory systems are critically injured? What conditions warrant activation of the emergency medical plan, including summoning the local EMS agency?

Injuries or conditions that impair—or that have the potential to impair—vital function of the CNS and cardiorespiratory system are considered to be emergency situations. In responding to an on-field or on-site injury, the initial assessment performed by the athletic trainer is intended to rule out any life-threatening conditions. The **primary survey** determines level of responsiveness and assesses airway, breathing, and circulation. If at any time during the assessment conditions exist that are an immediate threat to life, or if "red flags" are noted (Box 5.2), the assessment process should be terminated and the emergency medical plan activated.

Occasionally, situations can occur in which more than one individual is injured. **Triage** refers to the rapid assessment of all injured individuals followed by return to the most seriously injured to provide immediate treatment.

Once it has determined that a life-threatening condition does not exist, a secondary survey is performed to identify the type and extent of any injury and the immediate **disposition** of the condition. Decisions must be made regarding the on-field management of the injury (e.g., controlling bleeding or immobilizing a possible fracture or dislocation), the safest method of transportation from the field (e.g., manual conveyance, stretcher, or spine board), and the need for rapid referral of the individual for further medical care.

On-Site History

Regardless of the setting (e.g., on-site or athletic training room), assessment protocols should contain the same basic components. During an on-field (on-site) assessment, the athletic trainer should assume a position close to the injured individual. One hand should be placed on the forehead of the injured individual to stabilize the head and neck and prevent any unnecessary movement. The history of the injury can be obtained from the individual or, if the individual is unconscious, from bystanders who may have witnessed the injury. Questions should be open-ended to allow the person to provide as much information as possible about the injury. The athletic trainer should listen attentively for clues that may indicate the nature of the injury. On-site history taking should be relatively brief as compared to a more comprehensive clinical evaluation. Critical areas of information include:

- **Location of pain.** The site of the injury should be identified; it is important to be aware that several areas may be injured.
- **Presence of abnormal neurologic signs.** The presence of any tingling, numbness, or loss of sensation should be noted.
- **Mechanism of injury.** The position of the injured body part at the point of impact and the direction of force should be identified.

Box 5.2 "Red Flags" Indicating a Serious Emergency and Activation of the Emergency Medical Plan

- Airway obstruction
- Respiratory failure
- Severe shock
- Severe chest or abdominal pains
- Excessive bleeding
- Suspected spinal injury
- Head injury with loss of consciousness
- Severe heat illness
- Fractures involving several ribs, the femur, or pelvis

FIELD STRATEGY 5.3

Determining the History of Injury and Level of Responsiveness

Stabilize the head and neck. Do not move the individual unnecessarily until a spinal injury is ruled out. If nonresponsive:

1. Call the person's name loudly, and gently tap the sternum or touch the arm. If no response, rap the sternum more forcibly with a knuckle, or pinch the soft tissue in the armpit (axillary fold). Note if withdrawal from the painful stimulus occurs. If no response, immediately initiate the primary survey.
2. If airway, breathing, and circulation (ABCs) are adequate, gather a history of the injury. If you did not see what happened, question other players, supervisors, officials, and bystanders. Ask:
   - What happened?
   - Did you see the individual get hit, or did the individual just collapse?
   - How long has the individual been unresponsive?
   - Did the individual become unresponsive suddenly or deteriorate gradually?
   - If it was gradual, did anyone talk to the individual before you arrived?
   - What did the person say? Was it coherent? Did the person moan, groan, or mumble?
   - Has this ever happened before to this individual?

   If conscious, ask:

   1. What happened? Note if the individual is alert and aware of his or her surroundings or has any short- or long-term memory loss. If the individual is lying down, determine if the person was knocked down, fell, or rolled voluntarily into that position.
   2. Are you in pain? Where is the pain? Is it localized, or does it radiate into other areas?
   3. Did you hear any sounds or any unusual sensations when the injury occurred?
   4. Have you ever injured this body part before or experienced a similar injury?
   5. Do you have a headache? Are you experiencing any nausea? Are you dizzy? Can you see clearly?
   6. Are you taking any medication (e.g., prescription, over-the-counter, or vitamins)?

   It is important to avoid leading the individual. Instead, the individual should be encouraged to describe what happened, and the examiner should listen attentively for clues to the nature of the injury.

- **Associated sounds.** A report of hearing a "snap" or a "pop" may indicate a fracture or rupture of a ligament or tendon.
- **History of the injury.** Any preexisting condition or injury may have exacerbated the current injury or may complicate the injury assessment.

The history of the evaluation will enable the athletic trainer to determine the possibility of an associated head or spinal injury, to rule out injury to other body areas, and if necessary, to calm the individual. If the individual cannot open the eyes on verbal command or does not demonstrate withdrawal from painful stimulus, a serious "red flag" injury exists. Field Strategy 5.3 lists several questions to determine a history of the injury and assess the level of responsiveness.

On-Site Observation and Inspection

In an on-site evaluation, the initial observation is completed en route to the injured individual and, therefore, occurs prior to the history taking. Critical areas to observe include:

- **The surrounding environment.** Any equipment or apparatus that may have contributed to the injury should be noted.

- **Body position.** The position of the individual (e.g., prone, supine, or side-lying) should be observed. The appearance of a gross deformity in one of the limbs should be noted. In severe brain injuries, a neurologic sign called "posturing" of the extremities can occur (Fig. 5.10). **Decerebrate rigidity** is characterized by extension of all four extremities. **Decorticate rigidity** is characterized by extension of the legs and marked flexion in the elbows, wrists, and fingers.
- **Movement of the individual.** An individual holding an injured body part and expressing pain indicates consciousness as well as an intact CNS and cardiovascular system. If the individual is not moving or is having a seizure, possible systemic, psychological, or neurologic dysfunction should be suspected.
- **Level of responsiveness.** Sometimes referred to the "shake and shout" stage, the examiner tries to arouse the unconscious individual by gently shaking (without moving the head or neck) and by shouting into each ear. This action will determine whether the person is alert, restless, lethargic, or nonresponsive.
- **Primary survey.** The "ABC technique" should be employed to ensure an open **A**irway, adequate **B**reathing, and **C**irculation.
- **Inspection for head trauma.** The pupils of the eyes should be observed, noting a normal appearance, dilation, or constriction. The facial area and the area behind the ears should be inspected for any redness or ecchymosis. The presence of any clear fluid or bloody discharge from the

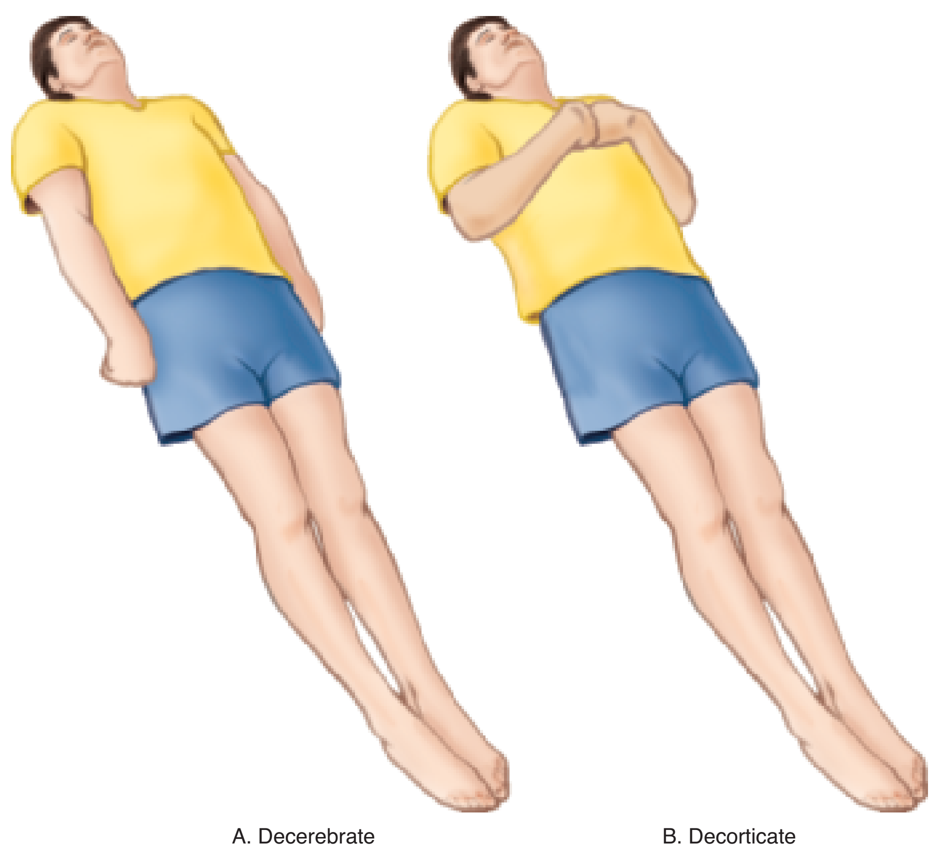


FIGURE 5.10 Body posturing. A, Decerebrate rigidity is characterized by extension in all four extremities. **B,** Decorticate rigidity is characterized by extension of the legs and flexion of the elbows, wrist, and fingers. Both conditions indicate a severe brain injury.

ears or nose should be noted; this fluid could be cerebrospinal fluid leaking from the cranial area as a result of a skull fracture.

- **Inspection of the injured body part.** The injured area should be checked for joint alignment, redness, ecchymosis, swelling, or cuts. These observations should always be compared to the uninjured body part.

On-Site Palpation

The palpation should include a general head-to-toe assessment. This is done using a gentle, squeezing motion to palpate methodically down the trunk of the body to the fingers and toes. Palpation includes:

- **Bony palpation.**
  - **Possible fractures.** Detected with palpation, percussion, vibration, compression, and distraction (Fig. 5.2).
  - **Crepitus.** Associated with fracture, swelling, or inflammation.
- **Soft-tissue palpation.**
  - **Swelling.** May indicate diffuse hemorrhage or inflammation in a muscle, ligament, bursa, or joint capsule.
  - **Deformity.** An indentation may indicate a rupture in a musculotendinous unit; a protruding, firm bulge may indicate a joint dislocation, ruptured bursa, muscle spasm, or hematoma.
- **Skin temperature.**
  - Normally, the skin is dry, but certain conditions, such as cold, shock, or fever can alter surface blood vessels.
  - Skin temperature is assessed by placing the back of the hand against the individual's forehead or by palpating appendages bilaterally.

On-Site Functional Testing

When not contraindicated, the athletic trainer should identify the individual's willingness to move the injured body part. For a lower extremity injury, this should be expanded to include the willingness to bear weight. Movement is contraindicated, however, in the presence of a possible head or spinal injury, fracture, dislocation, or muscle/tendon rupture. Functional testing includes:

- **Active range of motion.** The individual is asked to move the injured body part through the available ROM. The quantity and quality of movement in the absence of pain should be noted.
- **Passive range of motion.** The examiner moves the injured extremity through the available pain-free ROM, noting any painful arc of motion.
- **Resisted range of motion.** An overpressure (break pressure) should be applied to the involved muscle or muscle group to determine the ability to sustain a forceful contraction.
- **Weight bearing.** If the individual successfully completes active, passive, and resisted motion, walking may be permitted. If the individual is unable to perform these tests, however, or if critical signs and symptoms are apparent, removal from the area should be performed in a non–weight bearing manner.

On-Site Stress Testing

Testing for ligamentous integrity is performed before any muscle guarding or swelling occurs to prevent the extent of injury from being obscured. Typically, only single-plane tests are performed, the results of which are then compared with the noninjured limb.

On-Site Neurologic Testing

Neurologic testing is critical to prevent a catastrophic injury. Although listed as a separate testing phase, neurologic testing, if warranted, may be performed earlier in the evaluation. Critical areas to include are:

- **Cutaneous sensation.** This can be done by running the fingernails along both sides of the injured individual's arms and legs to determine if the same feeling is experienced on both sides of the body part. Pain perception also can be tested by applying a sharp and a dull point to the skin; the ability of the individual to distinguish the difference should be noted.
- **Motor function.** A cranial nerve assessment (see Chapter 9) should be completed. In addition, the ability of the individual to wiggle the fingers and toes on both hands and feet should be assessed, and a bilateral comparison of grip strength should be performed.

Vital Signs

When warranted, the vital signs should be assessed to establish a baseline of information. Vital signs indicate the status of the cardiovascular system and the CNS and include pulse, respiratory rate and quality, blood pressure, and temperature. Although not specifically cited as vital signs, skin color, pupillary response to light, and eye movement also may be assessed to determine neurologic function. Abnormal vital signs indicate a serious injury or illness (Table 5.9).

Pulse

Factors such as age, gender, aerobic physical condition, degree of physical exertion, medications or chemical substances being taken, blood loss, and stress can influence pulse rate and volume. Pulse usually is taken at the carotid artery, because a pulse at that site is not normally obstructed by clothing, equipment, or strappings. Normal adult resting rates range from 60 to 100 beats a minute; for children, the normal resting range is from 120 to 140 beats per minute. Aerobically conditioned athletes may have a pulse rate as low as 40 beats per minute. Pulse rate is assessed by counting the carotid pulse rate for a 30-second period and then doubling it. An assessment of pulse volume, which reflects the sensation of the contraction (e.g., strong/weak), also is important.

Respiration

Breathing rate also varies with gender and age. It averages from 10 to 25 breaths per minute in an adult and from 20 to 25 breaths per minute in a child. Breathing rate is assessed by counting the number of respirations in a 30-second period and then doubling it. The character of the respiration (e.g., rapid, shallow, deep, gasping, or labored) should be noted as well.

Blood Pressure

Blood pressure is the pressure or tension of the blood within the systemic arteries, generally considered to be the aorta. As one of the most important vital signs, blood pressure reflects the effectiveness of the circulatory system. Changes in blood pressure are very significant. **Systolic blood pressure** is measured when the left ventricle contracts and expels blood into the aorta. It is approximately 120 mm Hg for a healthy adult and 125 to 140 mm Hg for healthy children aged 10 to 18 years. **Diastolic blood pressure** is the residual pressure in the aorta between heartbeats and averages 70 to 80 mm Hg in healthy adults and 80 to 90 mm Hg in healthy children aged 10 to 18 years. Blood pressure may be affected by gender, weight, race, lifestyle, and diet. Blood pressure is measured in the brachial artery with a sphygmomanometer and stethoscope (see Field Strategy 2.1).

Temperature

Core temperature can be measured by a thermometer placed under the tongue, in the ear or armpit, or in case of unconsciousness, in the rectum. Average oral temperature usually is quoted at 37°C (98.6°F), but this can fluctuate considerably. During the early morning hours, it may fall as low as

TABLE 5.9 Abnormal Vital Signs and Possible Causes

PULSE	
Rapid, weak	Shock, internal hemorrhage, hypoglycemia, heat exhaustion, or hyperventilation
Rapid, bounding	Heat stroke, fright, fever, hypertension, apprehension, hyperglycemia, or normal exertion
Slow, bounding	Skull fracture, stroke, drug use (barbiturates and narcotics), certain cardiac problems, or some poisons
No pulse	Blocked artery, low blood pressure, or cardiac arrest
RESPIRATORY RATE AND QUALITY	
Shallow breathing	Shock, heat exhaustion, insulin shock, chest injury, or cardiac problems
Irregular breathing	Airway obstruction, chest injury, diabetic coma, asthma, or cardiac problems
Rapid, deep	Diabetic coma, hyperventilation, or some lung diseases
Frothy blood	Lung damage, such as a puncture wound to the lung from a fractured rib or other penetrating object
Slowed breathing	Stroke, head injury, chest injury, or use of certain drugs
Wheezing	Asthma
Crowing	Spasms of the larynx
Apnea	Hypoxia (lack of oxygen), congestive heart failure, or head injuries
No breathing	Cardiac arrest, poisoning, drug abuse, drowning, head injury, or intrathoracic injuries, with death imminent if action is not taken to correct condition
BLOOD PRESSURE	
Systolic < 100 mm Hg	Hypotension caused by shock, hemorrhage, heart attack, internal injury, or poor nutrition
Systolic > 140 mm Hg	Hypertension caused by certain medications, oral contraceptives, anabolic steroids, amphetamines, chronic alcohol use, and obesity
SKIN TEMPERATURE	
Dry, cool	Exposure to cold or cervical, thoracic, or lumbar spine injuries
Cool, clammy	Shock, internal hemorrhage, trauma, anxiety, or heat exhaustion
Hot, dry	Disease, infection, high fever, heat stroke, or overexposure to environmental heat
Hot, moist	High fever
Isolated hot spot	Localized infection
Cold appendage	Circulatory problem
"Goose pimples"	Chills, communicable disease, exposure to cold, pain, or fear
SKIN COLOR	
Red	Embarrassment, fever, hypertension, heat stroke, carbon monoxide poisoning, diabetic coma, alcohol abuse, infectious disease, inflammation, or allergy
White or ashen	Emotional stress (e.g., fright or anger), anemia, shock, heart attack, hypotension, heat exhaustion, insulin shock, or insufficient circulation
Blue or cyanotic	Heart failure, some severe respiratory disorders, and some poisoning; in dark-skinned individuals, a bluish cast can be seen in the mucous membranes (mouth, tongue, and inner eyelids), lips, and nail beds
Yellow	Liver disease or jaundice
PUPILS	
Constricted	Individual is using an opiate-based drug or has ingested a poison
Unequal	Head injury or stroke
Dilated	Shock, hemorrhage, heat stroke, use of a stimulant drug, coma, cardiac arrest, or death

35.8°C (96.4°F), and during the later afternoon or evening hours, it may rise as high as 37.3°C (99.1°F). Rectal temperatures are higher than oral temperatures by an average of 0.4 to 0.5°C (0.7–0.9°F). Although this too can be quite variable, it is considered to be a more accurate measurement of core temperature. In contrast, axillary temperatures are lower than oral temperatures by approximately 1°F. In addition, axillary temperature may take 5 to 10 minutes to register and generally is considered to be less accurate than other measurements (7). Infrared tympanic thermometers measure infrared energy emitted by the tympanic membrane and provide a rapid, efficient, and noninvasive method of measuring body temperature. Infrared tympanic thermometers, however, have failed to detect fever in some patients with AIDS and in neonates, infants, and children, and they are not useful in hypothermic or significantly hyperthermic individuals (8).

Skin Color

Skin color can indicate abnormal blood flow and low blood oxygen concentration in a particular body part or area. Three colors commonly are used to describe light-skinned individuals: red, white or ashen, and blue. The colors and their potential indications also can be seen in Table 5.9. In dark-skinned individuals, skin pigments mask cyanosis; however, a bluish cast can be seen in mucous membranes (e.g., mouth, tongue, and inner eyelids), the lips, and nail beds. Fever in these individuals can be seen by a red flush at the tips of the ears.

Pupils

The pupils are extremely responsive to situations affecting the CNS. Rapid constriction of pupils when the eyes are exposed to intense light is called the **pupillary light reflex**. The pupillary response to light can be assessed by holding a hand over one eye and then moving the hand away quickly, or by shining the light from a penlight into one eye and then observing the pupil's reaction. A normal response would be constriction with the light shining in the eye and dilation as the light is removed. The pupillary reaction is classified as brisk (normal), sluggish, nonreactive, or fixed. The eyes may appear normal, constricted, unequal, or dilated.

Eye movement is tested by asking the individual to focus on a single object. An individual experiencing **diplopia** sees two images instead of one. This condition is attributed to failure of the external eye muscles to work in a coordinated manner. The tracking ability of the eyes can be assessed by asking the individual to follow the examiner's fingers as they move through the six cardinal fields of vision. The individual's depth perception can be assessed by placing a finger several inches in front of the individual and then asking the person to reach out and touch the finger. This assessment should be repeated several times, with the examiner's finger in several different locations.

Disposition

Information gathered during the assessment must be analyzed and decisions made based on the best interests of the injured individual. It is especially important to determine whether the situation can be handled on-site or whether referral to a physician is warranted. As a general rule, the individual should always be referred to the nearest trauma center or emergency clinic if any life-threatening situation is present, if the injury results in loss of normal function, or if no improvement is seen in injury status after a reasonable amount of time. Examples of these injuries are provided in Box 5.2. Other conditions that are not necessarily life-threatening but are serious enough to warrant referral to a physician for immediate care include:

- Eye injuries
- Dental injuries in which a tooth has been knocked loose or knocked out
- Minor or simple fractures
- Lacerations that might require suturing
- Injuries in which a functional deficit is noticeable
- Loss of normal sensation or diminished or absent reflexes
- Noticeable muscular weakness in the extremities
- Any injury if you are uncertain about its severity or nature

Equipment Considerations

One of the primary concerns during an on-site assessment of an injured individual is that of equipment, particularly with regard to removal of an athletic helmet. For an individual with a potential cervical spine injury, removal of a helmet may worsen the condition or lead to additional injury.

Therefore, removal of any helmet should be avoided unless individual circumstances dictate otherwise, especially when the following are considered (1,8):

- Removal of the face mask allows full airway access. The face mask should be removed immediately when the decision is made to transport the injured individual, regardless of his or her current respiratory status.
- Most injuries can be visualized with the helmet in place.
- Neurologic tests can be performed with the helmet in place. The eyes may be examined, the nose and ears checked for fluid or blood, and the level of consciousness determined.
- The individual can be immobilized on a spine board with the helmet in place.
- When both a helmet and shoulder pads are worn, removing the helmet without removing the shoulder pads results in cervical hyperextension.
- Many helmets are radiographically translucent. Therefore, a definitive diagnosis can be made before removal.

Guidelines for removal of any piece of protective equipment should be defined within the emergency medical plan. Situations in which helmets may need to be removed include (1):

- When the helmet and chin strap do not hold the head securely so that immobilization of the helmet does not necessarily immobilize the head.
- When the design of the helmet and chin strap is such that even after removal of the face mask, the airway cannot be controlled.
- When the face mask cannot be removed after a reasonable amount of time.
- When the helmet prevents immobilization for transportation in an appropriate position.
- When extraordinary cases, such as when an automated external defibrillator (AED) is needed, occur.

Use of a defibrillator requires that the individual's chest be fully exposed and dry. Contact points for the defibrillator pads must be placed over the apex of the heart and inferior to the right clavicle. If the defibrillator pads touch wet shoulder pads, the defibrillator's current could arc, leading to decreased effectiveness of the defibrillator; more important, the current could defibrillate the operator. As the use of AEDs becomes more common, standardized protocols for their use must be documented and regularly practiced before their actual use during an emergency situation.

Regardless of the injured individual's condition, the helmet or shoulder pads must be removed at some point, whether at the site or in the hospital. Because of their familiarity with the equipment, athletic trainers often are asked to assist medical personnel with this procedure.

Field Strategy: Removal of Protective Equipment, located on the companion website at thePoint, summarizes the basic steps in removing a face mask, helmet, and shoulder pads.

Face Mask Removal

The face mask should be removed before transportation, regardless of the current respiratory status. Face masks typically are attached to the helmet with four plastic clips. It is recommended that all four clips be cut so that the facemask can be completely removed (9). Several commercial products (e.g., anvil pruner, FM Extractor, Trainer's Angel, PVC pipe cutter, X-Acto knife, and electric screwdriver) can be used to cut the clips or to unscrew the bolts holding the clips. It is important to recognize that older clips harden with age, making them harder to cut, and that screws may become rusted or stripped. Regardless of the manner in which the face mask is removed, it is essential that that in-line stabilization of the head and neck be maintained during the entire procedure.

Helmet Removal

If possible, the helmet should be removed in a controlled environment after radiographs have been obtained—and even then only by qualified medical personnel with training in equipment removal

(9). Two trained individuals are needed to carry out the task. One individual maintains in-line stabilization of the head, neck, and helmet while another person cuts the chin strap. Next, while one assistant continues to maintain stabilization of the chin and back of the neck, the other individual removes any accessible internal helmet padding, such as cheek pads. In removing the pads, a flat object, such as a tongue depressor or the flat edge of tape scissors, can be slid between the helmet and the pad. A slight turn of the inserted object causes the pad to unsnap from the helmet. If an air cell–padding system is present, the system should be deflated by releasing the air at the external port with an inflation needle or large-gauge hypodermic needle. The helmet should then be slid off the occiput with slight forward rotation of the helmet. If the helmet does not move with this action, slight traction can be applied to the helmet as it is carefully rocked anteriorly and posteriorly, with great care being taken not to move the head and neck unit. The helmet should not be spread apart by the ear holes, because this only serves to tighten the helmet on the forehead and occiput region (9).

Shoulder Pad Removal

Shoulder pads should not be removed unless the athlete's life is in danger and this threat outweighs the risk of a possible spinal cord injury that may result from moving the individual. The chest can be exposed without removing the pads to allow the athletic trainer access for evaluation, auscultation of breath and cardiac sounds, chest compression during CPR, and placement of AED pads. The chest is exposed by cutting the shirt from neck to waist and from the midline to the end of each arm sleeve. Next, the rib straps on the sternal portion of the pads should be unfastened or cut. Finally, the halves of the shoulder pads are spread to expose the sternum.

The Inter-Association Task Force recommends that neither the football helmet nor the shoulder pads be removed before transportation (9). Such removal is best done in a controlled environment, such as the emergency room, where several highly trained individuals can assist in simultaneously removing the helmet and shoulder pads. If the pads must be removed, the jersey is first removed using the process described above. Next, all straps securing the shoulder pads to the arms are cut, the laces or straps over the sternum are cut, and the two halves of the shoulder pads are spread apart. All accessories, such as neck rolls or collars, are then cut and/or removed. One individual maintains cervical stabilization in a cephalad direction by placing his or her forearms on the athlete's chest while manually stabilizing the chin and occiput. Assistants should be positioned on each side of the athlete with their hands placed directly against the skin in the thoracic region of the back. Additional support should be provided at other strategic locations down the body as deemed appropriate for the size of the patient. While the patient is lifted, the individual in charge of the head/shoulder stabilization should remove the helmet and then immediately remove the shoulder pads by spreading apart the front panels and pulling them around the head. Next, the remaining jersey and any other accessories are removed, and the patient is lowered, with appropriate immobilization being continued (9).

A *When evaluating the gymnast, a primary survey should be conducted to assess the level of responsiveness, airway, breathing, and circulation. Measurement of vital signs and evaluation of the signs and symptoms gathered during the on-site assessment will determine if the emergency plan should be activated and EMS summoned.*

MOVING THE INJURED PARTICIPANT

Q *What criteria should be used to determine whether an injured individual should be allowed to walk off the field or site of the injury? What is the safest method for transporting an individual with a lower extremity injury?*

Once the extent and severity of the injury have been determined, a decision must be made regarding how to safely remove the individual from the area. Possible methods include ambulatory assistance, manual conveyance, and transport by a stretcher or spine board.

Ambulatory Assistance

Ambulatory assistance is used to aid an injured individual who is able to walk. This implies that the injury is minor and no further harm will occur if the individual is ambulatory. In performing this technique, two individuals of equal or near-equal height should support both sides of the individual. The injured individual drapes his or her arms across the shoulders of the assistants while the arms of the assistants encircle the injured person's back. This position enables the assistants to escort the individual to an appropriate area for further evaluation and treatment.

Manual Conveyance

If the individual is unable to walk or the distance is too great to walk, manual conveyance should be used. The individual continues to drape his or her arms across the assistants' shoulders while one arm of each assistant is placed behind the individual's back and the other arm is placed under the individual's thigh. Both assistants lift the legs up, placing the individual in a seated position. The individual is then carried to an appropriate area. Again, it is essential that the injury be fully evaluated before moving the individual in this manner.

Transport by Spine Board

In the absence of a suspected spinal injury, the safest method to move an individual is with a spine board or stretcher. Ideally, five or six individuals should roll, lift, and carry an injured person. The captain (i.e., the individual with medical seniority) stabilizes the head and gives commands for each person to slowly lift and place the injured individual onto the stretcher. The individual is then secured onto the stretcher. On command, the stretcher is raised to waist level. The individual should be carried feet first so that the captain can constantly monitor the individual's condition. Field Strategy 5.4 describes the process of securing and moving an individual on a spine board.

Pool Extrication

Serious injuries also can occur in a swimming pool environment. If a head or neck injury is suspected, the individual must be placed on a spine board before being removed from the water. Although the principles are the same, carrying out the tasks in water requires practice. Field Strategy 5.5 describes the process of securing and moving an individual in water onto a spine board.

FIELD STRATEGY 5.4

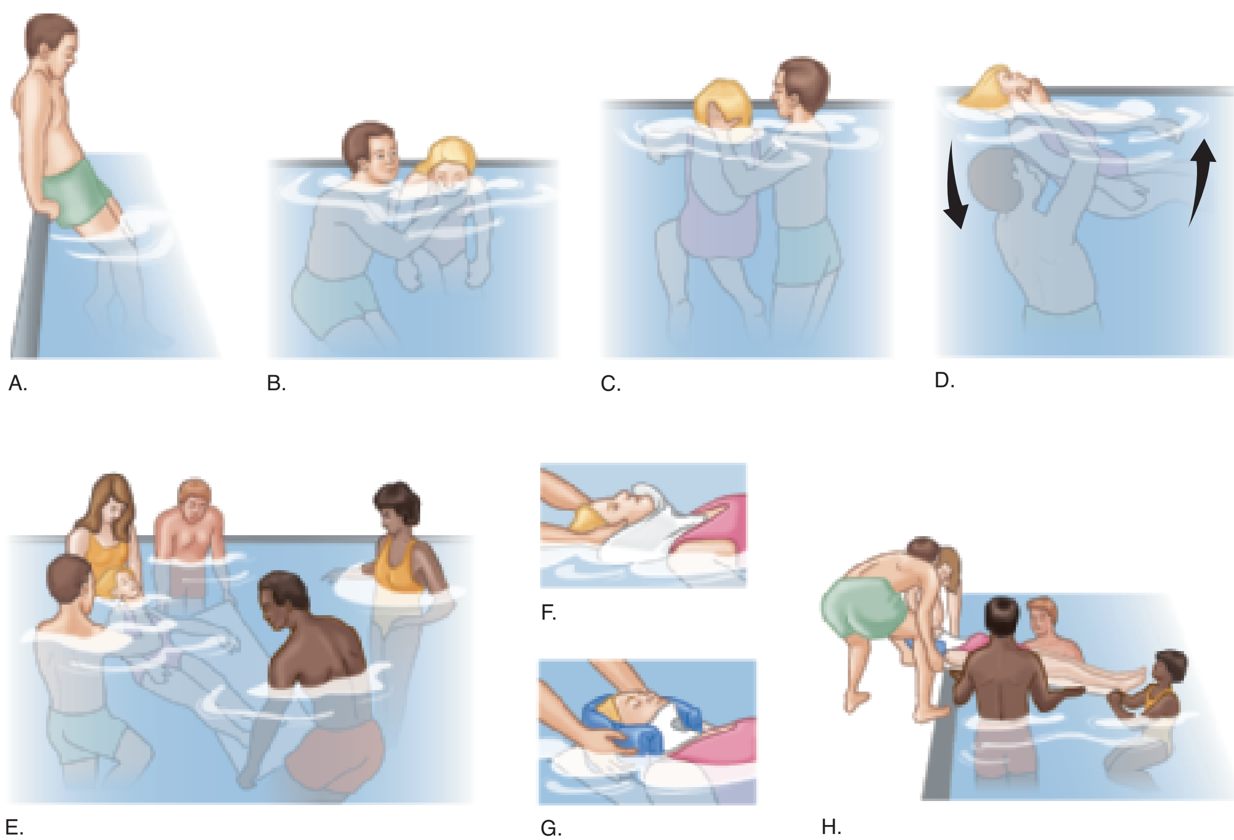
Transporting an Injured Individual on a Spine Board

1. ***Unless ruled out, assume the presence of a spinal injury.*** The captain of the team stabilizes the head and neck in the exact position in which they were found, regardless of the angle. The arms should be placed next to the body, and the legs should be straight. If the individual is lying face down, the individual should be rolled supine. Four or five people are required to "log roll" the individual. The captain should position the arms in the cross-arm technique so that during the log roll, the arms will end in the proper position.
2. The spine board should be placed as close as possible beside the individual. Each person is responsible for one body segment: one at the shoulder, one at the hip, one at the knees, and if needed, one at the feet. On command, the individual should be rolled onto the board in a single motion.
3. Once the injured individual is on the spine board, the captain continues to stabilize the head and neck while another person applies support around the cervical region. The chest is secured to the board first, and then the feet are secured. A helmet should not be removed unless individual circumstances dictate otherwise.
4. When the injured individual is secured, four people lift the stretcher while the captain continues to monitor the individual's condition. The individual should be transported feet first.

FIELD STRATEGY 5.5

Pool Extrication

1. Ease yourself into the water near the individual to avoid any additional wave movement.
2. Face the individual's side, and place one forearm along the length of the individual's sternum. Support the chin by placing the thumb on one side of the individual's chin and the fingers on the other.
3. Place the other forearm along the length of the individual's back, and cradle the head near the base of the skull. Lock both wrists. Press the forearms inward and upward to provide mild traction and stabilization of the neck.
4. Turn the individual supine by slowly rotating the person toward you as you submerge and go under the individual. Avoid any unnecessary movement of the individual's trunk or legs. Slowly tow the individual to the shallow end of the pool. [**Note:** In diving pools without a shallow end, move the individual to the side of the tank. The "captain" lies prone on the deck with arms in the water and takes over the in-line stabilization of the neck.]
5. With the backboard, approach the individual from the side. Glide the foot of the board diagonally under the individual, making sure the board extends beyond the head. Allow the board to rise under the individual.
6. Maintain in-line stabilization while a rigid cervical collar is applied. Secure the individual to the backboard, beginning at the chest and then moving to the hips, thighs, and shins.
7. Before securing the head, it may be necessary to place padding under the head to fill the space between the board and head to maintain stabilization. Place a towel or blanket roll in a horseshoe configuration around the head and neck, and secure to the board.
8. Place the board perpendicular to the pool, and maintain the board in a horizontal position. Remove the board, head first. Tip the board at the head to break the initial suction holding it in the water. Two people should be on the deck to lift and slide the board onto the pool deck. Once on the deck, check vital signs, and assess the individual's condition. Treat for shock, and transport.



A: An injured individual may walk off the field or site of injury if it is determined that the injury is minor and no further harm will occur if the individual is ambulatory. If the injury is more serious, however, the individual should be non–weight bearing. Manual conveyance or removal by a spine board, stretcher, or chair may be necessary to avoid any additional pain or injury to the individual.

DIAGNOSTIC TESTING

Q: In assessing an injury, what special imaging techniques can be used by the athletic trainer to reach an accurate diagnosis?

Injury recognition is the final step in assessment. A **diagnosis** is the definitive determination of the nature of the injury or illness. Various forms of laboratory tests and imaging techniques may be necessary in establishing a diagnosis. In the majority of cases, these tests can only be ordered by a physician or appropriately licensed medical specialist.

Laboratory Tests

Additional information about laboratory tests, including synovial fluid classifications, normal ranges for selected blood variables in adults, and normal urine values, is available on the companion website at thePoint.

A variety of laboratory tests can be used in the assessment of an injury and illness (Box 5.3). For example, if an individual has a grossly swollen knee, the physician may draw fluid out of the joint with a hypodermic needle for examination. If the individual reports a sore throat, lethargy, and fever, a throat culture and blood test may be ordered. A complete blood count (CBC) can address several factors; however, other common factors that are tested include hemoglobin, hematocrit, and iron levels. An individual who has blood in the urine likewise requires a urinalysis. Common factors assessed in this laboratory test include pH, glucose, and bacteria.

Radiography

The most common imaging technique is radiography, or the x-ray (Fig. 5.11). A radiograph provides an image of certain body structures and can rule out fractures, infections, and **neoplasms**. The image is formed when a minute amount of radiation passes through the body to expose sensitive film placed on the other side. The ability to penetrate tissues depends on the tissue composition and mass. For example, bones (calcium) restrict rays from passing through; therefore, these images appear white on the film. Lungs or other air-filled structures, however, allow most x-rays to pass through, resulting in the images appearing black. Soft tissues (e.g., heart, kidneys, or liver), allow

Box 5.3 Laboratory Blood Testing

- Red-blood-cell count determines the approximate number of circulating red blood cells (erythrocytes). A decreased count indicates possible anemia, chronic infection, internal hemorrhage, certain types of cancers, or deficiencies in iron, vitamin B_{12}, or folic acid.
- White-blood-cell count determines the approximate number of circulating white blood cells (leukocytes). A decreased count indicates an inability to fight infections.
- Hemoglobin gives the red color to erythrocytes. It transports oxygen to the tissues and carries away the carbon dioxide. A decreased count indicates possible anemia or carbon monoxide poisoning.
- Hematocrit measures the volume of erythrocytes packed by centrifugation in a given volume of blood and is expressed as a percentage. A decreased value indicates anemia.
- Platelets aid in blood clotting. A decreased value indicates decreased clotting ability, internal bleeding, or possible bleeding disorder.

varying degrees of penetration and are difficult to identify on the radiograph. Images are preserved on sheets of film. As film quality and electronic technology have advanced, better imaging has been achieved, and the dose of radiation to the patient has been decreased. The use of radiographs is contraindicated over the thyroid gland, pregnant abdomen, and reproductive organs. If the information gained outweighs the risk, however, these areas can be shielded with a lead drape.

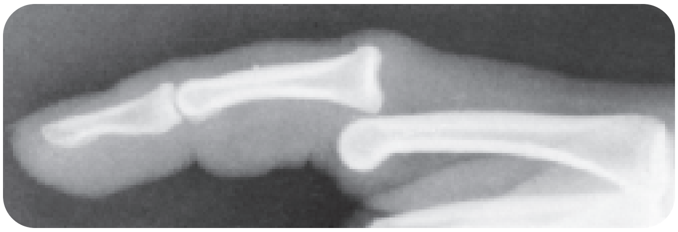


FIGURE 5.11 **Radiography.** Bone absorbs the x-rays and, therefore, appears white on the radiograph. This radiograph demonstrates a dorsal dislocation of the posterior interphalangeal joint.

Some forms of radiographs use radio-opaque dyes that are absorbed by the tissues, allowing them to be visualized by radiographic examination. A **myelogram** uses an opaque dye that is introduced into the spinal canal through a lumbar puncture. The patient is placed in a tilted position, allowing the dye to flow to different levels of the spinal cord. In viewing the contrasts, physicians can identify pathologies of the spinal canal (e.g., tumors, nerve root compression, and disk disease). Another form of radiographic testing is the **arthrogram**. Again, an opaque dye, air, or a combination of the two is injected into a joint space. The visual study of the joint can detect capsular tissue tears and articular cartilage lesions.

Computed Tomography

Computed tomography (CT) scan is a form of radiography that produces a three-dimensional, cross-sectional picture of a body part (Fig. 5.12). This test is used to reveal abnormalities in bone, fat, and soft tissue and is excellent at detecting tendinous and ligamentous injuries in varying joint positions. Scanners use a beam of light across a "slice" or layer of the body. A special receptor located opposite the beam detects the number of rays passing through the body. The tube emitting the beams of light rotates around the body, and thousands of readings are taken by the receptors. The computer determines the density of the underlying tissues based on the absorption of x-rays by the body, allowing more precision in viewing soft tissues. The computer records the data, analyzes the receptor readings, and calculates the absorption of the light beams at thousands of different points. This information is then converted into a two-dimensional image, or slice, of the body and is displayed on a video screen and/or radiographic film. These slices can be obtained at varying positions and thicknesses, allowing the radiologist or physician to study the area and its surroundings. A CT scan is relatively safe, because the patient is exposed to little radiation during the procedure. A CT scan also yields highly detailed results.

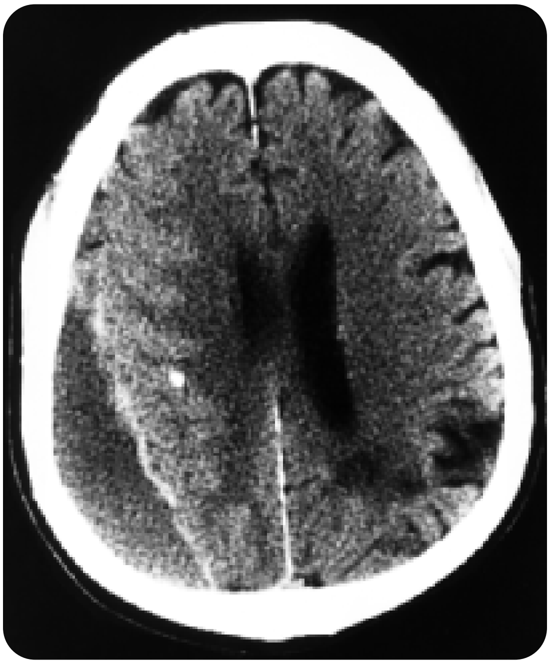


FIGURE 5.12 **Computed tomography.** A male patient reported increased sleepiness and a change in personality 3 weeks after falling and striking his head. The cranial computed tomographic scan demonstrates a chronic subdural hematoma.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is an excellent tool for visualizing the CNS, spine, and musculoskeletal and cardiovascular systems (Fig. 5.13). One of its assets is the ability to provide soft-tissue differentiation (e.g., ligamentous disruption, such as an anterior cruciate ligament tear). It also is used to demonstrate space-occupying lesions in the brain (e.g., tumor or hematoma) and joint damage (e.g., meniscal tears or osteochondral fractures) as well as to view blood vessels and blood flow without the use of a contrast medium (e.g., cardiac function). In many cases, the MRI has replaced myelography and arthrography.

Images are obtained by placing the patient in an MRI tube that produces the magnetic field. This causes the body's hydrogen

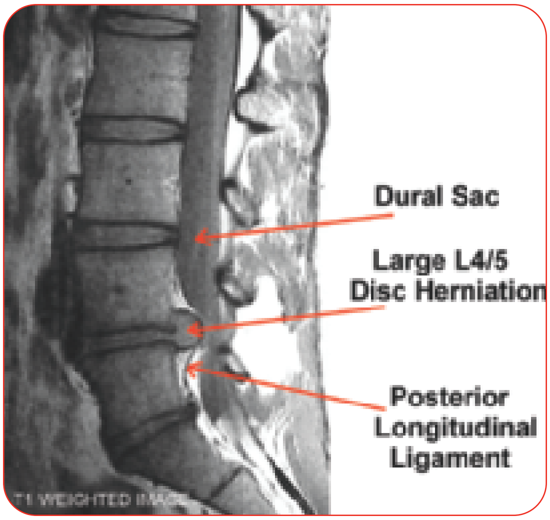


FIGURE 5.13 Magnetic resonance imaging. This magnetic resonance image depicts a large L4–L5 disk herniation.

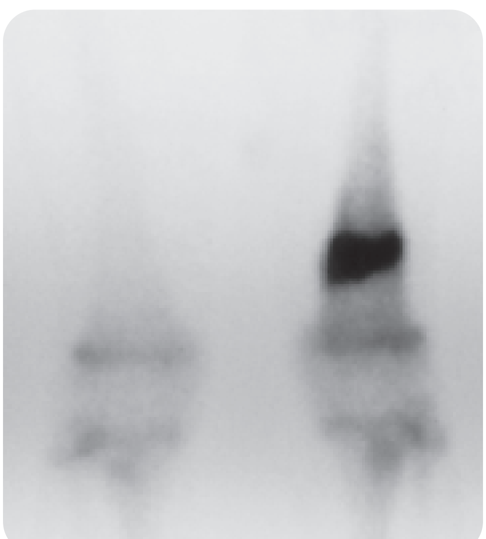


FIGURE 5.14 Radionuclide scintigraphy. Bone scans can detect stress fractures long before the fracture becomes visible on traditional radiographs. This individual had increased his daily run from 5 to 8 miles per day and included hill climbing over the past few months. He reported increasing pain in his thigh. The bone scan showed increased density in a transverse line, indicating medial periosteal reaction.

nuclei to align with the magnetic axis. The tissues are then bombarded by radio waves, which causes the nuclei to resonate as they absorb the energy. When the energy from the radio waves ceases, the nuclei return to their state of equilibrium by releasing energy, which is then detected by the MRI unit and transformed by a computer into visible images.

Radionuclide Scintigraphy (Bone Scan)

A bone scan is used to detect stress fractures of the long bones and vertebrae, degenerative diseases, infections, or tumors of the bone. A **radionucleotide** material, technetium 99m, is injected into a vein and is slowly absorbed by areas of bone undergoing remodeling. Several hours after the injection, the patient is placed under a recording device that scans radioactive signals and records the images on film. In some scans, active images are recorded on videotape. A total body scan or even a localized scan can take close to an hour. Any areas subject to stress (e.g., fractures or increases of metabolic activity, such as bone marrow centers or tumors) show as areas of greatest uptake and appear darker on the film (Fig. 5.14). Bone scans may be clinically correlated to plain-film radiographs or other diagnostic tests. No special preparation is needed before the bone scan, and the risk to the patient is minimal. The body excretes the radioactive material over a 24-hour period.

Ultrasonic Imaging

Sonography, as it sometimes is called, uses sound waves to view the various internal organs and certain soft-tissue structures, such as tendons. The energy produced is similar to that used during therapeutic ultrasound treatments but has a frequency of less than 0.8 MHz. Although it commonly is used to monitor development of the fetus during pregnancy, it also is used to view tendons and for other soft-tissue imaging. Similar to a sonar device on a submarine, a piezoelectric crystal is used to convert electrical pulses into vibrations that penetrate the body structures. The sound waves are reflected away from the tissues and create a two-dimensional image of the subcutaneous structures.

Electromyography

Certain muscular conditions can be detected using electromyography. This diagnostic tool consists of a thin electrode needle that is inserted into the muscle to determine the level of muscular contraction following an electrical stimulation. Motor unit potentials can be observed on an oscilloscope screen or recorded on an electromyogram. Electromyography is used to detect denervated muscles, nerve root compression injuries, and other muscle diseases.

In some cases, a definitive diagnosis requires laboratory tests or imaging techniques. In the majority of cases, these tests can only be ordered by a physician or appropriately licensed medical specialist. It is essential that athletic trainers be aware of their duty of care consistent with current state law.

SUMMARY

1. In an injury assessment, a problem-solving process incorporates subjective and objective information that is reliable, accurate, and measurable.
2. The HOPS format includes history, observation and inspection, palpation, and special tests.
3. A more popular method of injury management is the SOAP note format, which assesses the individual's status and prognosis and establishes short- and long-term goals for recovery. The format outlines the treatment plan, such as the frequency and duration of treatments, rehabilitation exercises, ongoing patient education, evaluation standards to determine progress, and criteria for discharge.
4. The subjective information gathered during the history taking should include the primary complaint, mechanism of injury, characteristics of the symptoms, disabilities resulting from the injury, and related medical history.
5. The objective assessment should include observation and inspection, bony and soft-tissue palpation, functional tests, stress tests for specific joints or structures, neurologic testing, and activity-specific functional tests.
6. In consultation with the supervising physician and local EMS agencies, the athletic trainer should coordinate the development of an emergency plan. The purpose of this plan is to ensure rapid and complete emergency care to an injured individual. The plan should be evaluated annually and practiced by all parties on a regular basis.
7. In an emergency injury assessment, the presence of a head or spinal cord injury should be assumed. As such, the head and neck should be stabilized before proceeding. Assessment of all injuries, no matter how minor, should include a primary injury assessment to determine level of responsiveness and to assess the ABCs. A secondary assessment determines the presence of moderate to severe injuries.
8. As a general rule, an individual should always be referred to the nearest trauma center or emergency clinic if any life-threatening situation is present or if the injury results in loss of normal function.
9. The use of a variety of laboratory tests and imaging techniques can be instrumental in establishing an accurate diagnosis of an injury or illness. In the majority of cases, these tests can only be ordered by a physician or appropriately licensed medical specialist.

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