Basic Athletic Training
Course Pack A

CHAPTER

6

Clinical Assessment and Diagnosis

STUDENT OUTCOMES

1. Differentiate between the history of the injury, observation and inspection, palpation, and special tests (HOPS) injury assessment format; the subjective evaluation, objective evaluation, assessment, and plan (SOAP) note format used to assess and manage musculoskeletal injuries; and the history and physical examination model used to assess for general medical conditions.
2. Explain the general components of the history portion of the assessment process.
3. Differentiate the types of pain as indicators of potential

pathologies.

4. Describe the processes involved in the visual observation and inspection of an ill or injured patient.
5. Describe the basic principles that direct the palpation component of the assessment process.
6. Identify the various types of tests included during a physical examination.
7. Describe how range of motion (ROM), goniometry, and manual muscle testing are similar yet different with regard to testing procedures and purpose.
8. Explain how the assessment process differs based on purpose for conducting assessment.
9. Describe testing techniques used by medical specialists in diagnosing an injury.
10. List the reasons for maintaining clear, accurate, and up-to-date medical documentation of services provided.

INTRODUCTION

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 assessment process involves searching for atypical or dysfunctional anatomy, physiology, or biomechanics, a strong understanding of each content area in conjunction with the knowledge of how to conduct a thorough evaluation is essential for an accurate clinical assessment. A poor assessment can have a devastating effect on the proper treatment and development of appropriate rehabilitation protocols.

This chapter begins with a description of the assessment process. The process has two main steps: the history and the physical examination. Both the history portion and the physical examination have several subcomponents that may or may not be used, depending on the situation and purpose for which the

assessment is being conducted. When working with healthy individuals who have orthopedic complaints with no underlying medical issues, the assessment process follows a more narrow sequence called HOPS/HIPS (history, observations/inspection, palpation, and special tests). When assessing a patient for the purposes of developing a complex therapeutic intervention program, a subjective evaluation, objective evaluation, assessment, and plan (SOAP) sequence is followed. For patients who present with broader general medical issues, the history and physical examination (HPE) becomes more complex and lengthy. A table comparing these different assessment formats is presented in **Table 6.1**.

TABLE 6.1 Comparison of Assessment Models

HOPS/HIPS	SOAP	HPE
Primary use: orthopedic assessment	Primary use: therapeutic intervention plan	Primary use: medical assessment
History ▪ Chief complaint • Onset/MOI • Symptoms • Signs • Dysfunction • Training/working conditions • Recurrent condition • Previous treatment • Disabilities resulting from injury or illness ▪ Related medical history • Past injury/illness • Family history • Medical conditions	**Subjective** ▪ Includes all information obtained in the history portion of the HOPS/HIPS format ▪ Pain rating scales and other standardized patient outcome measures utilized more frequently in this format.	**History** ▪ History of present illness: includes all information obtained in the history portion of the HOPS/HIPS format ▪ Past medical history ▪ Past surgical history ▪ Medications ▪ Allergies and reactions ▪ Social history ▪ Family history ▪ Review of systems
Inspection, Palpation, and Special Tests ▪ Observation and analysis of overall appearance, body symmetry, swelling, deformity, discoloration, bleeding, deformity, general motor function, balance, gait, and posture ▪ Palpation and analysis of overall skin temperature and moisture, tone, tenderness, crepitus, deformity, swelling, and pulse ▪ Findings from range of motion, MMT, neurological testing, joint stress testing, and other special tests to assess for specific pathologies	**Objective** ▪ Includes all information obtained in the inspection, palpation, and special tests section of HOPS/HIPS ▪ Information more frequently recorded using objective measures such as goniometry, grading scales, and other standardized patient outcome measures. ▪ Includes information obtained from other providers such as physician notes, results from imaging studies, or records documenting prior treatment/progress ▪ When used with providing daily treatments, type, duration, and frequency of treatment is also included.	**Physical Examination** ▪ All information included with the HOPS/HIPS and SOAP note format is included as needed. ▪ Overall appearance ▪ Vital sign assessment ▪ HEENT examination ▪ Cardiac auscultation ▪ Respiratory auscultation and percussion ▪ Abdominal auscultation and percussion ▪ Gross motor function screening ▪ Neurological screening ▪ Laboratory diagnostics as needed • Blood work • Imaging • Urinalysis
At the conclusion of the HOPS/HIPS format, the clinician should be able to identify potential clinical diagnoses and initiate appropriate management strategies.	**Assessment** ▪ The clinical diagnosis is entered in the assessment section when completing an initial evaluation. For example: grade 2 ATFL sprain. ▪ When the clinician is evaluating a patient frequently to determine how the patient is responding to treatment, the assessment should indicate the patient's progress. For example: Patient is responding to treatment and progressing appropriately toward meeting goals. ▪ Problems list	**Assessment** ▪ Differential diagnoses ▪ Problems list ▪ Treatment plan
	Plan ▪ Short-term goals ▪ Long-term goals ▪ Treatment plan	

ATFL, anterior talofibular ligament; *MOI*, mechanism of injury.

From Kettenbach G. *Writing Patient/Client Notes: Ensuring Accuracy in Documentation.* 4th ed. Philadelphia, PA: FA Davis; 2009; Bickley LS, Szilagyi PG. *Bates' Guide to Physical Examination and History Taking.* Philadelphia, PA: Lippincott Williams & Wilkins; 2007; Magee DJ. *Orthopedic Physical Assessment.* 5th ed. Philadelphia, PA: Elsevier Saunders; 2008.

THE EVALUATION PROCESS

? A 15-year-old male ice hockey athlete enters the athletic training clinic complaining of hip pain. What additional information is needed to make

a clinical diagnosis and devise a plan of treatment? What steps need to be taken in order to obtain the needed information?

The purpose of the evaluation process is to determine which tissues have been damaged and the extent or severity of the damage so that appropriate treatment can be rendered. The evaluation process involves gathering information from multiple sources: the patient, the physical examination, and diagnostic testing. The clinician looks for diagnostic signs and symptoms obtained through the evaluation process and interprets the information to help determine the type and extent of the injury. A **diagnostic sign** is an objective, measurable, physical finding regarding an individual's condition. A sign is what the clinician hears, feels, sees, or smells when assessing the patient. For example, a swollen knee is a diagnostic sign. A **symptom** is information provided by the patient regarding his or her perception of the problem. Examples of these subjective feelings include blurred vision, ringing in the ears, sharp stinging pain, locking or catching within the knee joint, 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. Another important source of information is the opposite, healthy paired limb or organ.

For example, 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. This process is referred to as **bilateral comparison**. 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 a return to full participation in an activity. Under most circumstances, an assessment of the noninjured body part should precede an assessment of the injured body part. In some acute injuries, such as fractures or dislocations, an 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 use for assessing patients with orthopedic conditions 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. A third method, the HPE, is utilized when assessing patients for general medical complaints.

The HOPS Format

The HOPS format is often followed when evaluating the initial injury and forms the basis of the initial injury report. The HOPS format is easy to use and follows a basic, consistent format. Information obtained in the *history* is then verified during *observation*, *palpation*, and *special tests*. As the clinician moves through the sequence, information is obtained that either helps to support or eliminate potential pathologies until the final clinical diagnosis is made. Both subjective and objective information are obtained through this sequence and help the clinician in recognizing and identifying problems contributing to the condition. The HOPS format focuses on the evaluation component of injury management and excludes the rehabilitation process.

History

The *subjective* evaluation (i.e., history of the injury) includes the primary complaint (also known as the chief complaint or current complaint), mechanism of injury (MOI), characteristics of the symptoms, and pertinent medical history. This information comes from the patient and reflects his or her attitude, mental condition, and perceived physical state.

Observation, Palpation, and Special Tests

The *objective* evaluation utilizes measurable findings relative to the patient's condition. Observations are made to detect signs that may suggest certain pathologies. Palpation is used to assess areas of tenderness and abnormalities in the surface anatomy. Special tests include a wide range of clinical assessment techniques such as ROM testing, testing for joint instability, the balance error scoring system, and test for specific pathologies. Although the history may sometimes elicit inconsistent information depending on how questions are posed and the ability of the patient to accurately respond to questions, objective information should remain consistent relative to the patient's recovery process. This information can be measured repeatedly to track progress from the initial evaluation through the final clearance for discharge and a return to participation in a sport or other physical activity.

The SOAP Note Format

The **SOAP** note format is actually a method of documenting findings and provides a structured sequence for the clinician to follow when completing the evaluation process.[1] The SOAP format utilizes a problem-oriented approach and advanced sequence structure for decision making and problem solving in the management and rehabilitation phase. SOAP notes can also be tailored to use during an initial intake or during follow-up evaluations. SOAP 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.

Subjective Portion

The **subjective** evaluation includes all information obtained through the history portion of the process. When used during the initial intake of a new patient, the subjective portion is very similar to that used in the HOPS format. When using the SOAP note format for follow-up evaluations with patients who have been receiving ongoing treatment or participating in ongoing rehabilitation programs, the subjective portion provides the clinician opportunity to

document the patient's progress using the patient's own words, that is, "I have less pain now than I did 2 days ago."

Objective Portion

The objective evaluation includes information obtained through observation, inspection, palpation, and special testing, just as in the HOPS format. However, results of diagnostics testing as well as notes from other health care providers are also included. For example, if the patient had imaging studies performed and the results were known, the results would be included under objective findings. When used with follow-up evaluations of patients who have been receiving ongoing treatments, the clinician documents the activities and treatments the patient completed during the session as well as the results from any tests (e.g., ROM) performed during the session in the objective portion of the SOAP note.

Two additional components are found in the SOAP note format that is not included within the HOPS format: assessment and planning.

Assessment

Following the objective evaluation, the clinician analyzes and assesses the patient's status and prognosis. Although a definitive diagnosis may not be known, the clinician can indicate his or her clinical or working diagnosis. The suspected site of injury, involved structures, and severity of damage are identified and documented as problems to be addressed during treatment. Subsequent to having made an assessment, both long-term and short-term goals are established based on the problems list generated. Long-term goals should reflect the anticipated status of the patient after a period of rehabilitation and might include pain-free ROM; bilateral strength, power, and muscular endurance; cardiovascular endurance; and a 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. When making an assessment for follow-up evaluations of patients who have been receiving ongoing treatments, assessment focuses on the patient's progress and response

to treatment. Long-term goals are updated only when patient is being fully assessed again. Short-term goals are updated with each progress note. Progress notes may be written daily, weekly, or biweekly to document progress.

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 or ill individual
- If referral is needed, where is the patient being referred and for what purpose
- 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, a periodic "in-house review" of the patient'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, the efficacy of treatment, the average time to discharge, and other parameters that may reflect quality of care. When it is determined that the patient 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 importantly, 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 the regular review of records can reduce this threat and can minimize the likelihood that inappropriate or inadequate care is being rendered to a patient.[1]

The History and Physical Examination Format

In addition to being able to perform comprehensive clinical assessments of patients with orthopedic conditions, athletic trainers also see patients who present with common illnesses and general medical conditions. Athletic trainers need to be able to recognize and differentiate among conditions in order to determine if referral is warranted and, if so, how quickly (urgency) and to which specialist. Athletic trainers working as physician extenders in the private medical practice or hospital setting may only use the HPE format when assessing patients.

History

Consistent with histories taken in the HOPS and SOAP note model, history taking within the HPE also focuses on obtaining subjective information from the patient. However, the amount and type of information solicited is much more in-depth and, in addition to history of current complaint, may include the following: past medical history, past surgical history, family medical history, social history, allergies and reactions, and medications. Often, much of the extended history information is obtained through questionnaires the patient completes prior to seeing the clinician. The clinician should review the forms and clarify with the patient any information that has not been included or needs to be discussed in greater depth. **Review of systems** (ROS) is also included as

part of the history. When conducting an ROS history, the clinician poses questions to the patient that targets every system within the body in an attempt to screen for potential problems that may impact the patient's overall health. Sample questions used to conduct an ROS are presented in Table 6.2.

TABLE 6.2 Review of Systems

SYSTEM	SAMPLE QUESTIONS
General	Have you noticed that your clothes are fitting differently now? What is your energy level like?
Skin	Have you been experiencing any skin irritations or changes in skin color, freckles, or moles?
HEENT (head)	Have you been experiencing headache or dizziness?
HEENT (eyes)	Have you had any trouble seeing lately?
HEENT (ears)	Have you noticed a ringing in your ears or having a more difficult time hearing people speak?
HEENT (nose/sinus)	Have you had a running nose, nosebleeds, or a sense of being stuffed up?
HEENT (throat)	Has your throat been sore lately or have you experienced any toothaches or bleeding gums?
Lymphatic	Have you noticed any lumps or tenderness in your neck or groin?
Respiratory	Have you experienced any wheezing, shortness of breath, feeling winded, or coughing up phlegm?
Cardiovascular	Do you ever feel as though your heart is racing or experience pain in your chest, arms, or jaw?
Gastrointestinal	Do you have stomachaches, heartburn, or nausea? Any trouble with bowels?
Urinary	Any trouble with urination?
Peripheral vascular	Do your feet and hands ever feel inappropriately cold? Do you have problems with leg or feet cramping or swelling?
Musculoskeletal	Do you have pain, stiffness, or aching in any of your joints? Do you have difficulty walking, getting up from or into chairs, beds, cars? Have you experienced joints that are swollen and warm?
Hematologic	Have you noticed that you bruise easily or have difficulty stopping a cut from bleeding?
Endocrine	Have you noticed that you often feel thirsty or sweat excessively? Are you more sensitive to heat and cold than you used to be?
Neurological	Do you ever experience a pins and needles sensation anywhere in your body? How about changes in memory, concentration, or orientation? Has anyone told you that it is becoming more difficult to understand you?
Psychiatric	Have you noticed any change in your mood? Do you feel anxious or nervous, depressed or blue?
Genital	Females: Has there been a change in the frequency, flow, or consistency of your period? Have you noticed any vaginal discharge, irritation, or smell? Have you noticed any lumps in your breast or discharge? Males: Have you noticed any penal discharge, irritation, masses, or pain?

From Bickley LS, Szilagyi PG. *Bates' Guide to Physical Examination and History Taking*. Philadelphia, PA: Lippincott Williams & Wilkins; 2007.

Physical Examination

The physical examination (PE) seeks to obtain objective information about the patient's current health status and potential causes of the reason for seeking assistance. Like HOPS, the PE includes observation of the patient's overall appearance, movements, responses, and reactions. Palpation and special tests are also included within the PE but are not individual categories of the PE but rather are used to gather information about different aspects of the patient's health. See Table 6.1 for a list of components included under the PE. At the conclusion of the examination process, the clinician will make an assessment

or clinical diagnosis, identify problems, and develop a plan for meeting the patient's needs. When conducting an evaluation of patient with a general medical condition, the plan will often include referral to another health care provider who specializes in the treatment of a specific illness or medical condition.[2]

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.

In order to develop a list of differential diagnoses and come to a clinical diagnosis, the clinician will need to obtain both subjective and objective information from the patient. An easy way to remember the proper sequence is HOPS: History, Observation/inspection, Palpation, and Special Tests. During the history-taking portion of the evaluation, the clinician allows the patient to state in his or her own words (subjective) the MOI and the onset and characteristics of symptoms he or she is experiencing. During the observation and inspection phase, the clinician will look for signs that might provide clues into what injury or illness the patient might have. Next, the clinician will palpate, looking for areas of tenderness or abnormalities. Information gathered during the history, observation/inspection, and palpation will direct the clinician in the next step of the process: special tests. There are many different kinds of special tests, and the clinician should select only those tests needed to help reject or support possible diagnosis that were considered based on information obtained in the history, observation, and palpation portion of the exam.

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?

Obtaining an accurate and complete history of the injury can be the most important step of the clinical assessment process. 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 can identify injured structures before initiating the PE. 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 6.1).[3]

BOX 6.1 National Collegiate Athletic Association 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 the following:
   - 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 a 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 syndrome
- Menstrual history
- Exposure to tuberculosis

4. Immunization records, including the following:
   - 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 Parsons JT, ed. *2014–2015 NCAA Sports Medicine Handbook*. Indianapolis, IN: National Collegiate Athletic Association; 2014.

History taking involves asking appropriate questions, but it also requires establishing a professional and comfortable atmosphere. When taking a history, the athletic trainer should introduce himself or herself to the patient and

address the patient by name. The athletic trainer should present with 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.

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.[4] 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 clinician 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 hearing loss might feel uncomfortable asking the interviewer to repeat information.[4] A skilled clinician 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.

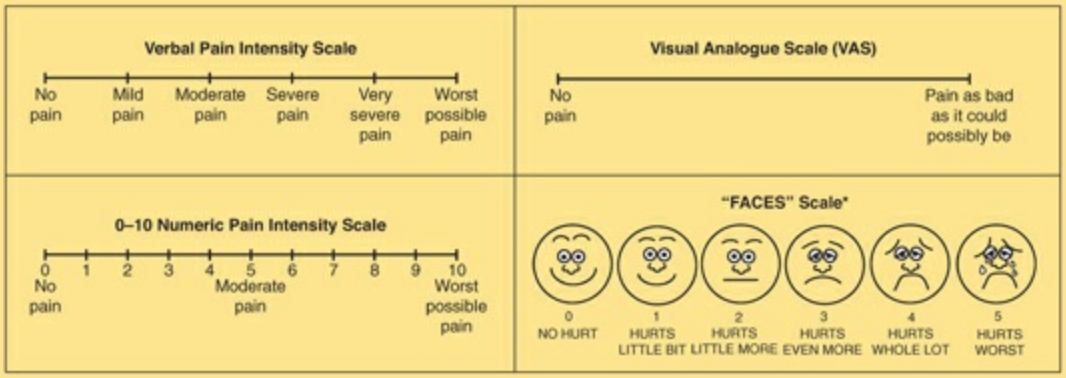
The history begins by gathering general information, such as the individual's name, sex, age, date of birth, occupation, and activity in which the individual was participating when the injury occurred. Notes regarding body size, body type, and general physical condition also are appropriate.

Although information provided by the individual is subjective, it should still be gathered and recorded as quantitatively as possible. The individual should be asked to quantify the severity of pain using a pain rating scale, of which there are many types. The Visual Analogue Scale (VAS) and the Numerical Rating Scale (NRS) are generic pain rating scales that are simple to use; easy to administer, complete, and score; and have been found to be valid and reliable measures of pain.[5] The patient is asked to rate his or her severity of pain using a graph, number, or image that is placed within a continuum anchored by two opposing descriptions of pain severity. Examples of VAS and NRS are shown in **Box 6.2**. Pain rating scales should only be used to record a patient's pain level throughout the length of treatment or rehabilitation process and be compared to baseline or prior scores in order to generate data points indicating how well the patient is progressing. 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. Pain rating scales should not be used to compare a patient's perceived level of pain to that reported by other patients.

BOX 6.2 Using Pain Scales

1. Pain scales allow patient to "quantify" his or her level of pain by rating the level of pain he or she is experiencing (perceived level of pain) based on an existing scale.
2. Patients rate his or her pain level during the initial meeting and again at predetermined times through the length of the treatment.
3. Subsequent pain ratings can be compared to the baseline rating and each additional rating to measure patient progress toward meeting treatment outcomes.

Examples of pain scales can be seen below:



From Hawker GA, Mian S, Kendzerska T, et al. Measures of adult pain. Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res*. 2011;63(suppl 11):S240–S252.

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 reason the patient is seeking assistance may be multilayered. Although the patient's primary complaint may be pain or dysfunction, your goal is to determine the cause of his or her pain or dysfunction. The starting point is to learn as much as you can from the patient about his or her perception of the current injury or the patient's *primary complaint*. Questions should be phrased to allow the individual to describe the current nature, location, and onset of the condition.[2] The following questions could be asked:

- How can I help you today? What seems to be the problem?
- Do you have pain or discomfort? If so, where? Describe how it feels. What

increases your pain? What decreases your pain?

- When did the injury occur? Or if a general medical issue, when did the symptoms begin?
- 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 clinician 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 MOI. When assessing a patient who has sustained an injury, the MOI is probably the most important information gained in the history. For an acute injury, questions that might be asked to determine MOI include the following:

- 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 chronic injuries or conditions, potential questions to determine MOI may include the following:

- 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. However, analyzing the mechanics of injury to the human body is complicated by several factors. First, potentially injurious forces applied to the body act at different angles, over different surface areas, and over different periods of time. Second, the human body is composed of many different types of tissue, which respond differently to applied forces. Finally, injury to the human body is not an all-or-nothing phenomenon; that is, injuries range in severity. The skilled clinician needs to be able to connect information gained in the history about the MOI with how different types of mechanical load affect anatomical structures in order to safely and effectively conduct the rest of the evaluation. Injury mechanisms and how tissues respond to specific types of mechanical load is described in depth in Chapter 10.

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.[2] 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 6.1 illustrates cutaneous areas where pain from visceral organs can be referred.

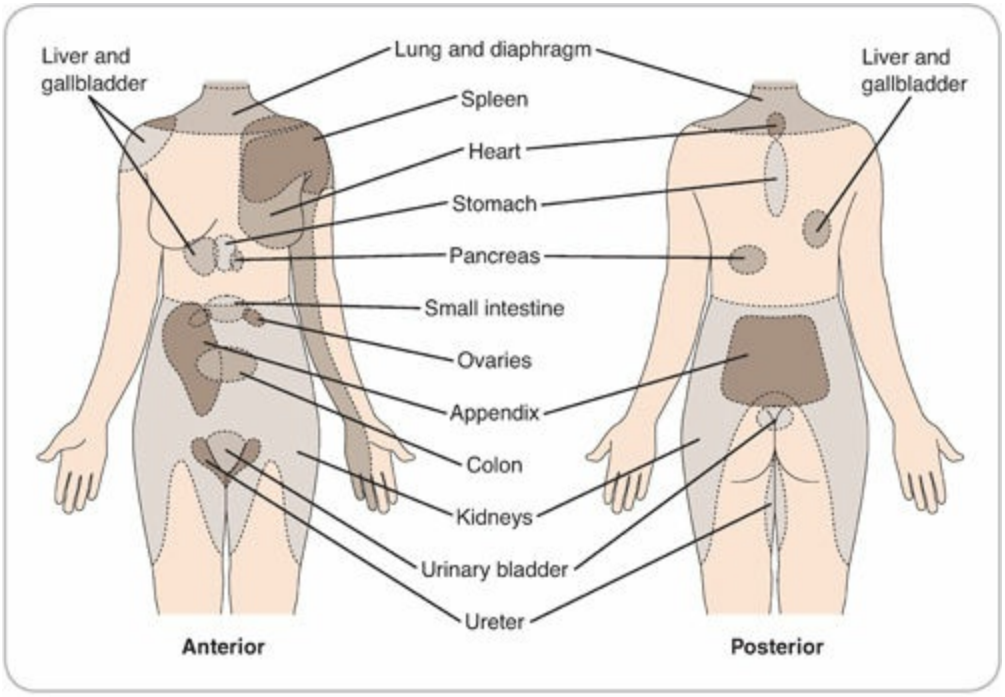


Figure 6.1. Referred pain. Certain visceral organs can refer pain to specific cutaneous areas. If all special tests are negative yet the individual continues to feel pain at a specific site, it may be referred pain.

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.

In assessing the injury, the clinician 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?
- Can you describe the pain (e.g., dull, sharp, or aching)?
- What decreases or increases the intensity and/or type of pain you are experiencing?

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 6.3** provides more detailed information regarding pain characteristics and probable causes.

TABLE 6.3 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 sounds/sensations at the time of injury. Sometimes, patients will report "feeling" a pop or snap that was not heard. 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. In future chapters, signs and symptoms that are unique to specific injuries and conditions will be discussed.

Disability Resulting from the Injury

The clinician 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 (ADLs)** are actions that most people perform without thinking, such as combing one's hair, brushing one's teeth, and walking up or down stairs. A skilled clinician will be able to apply his or her knowledge of functional anatomy to identify structures that might be potentially damaged based on the patient's ability or inability to perform ADLs pain-free.

Related Medical History

Information should be obtained regarding other problems or conditions that might have affected the current injury. Information documented on patient's preparticipation examination or medical clearance forms may provide baseline data that can be used to verify past childhood diseases; allergies; cardiac, respiratory, vascular, musculoskeletal, or neurological 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.[2] Previous musculoskeletal injuries or congenital abnormalities may place additional stress on joints and may 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.

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), MOI (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

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

Often, the athletic trainer observes the individual sustaining an injury and will quickly form a list of potential injuries based on the witnessed MOI. In many instances, however, the individual comes to the sideline, office, athletic training room, or clinic complaining of pain or discomfort. The specifics of what the athletic trainer needs to attend to will depend on how the patient presents on first glance. Patients with acute injury or illness usually present differently than those with chronic conditions or illnesses. 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 in order to determine the severity of the condition and the urgency of the situation. Evaluation and management of acute injury and illnesses will be specifically addressed in Chapter 7.

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

observation include the following:

- Does the individual appear to be healthy? Is skin color and moisture appropriate for environment? Is there any obvious discoloration, swelling, bleeding, deformity, or limited ROM present?
- 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 his or her injury?
- Is the individual's speech slurred, hoarse, loud, soft, incoherent, slow, fast, or hesitant?
- How is the individual's breathing pattern, depth, and quality?
- Is the individual's 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.[6]

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 clinician 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, an 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. Postural and gait assessment will be discussed in depth in a later chapter.

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. Assessing motor function should only be conducted after fracture, dislocation, or spinal injury has safely been ruled out. To assess gross motor function, observe the injured person performing gross motor movements of the neck, trunk, and extremities by asking the individual to do the following:

- 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 (Application Strategy 6.1). **Ecchymosis** is the superficial discoloration of tissue indicative of injury. **Keloids**, which are scars that form at a wound but grow beyond its boundaries, may indicate a 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.

APPLICATION STRATEGY 6.1

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 in, 4 in, and 6 in) 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 5th 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.

Observable factors relative to the injured site 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 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 patient's ankle revealed mild swelling on the anterolateral aspect of the ankle. Otherwise, no abnormal findings were evident. Observation of the patient, however, suggests guarding and hesitation to walk. Based on the information provided concerning the patient's condition, explain how palpation can be utilized to help 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 anatomical 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 clinician 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, may 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. 6.2). The region should be immobilized if test results indicate a possible fracture.

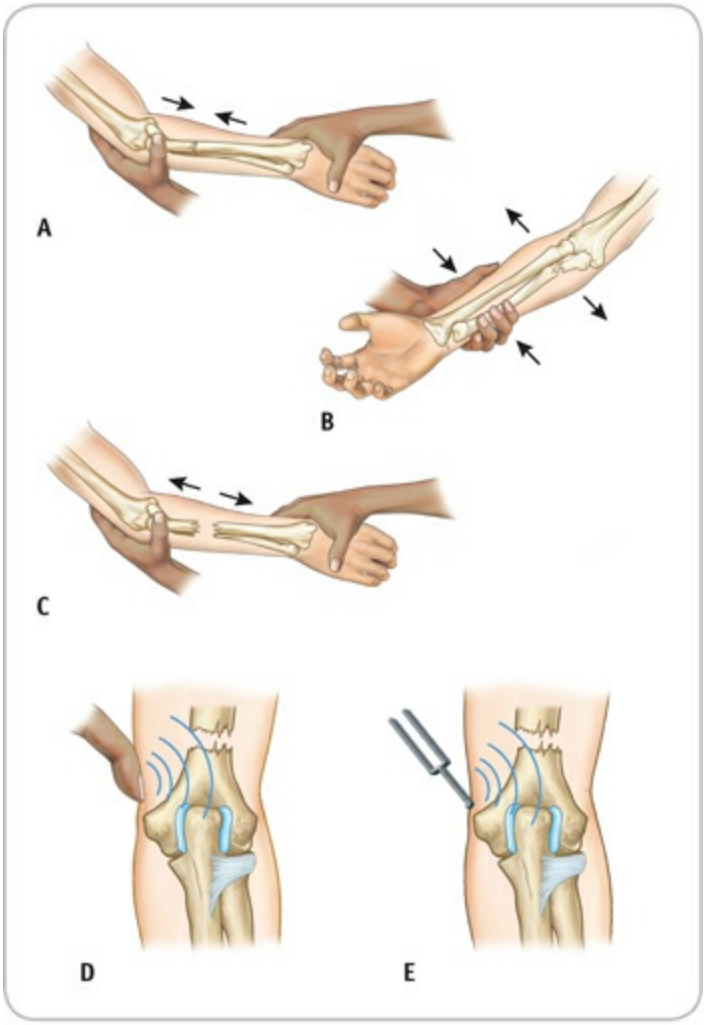


Figure 6.2. Determining a possible fracture. A and **B,** Compression (axial and circular). **C,** Distraction. **D,** Percussion. **E,** Vibration.

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. 6.3).

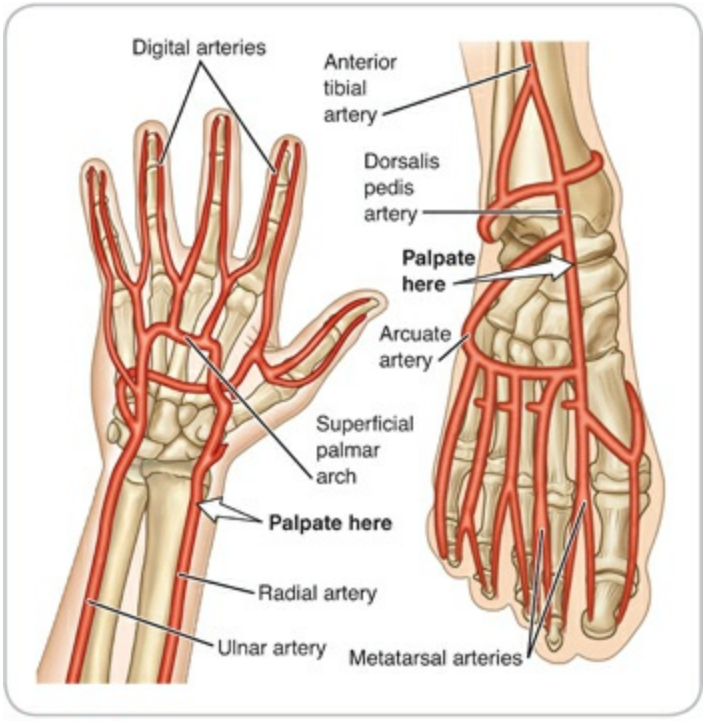


Figure 6.3. Peripheral pulses. The pulse can be taken at the radial pulse in the wrist **(A)** or at the dorsalis pedis on the dorsum of the foot **(B)**.

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. It is important to perform a bilateral palpation of key anatomical structures of the foot, ankle, and lower leg.

PHYSICAL EXAMINATION TESTS

? The palpation component of the assessment of the patient's ankle confirms the presence of fever and swelling over the anterolateral aspect of the ankle. Palpation 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?

This portion of the examination may require the clinician to use many different types of "special test" in order to help confirm or rule out a potential diagnosis. The tests are grouped by category: (1) ROM and functional testing, (2) stress tests, (3) special tests, (4) neurological testing, and (5) activity-specific functional testing. The specific tests needed and the order in which the tests are performed will be guided by the information gained through the history, inspection, and palpation portions of the assessment process. General principles regarding the PE are discussed in this chapter; more extensive explanations are provided in the individual joint chapters.

Range of Motion and Functional Tests

Functional tests identify the patient's ability to move a body part through the ROM actively passively and against resistance. The purpose of conducting ROM and functional testing is to determine which type of tissue has been damaged based on when the patient experiences pain. Contractile tissue such as muscles and tendons are assessed using active and resistive ROM. Inert tissues, such as joint capsules, ligaments, bones, cartilage and such, are assessed using passive range of motion. By looking at how the body responds to the various ROM testing will assist the clinician in identifying where the source of the pain is located. Once the source of pain has been identified, a treatment program can be designed to target the pain source and address the underlying problem causing the pain.[7] 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. Active and

passive range of motion can be measured subjectively by the clinician "eyeballing" how much ROM occurs at the injured joint and comparing with the ROM found at the comparative noninjured joint. The motion is then documented as either full or limited. If pain is present, the motion is also documented as painful. If pain is not present, the test is documented as being painless. Active and passive range of motion can also be objectively measured using a **goniometer** to measure the actual degrees of motion that occur at the injured joint.[8]

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.[8] Active movement determines possible damage to contractile tissue (i.e., muscle, muscle–tendon junction, tendon, and tendon–periosteal union)[7] and measures muscle function and movement coordination.

Measurement of all motions, except rotation, starts with the body in anatomical position. For rotation, the starting body position is midway between internal (medial) and external (lateral) rotation. The starting position is measured as 0°.

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. Limitations 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[8]:

- 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. Findings from AROM alone are not adequate to help the clinician determine the source of the patient's pain.[9] The clinician should make note of all motions that cause pain as well as where the pain was located and compare findings with information gathered through the PROM and resisted range of motion portions of the examination.

Passive Range of Motion

In **passive movement**, the injured limb or body part is moved by the clinician through the ROM with no assistance from the injured individual (Fig. 6.4). 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).[9] Again, any potentially painful motions should be performed last to avoid any carryover of pain from one motion to the next.

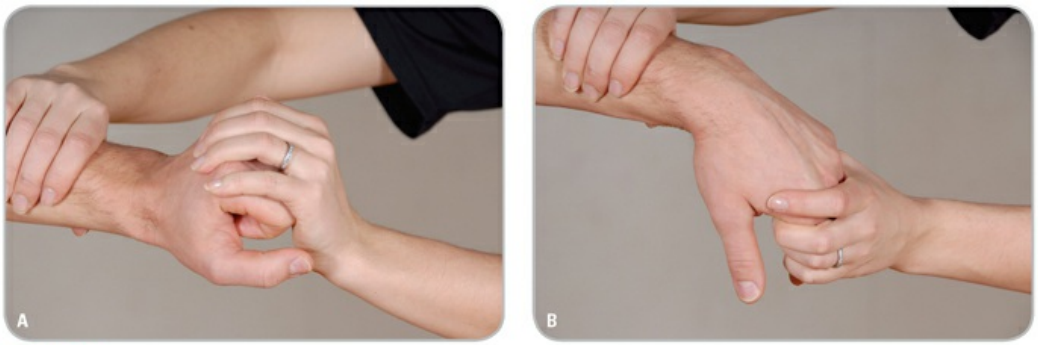


Figure 6.4. Passive movement. The body part is moved through the ROM with no assistance from the injured individual. Any limitation of movement or presence of pain is documented. **A,** Starting position. **B,** End position.

A gentle overpressure should be applied at the end of the ROM to determine **end feel**.[8] Overpressure is repeated several times to determine whether an increase in pain occurs, which could signify damage to noncontractile joint structures. Different end feels can assist the clinician in identifying the type of disorder present. 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 6.4).

TABLE 6.4 Normal and Abnormal Joint End Feels

END FEEL	STRUCTURE	EXAMPLE
Normal End Feel Sensations (Physiological)		
Soft	Soft-tissue approximation	Elbow flexion (contact between soft tissue of the forearm and anterior arm)
Firm	Muscular stretch Capsular stretch Ligamentous stretch	Hip extension (passive stretch of iliopsoas muscle) External rotation at the shoulder (passive stretch of anterior glenohumeral joint capsule) 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 (Pathological)		
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

From Cyriax JH. *Cyriax's Illustrated Manual of Orthopaedic Medicine*. 2nd ed. Oxford, United Kingdom: Butterworth-Heinemann; 1993; Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry*. 4th ed. Philadelphia, PA: FA Davis; 2009; Cyriax J. *Textbook of Orthopaedic Medicine, Volume One: Diagnosis of Soft Tissue Lesions*. 8th ed. London, United Kingdom: Baillière Tindall; 1982; Kendall FP, McCreary EK, Provance PG, et al. *Muscles: Testing and Function with Posture and Pain*. 5th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2005.

Differences in ROM between active and passive movements can result from muscle spasm, muscle deficiency, neurological 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. Interpreting the findings from ROM testing is presented in Table 6.5

TABLE 6.5 Interpreting Range of Motion Findings

AROM[a]	PROM[a]	TISSUE TYPE INJURED
Pain is elicited during concentric contraction of muscle (active contraction).	Pain is elicited when tissue is stretched (passive stretch).	Contractile
Pain is elicited with both eccentric and concentric contraction.	Pain is elicited with all passive motions.	Inert

[a]Through the full range of motion.

From Cyriax JH. *Cyriax's Illustrated Manual of Orthopaedic Medicine*. 2nd ed. Oxford, United Kingdom: Butterworth-Heinemann; 1993; Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry*. 4th ed. Philadelphia, PA: FA Davis; 2009; Cyriax J. *Textbook of Orthopaedic Medicine, Volume One: Diagnosis of Soft Tissue Lesions*. 8th ed. London, United Kingdom: Baillière Tindall; 1982.

Accessory movements are movements within the joint that accompany traditional AROM 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 the full normal ROM. If joint play movement is absent or decreased, this movement must be restored before functional voluntary movement can be accomplished fully.[10]

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** (Table 6.6). The resting position is the position in the ROM in which the joint is under the least amount of stress. It is also 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.

TABLE 6.6 Loose Packed Position of Selected Joints

JOINT(S)	POSITION
Glenohumeral	55° abduction, 30° horizontal adduction
Elbow (ulnohumeral)	70° elbow flexion, 10° forearm supination
Radiohumeral	Full extension, full forearm supination
Proximal radioulnar	70° elbow flexion, 35° supination
Distal radioulnar	10° forearm supination
Wrist (radiocarpal)	Neutral with slight ulnar deviation
Carpometacarpal	Midway between abduction–adduction and flexion–extension
Metacarpophalangeal	Slight flexion
Interphalangeal	Slight flexion
Hip	30° flexion, 30° abduction, slight lateral rotation
Knee	25° flexion
Ankle (talocrural)	10° plantar flexion, midway between maximum inversion and eversion
Subtalar	Midway between extremes of inversion and eversion
Tarsometatarsal	Midway between extremes of range of motion
Metatarsophalangeal	Neutral
Interphalangeal	Slight flexion

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 (Table 6.7). 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.

TABLE 6.7 Close Packed Positions of Selected Joints

JOINT(S)	POSITION
Glenohumeral	Abduction and lateral rotation
Elbow (ulnohumeral)	Extension
Radiohumeral	Elbow flexed 90°, 5° forearm supination
Proximal radioulnar	5° forearm supination
Distal radioulnar	5° forearm supination
Wrist (radiocarpal)	Extension with radial deviation
Metacarpophalangeal (fingers)	Full flexion
Metacarpophalangeal (thumb)	Full opposition
Interphalangeal	Full extension
Hip	Full extension, medial rotation and abduction
Knee	Full extension, lateral rotation of tibia
Ankle (talocrural)	Maximum dorsiflexion
Subtalar	Full supination
Midtarsal	Full supination
Tarsometatarsal	Full supination
Metatarsophalangeal	Full extension
Interphalangeal	Full extension

Resisted Range of Motion and Manual Muscle Testing [8,11]

Resisted range of motion (RROM) and manual testing can assess muscle strength/weakness. RROM testing is performed by applying an overload pressure in a stationary or static position (sometimes referred to as a **break test**) or dynamically throughout the full ROM. RROM testing allows the clinician to determine the presence of muscle weakness within a group of muscles performing the same task. For example, when testing resisted knee flexion, the patient describes pain and demonstrates weakness. The clinician is able to state that weakness was present with knee flexion but will be unable to state in which of the three hamstring muscles the lesion is located that caused the weakness. In contrast, manual muscle testing (MMT) guidelines require the clinician to place the body part in a very specific position in order to isolate one single muscle as much as possible in order to test only that one muscle. For example, to perform an MMT of the biceps femoris, which is one of the three flexors of the knee, the patient lies prone with the knee flexed between 50° and 70°. The hip is in slight lateral rotation, and the leg slightly externally rotated while the clinician applies resistance. Differences and similarities in

RROM and MMT are described in the following discussion.

Resisted Range of Motion

RROM testing follows PROM and is done prior to MMT. 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. To perform RROM throughout the full ROM, have the patient place the limb in the elongated position. The clinician stabilizes proximal to the joint and applies an accommodating resistance to the distal aspect of the limb. The patient is instructed to move the body part through the requested ROM while the clinician applies enough pressure to make the patient work but not so much as to prevent motion from occurring. RROM may also be tested in a static position through the use of a break test.

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 but do not allow the clinician to discover where within the ROM the weakness occurs. Performing RROM in a static position is also easily confused with performing an MMT. 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. Presence of pain and/or weakness during RROM is an indication that MMT should be performed to determine the exact muscle that is injured.

Manual Muscle Testing

MMT procedures require that before resistance can be applied, the patient first should be able to demonstrate the ability to contract the muscle, move the joint through full ROM with gravity eliminated and move the joint through full ROM against gravity.[11] If a patient can complete AROM and demonstrates weakness

or pain during RROM, MMT is indicated. When performing MMT, the body segment is placed in a specific position to isolate the muscle or muscle group. Slight variations in positioning will impact how well a specific muscle is isolated, so it is important when performing MMT to test the body part as depicted in your reference material.[11] As with the break test, the patient is asked to perform an isometric contraction while the clinician applies resistance in an attempt to "break" the contraction. A standardized grading system can be used to measure muscle contraction (**Table 6.8**).[11]

TABLE 6.8 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

From Kendall FP, McCreary EK, Provance PG, et al. *Muscles: Testing and Function with Posture and Pain.* 5th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2005.

Goniometry

The available AROM and PROM can be measured objectively using a goniometer (**Fig. 6.5**). 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.[8] The arms of the goniometer measure 0° to 180° of motion, or 0° to 360° of motion. The axis of the goniometer is aligned with the axis of the joint. The moving arm is aligned with specific landmarks on the moving body part. The stationary arm is aligned with specific landmarks on the nonmoving body part. Each joint has established landmarks for aligning the axis, moving arm, and nonmoving. To ensure that the measurements are valid and reliable, it is important that the clinician utilizes the established protocols for measuring ROM that are found in published reference materials.

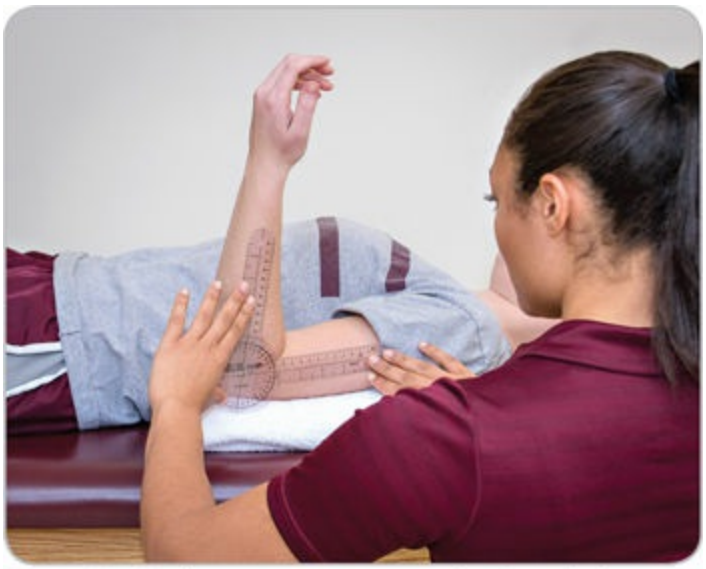


Figure 6.5. Goniometry measurement at the elbow. In the anatomical position, the elbow is flexed. The goniometer axis is placed over the lateral epicondyle of the humerus. To accommodate using a goniometer that ranges from 0° to 180°, the stationary arm is held parallel to the longitudinal axis of the 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. The ROM is measured at the site where the pointer intersects the scale.

The normal ROM for selected joints is listed in **Table 6.9** and in the individual joint chapters. Age and gender may influence ROM. Women in their teens and early 20s tend to have a greater ROM in all planes compared with men. ROM decreases after 20 years in both genders, with the decrease occurring to a greater extent in women.

TABLE 6.9 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	Flexion	0°–90°
	Extension	0°–70°	MCP	Extension	0°–45°
	Lateral flexion	0°–45°		Abduction	0°–20°
	Rotation	0°–80°			
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°	Knee	External rotation	0°–50°
	External rotation	0°–90°		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.

From Lesser JM, Hughes SV, Jemelka JR, et al. Compiling a complete medical history: challenges and strategies for taking a comprehensive history in the elderly. *Geriatrics*. 2005;60(11):22–25.

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 the 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 6.10). **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.

TABLE 6.10 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.

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 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 6.6 demonstrates a **valgus** stress test on the elbow joint to assess the integrity of the 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.

Figure 6.6. Stress tests. The application of a valgus stress on the elbow joint can assess the integrity of the joint medial collateral ligaments.

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 biceps tendon, and Thompson test is used to assess potential rupture of the Achilles tendon.

Neurological 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 MMT and noting cutaneous sensory changes in peripheral nerve patterns. Neurological testing is only necessary in orthopedic injuries when an individual complains of numbness, tingling, or a burning sensation or suffers from unexplained muscular weakness.

Dermatomes

The sensitivity of a dermatome can be assessed by touching a patient with a cotton ball, paper clip, the pads of the fingers, or opposite ends of a cotton-tipped applicator. In doing so, the clinician 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 6.7** illustrates dermatome patterns for the segmental nerves.

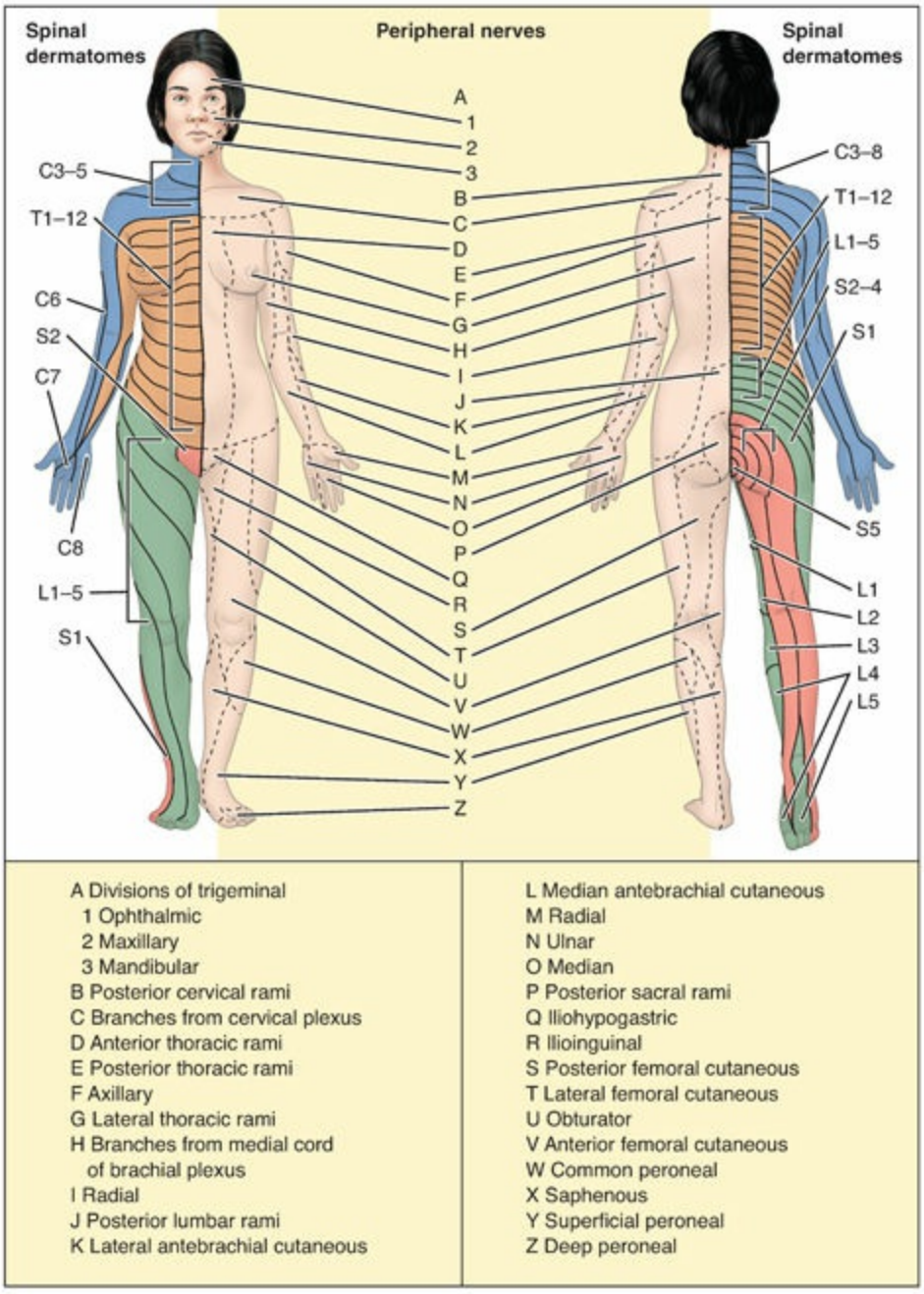


Figure 6.7. Cutaneous sensation. The cutaneous sensation patterns of the spinal nerve dermatomes differ from the patterns innervated by the peripheral nerves.

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 the myotome (Table 6.11). In assessing nerve integrity, the patient must hold the isometric muscle contraction for at least 5 seconds while the clinician resists the motion. A normal response is a strong muscle contraction and ability to withstand resistance.[11] 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 receives innervation from the 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 a knee extension.

TABLE 6.11 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.

Reflexes

Damage to the CNS can be detected by stimulation of the deep tendon reflexes (DTRs) (Table 6.12). 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. 6.8). DTRs 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.

TABLE 6.12 Deep Tendon Reflexes

REFLEX LEVEL	STIMULATION SITE	NORMAL RESPONSE	SEGMENTAL
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

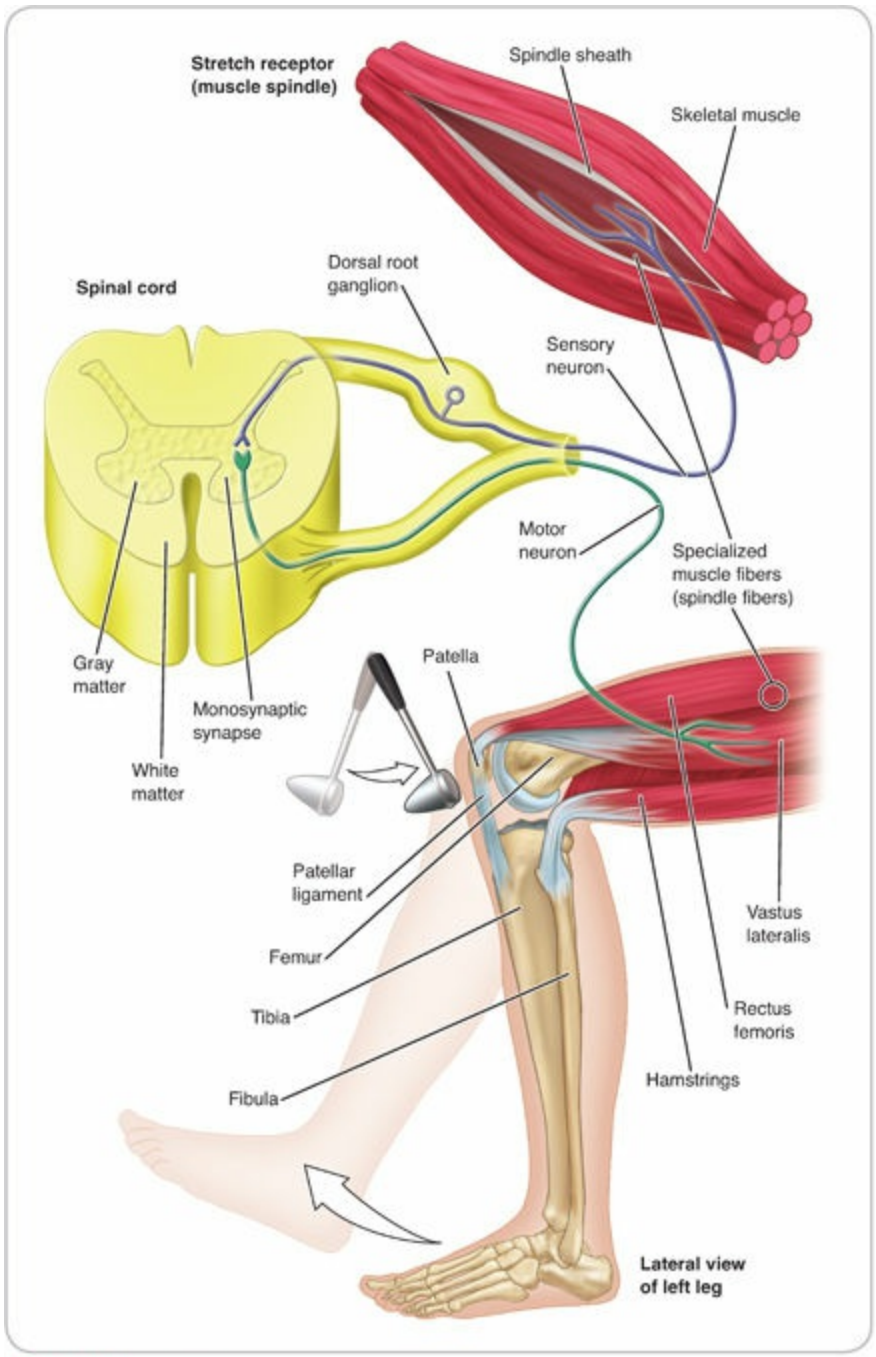


Figure 6.8. Reflexes. Reflexes can indicate the presence of nerve root damage. The most familiar stretch reflex is the knee jerk, or patellar reflex, performed by tapping the patellar tendon with a reflex hammer, causing involuntary knee extension.

Superficial reflexes are reflexes provoked by superficial stroking, usually with a moderately sharp object that does not break the skin (Table 6.13). This action produces a reflex muscle contraction. For 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

through T9. An absence of a superficial reflex indicates a lesion in the cerebral cortex of the brain (upper motor neuron lesion).

TABLE 6.13 Superficial Reflexes

REFLEX	NORMAL RESPONSE	SEGMENTAL LEVEL
Upper abdominal	Umbilicus moves up and toward area being stroked	T7–T9
Lower abdominal	Umbilicus moves down and toward area being stroked	T11–T1
Cremasteric	Scrotum elevates	T12, L1
Plantar	Flexion of toes	S1–S2
Gluteal	Skin tenses in the gluteal area	L4–L5, S1–S3
Anal	Anal sphincter muscles contract	S2–S4

Pathological reflexes (Table 6.14) 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 6.14 Pathological Reflexes[a]

REFLEX	ELICITATION	POSITIVE RESPONSE	PATHOLOGY
Babinski[b]	Stroke lateral aspect of sole of foot.	Extension of big toe; fanning of four small toes Test is normal in newborns.	Pyramidal tract lesion Organic hemiplegia
Chaddock	Stroke lateral side of foot beneath lateral malleolus.	Same response as previous	Pyramidal tract lesion
Oppenheim	Stroke anteromedial tibial surface.	Same response as previous	Pyramidal tract lesion
Gordon	Squeeze calf muscle firmly.	Same response as previous	Pyramidal tract lesion
Brudzinski	Passive flexion of one lower limb	Similar movement occurs in opposite limb.	Meningitis
Hoffman (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]A bilateral positive response indicates an upper motor neuron lesion. A unilateral positive response may indicate a lower motor neuron lesion.
[b]The test is most commonly performed in the lower limb.
[c]The test is most commonly performed in the upper limb.

Peripheral Nerve Testing

Motor function in peripheral nerves is assessed by resisted MMT throughout the full ROM. Sensory deficits are assessed in a manner identical to that of dermatome testing, except the cutaneous patterns differ (Fig. 6.7). 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. 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. Prior to starting the functional return to play testing sequence, the patient should have full pain-free ROM, have no active inflammation or acute swelling present, and demonstrate preinjury strength and ROM. Activity-specific tests involve the performance of active movements typical of those executed by the individual during sport or activity participation. The initial assessment should involve assessing the patient's walking gait, ability to perform double- and single-leg hopping, and ability to run in a straight line, figure eight, and Z and S patterns at one-fourth, one-half, three-fourth, and full speed without pain or instability. These movements should assess strength, agility, flexibility, joint stability, endurance, coordination, and balance. Once the patient has successfully completed the initial phase of functional testing, activity-specific skills can be introduced to an increasing, more challengingly levels until gamelike situations are replicated. Any individual who has been discharged from rehabilitation also should be cleared by a physician for participation.

The testing component of an assessment should include special tests to rule out possibility of fracture before beginning ROM and MMT. However, because a sprain of the anterior talofibular ligament is suspected based on the MOI and location of swelling, fever, and point tenderness, joint stability stress testing is most appropriate to perform at this point. Depending on the findings, additional tests that may be considered are ROM, MMT, neurological, and functional assessment. Based on those findings, activity-specific functional testing may or may not be appropriate.

LABORATORY TESTS

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

A variety of laboratory tests can be used in the assessment of an injury and illness (Box 6.3). For example, if an individual has a grossly swollen knee, the physician may draw fluid out of the joint with a hypodermic needle to examine the synovial fluid (Table 6.15). 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 (Table 6.16).

BOX 6.3 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 B12, 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 a possible bleeding disorder.

TABLE 6.15 Synovial Fluid Classifications

TYPE	APPEARANCE	SIGNIFICANCE
Group 1	Clear yellow	Noninflammatory state, no trauma
Group 2[a]	Cloudy	Inflammatory, arthritis, excludes most patients with osteoarthritis
Group 3	Thick exudate, brownish	Septic arthritis; occasionally seen in gout
Group 4	Hemorrhagic	Trauma, bleeding disorders, tumors, fractures

[a]Inflammatory fluids clot and should be collected in heparin-containing tubes. All group 2 or 3 fluids should be cultured if the diagnosis is uncertain.

TABLE 6.16 Normal Ranges for Selected Blood Variables in Adults

LABORATORY TEST	MEN	GENDER NEUTRAL	WOMEN
Hemoglobin (g/dL)	13–18		12–16
Hematocrit (%)	42–52		37–48
Red blood cell count (10^{12}/L)	4.5–6.5		3.9–5.6
White blood cell count		4.3–10.8 (10^9/L)	
Platelet count		150–350 (10^9/L)	
Iron, total (μg/dL)		50–100	

Radiography

The most common imaging technique is radiography, or the X-ray (Fig. 6.9). 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 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 on 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 6.9. Radiography. Bone absorbs the X-rays and, therefore, appears white on the radiograph. This radiograph demonstrates a dorsal dislocation of the proximal interphalangeal joint.

Some forms of radiographs use radiopaque 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

A computed tomography (CT) scan is a form of radiography that produces a three-dimensional, cross-sectional picture of a body part (Fig. 6.10). 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.

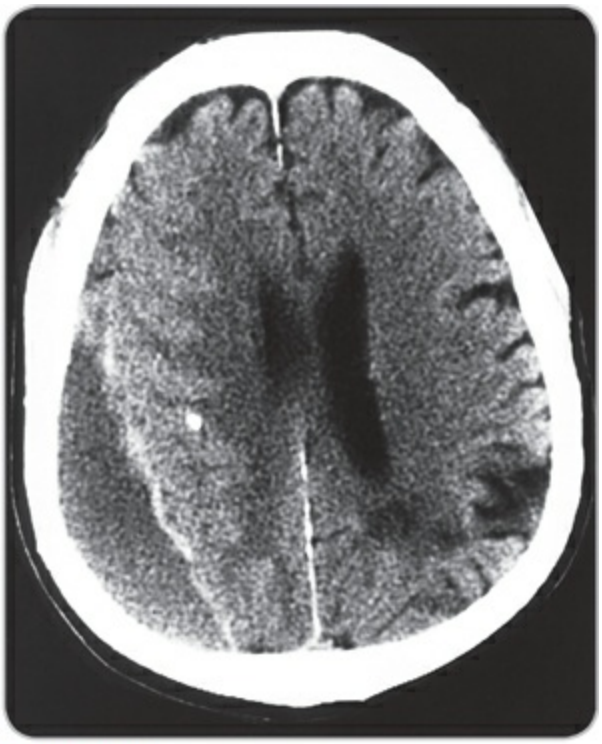


Figure 6.10. Computed tomography. A male patient reported increased sleepiness and a change in personality 3 weeks after falling and striking his head. The cranial CT scan demonstrates a chronic subdural hematoma.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is an excellent tool for visualizing the CNS, spine, and musculoskeletal and cardiovascular systems (Fig. 6.11). 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.

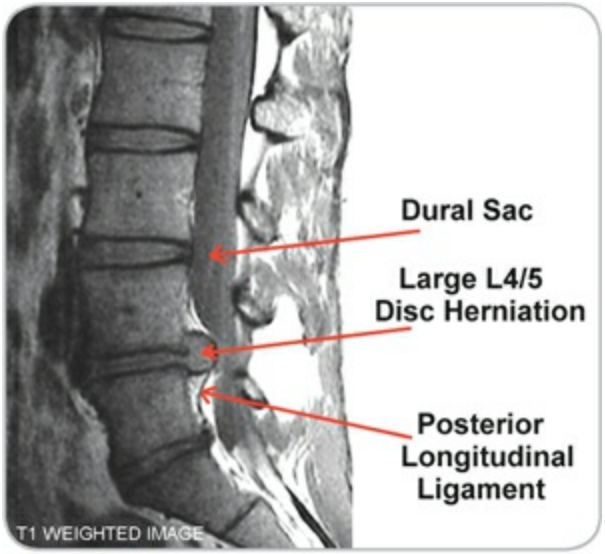


Figure 6.11. Magnetic resonance imaging. This magnetic resonance image depicts a large L4–L5 disk herniation.

Images are obtained by placing the patient in an MRI tube that produces the magnetic field. This causes the body's hydrogen 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. 6.12). 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.

Figure 6.12. 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.

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 the 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 that is consistent with current state law.

DOCUMENTATION

Why is it so critical that athletic trainers document their actions while caring for each patient?

Athletic trainers are required to maintain medical records in accordance with state and federal regulatory agencies.[12] Specifically, clinicians should conform to the Health Insurance Portability and Accountability Act (HIPAA) guidelines and when working in schools systems, the Federal Educational Rights Privacy Act (FERPA) guidelines.[12] Part of medical records is the report that documents the findings of the evaluation process and the subsequent treatment provided. Maintaining clear and accurately scribed injury reports and SOAP notes serve several purposes: (1) to enhance communication among those providing care for the patient by storing all pertinent information in a centralized document,

(2) to facilitate continuity of care by decreasing the chance of replication of services or risk of assuming services are being provided when they are not, and (3) to provide evidence of services provided for purposes of billing and legal protections.

When documenting the evaluation process and the subsequent treatment provided, the clinician should adhere to eight basic principles. **First**, use correct medical terminology so that you convey the precise structure, location, pathology, condition, or process under examination. **Second**, use only standardized and accepted medical abbreviations. Medical abbreviations are widely used in medical documentation to decrease time spent on writing notes. However, a downfall of using abbreviations is that information may not be accurately conveyed due to differences in interpretations. A list of commonly used and accepted medical abbreviations is provided in **Table 6.17**. **Third**, use correct punctuation. Periods, dashes, and slashes have specific meaning in medical documents (refer to **Table 6.17**), and the skilled clinician should be aware of how punctuation use is different when writing medical notes than when writing narratives. **Fourth**, strive to be as accurate as possible. **Fifth**, while maintaining accuracy, also strive for brevity. Although using anatomical/medical terms and abbreviations will aid in being brief, it is important to record information that is most pertinent. For example, when describing the MOI for an ankle sprain, a brief yet accurate description is as follows: *Patient inverted R ankle upon landing.* The longer version is as follows: *Patient was playing basketball and attempting to rebound an opponent's ball. Upon landing, the patient inverted her right ankle which she described as "rolling inward."* **Sixth**, write (or type) legibly with an instrument that cannot be erased or removed. If the revision is needed, the clinician simply draws one line (or strike out) through the original word or phrase and clearly writes in the new information so that both the original and revised information is visible. The clinician should sign and date when the revision was made. **Seventh**, documents should be completed and filed at the time services are rendered. And **eighth**, the clinician needs to sign and date each note in a manner that clearly identifies who created the note/provided services.

TABLE 6.17 Common Abbreviations and Symbols Used in Medical Documentation

<	Less than	EENT	Eyes, ears, nose, throat
>	Greater than	ELOP	Estimated length of program
↑	Increase	EMS	Emergency medical services
↓	Decrease	EMT	Emergency medical technician
Δ	Change	EOA	Examine, opinion, and advice; esophageal obturator airway
abnor.	Abnormal	ES	Electrical stimulation
AC	Acute; before meals; acromioclavicular	EV	Eversion
ADL	Activities of daily living	exam.	Examination
ant.	Anterior	FH	Family history
ante	Before	FROM	Full range of movement
A&O	Alert & oriented	FWB	Full weight bearing
AOAP	As often as possible	Fx	Fracture
AP	Anterior–posterior; assessment and plans	G1–4	Grades 1–4
AROM	Active range of motion	GA	General appearance
ASAP	As soon as possible	HA	Headache
AT	Athletic training; athletic trainer	H/O	History of
B	Bilateral	HP	Hot pack
BID or bid	Twice daily	H&P	History and physical
c	With	HPI	History of present illness
CC	Chief complaint; chronic complainer	ht.	Height; heart
ck.	Check	HTN	Hypertension
C/O	Complained of; complaints; under care of	Hx	History
CP	Cerebral palsy; chest pain; chronic pain	IC	Individual counseling
CPR	Cardiopulmonary resuscitation	IN	Inversion
CWI	Crutch walking instruction	IPPA	Inspection, percussion, palpation, and auscultation
D	Day	L	Left; liter
d/c, DC	Discharged; discontinue; decrease	LAT	Lateral
DF	Dorsiflexion	LBP	Low back pain
DOB	Date of birth	LE	Lower extremity
DTR	Deep tendon reflexes	LOM	Limitation of motion
DVT	Deep vein thrombosis	MAEEW	Moves all extremities equally well
Dx	Diagnosis	MEDS	Medication
E	Edema	mm	Muscle; millimeter; mucous membrane

(continued)

TABLE 6.17 Common Abbreviations and Symbols Used in Medical Documentation *(continued)*

MMT	Manual muscle test	PT	Point tender
MOD	Moderate	PWB	Partial weight bearing
N	Normal; never; no; not	Px	Physical examination; pneumothorax
NC	Neurological check; no complaints; not completed	qd	Once daily
NEG	Negative	qid	Four times daily
NKA	No known allergies	R	Right
NP	No pain; not pregnant; not present	rehab	Rehabilitation
NPO	Nothing by mouth	R/O	Rule out
NPT	Normal pressure and temperature	ROM	Range of motion
NSA	No significant abnormality	RROM	Resisted range of motion
NSAID	Nonsteroidal anti-inflammatory drug	RTP	Return to play
NT	Not tried	Rx	Therapy; drug; medication; treatment; take
NWB	Non–weight-bearing	s	Without
O	Objective finding; oral; open; obvious; often; other	SLR	Straight leg raises
OH	Occupational history	stat	Immediately
ORIF	Open reduction/internal fixation	STG	Short-term goals
p	After	Sx	Signs, symptom
P&A	Percussion and auscultation	T	Temperature
PA	Posterior–anterior; physician assistant; presents again	TENS	Transcutaneous electrical nerve stimulation
PE	Physical examination	tid	Three times daily
PF	Plantar flexion	TTWB	Toe touch weight bearing
PH	Past history; poor health	UE	Upper extremity
PMH	Past medical history	UK	Unknown
PNF	Proprioceptive neuromuscular facilitation	US	Ultrasound
PNS	Peripheral nervous system	w	White; with
PPPBL	Peripheral pulses palpable both legs	WBAT	Weight bearing as tolerated
pre-op	Preoperative	whp	Whirlpool
PRE	Progressive resistive exercise	WNL	Within normal limits
prn	As needed	W/O	Without
prog.	Prognosis	y.o.	Year old
PROM	Passive range of motion	1tive	Positive

Clear and accurate injury reports and SOAP notes in a centralized document can enhance communication between health care providers decreasing the chance of replication of services or assuming that services are being provided when they are not and can provide evidence of services provided for purposes of billing and legal protections.

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. When evaluating patients who present with symptoms suggestive of a general medical condition, the assessment process is divided into the history and physical examination.
5. The subjective information gathered during the history taking should include the primary complaint, the MOI, characteristics of the symptoms, disabilities resulting from the injury, and related medical history.
6. The objective assessment should include observation and inspection, bony and soft-tissue palpation, functional tests, stress tests for specific joints or structures, neurological testing, and activity-specific functional tests.
7. ROM testing includes assessing active, passive, and resistive motions and is used to gather information about the amount of motion present and the presence of pain.
8. ROM can be objectively measured using a goniometer. Specific landmarks are utilized to measure each specific ROM and thus are considered reliable methods of obtaining objective measurements of motion.
9. MMT is used to assess the strength of a specific muscle by isolating the

muscle and requiring the muscle to meet a specific resistance. MMT is graded based on a scale of 0 to 5.

10. Special tests denote any given number of tests that are used to assess for the presence of absence of a specific pathology.
11. 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.

APPLICATION QUESTIONS

1. You have been a high school athletic trainer for 5 years. Effective this year, the school hired a second athletic trainer on a part-time basis (i.e., working 20 to 25 hours per week). It has been your practice to use the HOPS method when performing and documenting an injury assessment. The new athletic trainer prefers to use the SOAP method and asks permission to continue to use that format. Describe the benefits and challenges to adopting this request.
2. As the host interscholastic athletic trainer, a member of the visiting lacrosse team sustains a knee injury during the first half of the game. In gathering a history of the injury on the field, what questions, if any, would be appropriate to ask regarding any previous history of injury to the same knee? What value is there in asking these questions?
3. A 15-year-old soccer player sustains an ankle injury. The MOI and observable signs suggest a mild inversion ankle sprain. Where would you begin palpating for point tenderness to determine the extent and severity of injury without causing additional pain?
4. While working as a physician extender, you routinely forget to complete the ROS portion of the history. Create a list of questions that will allow you to assess all systems required within the ROS process.

5. As a high school athletic trainer, you have a student athlete that has sustained a significant ankle injury that warrants an X-ray. How would you proceed?

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