Active and passive insufficiency examples

Biceps: when the muscle shortens, points (a) insertion and (b) origin are brought closer together and the arm is bent, or flexed at the elbow.Antique apparatus for recording successive muscular contractionsMyofibrils comprised of actin and myosin myofilamentsTension PotentialA muscle's ability to contract is dependent upon its length, or degree of contraction. A muscle can contract more forcefully when it is slightly stretched. Muscle generates maximal concentric tension at a length 1.2 times its resting length. Beyond this length, active tension decreases due to insufficient sarcomere overlap (Norkin & Levangie 1992). A muscle tension becomes weaker as it nears complete contraction. See muscle length-tension relation graph below. Also see active insufficiency and passive insufficiency below.Active InsufficiencyThe inability for a biarticulate muscle to exert enough tension to shorten sufficiently to complete full range of motion in both joints simultaneously. Active insufficiency explains the quantity of cross bridges active from the myosin to the actin dependent upon the muscle's length. Also see tension potential above and muscle length-tension relation graph below. These diagrams illustrate how hamstring involvement is influenced by the position of the knee. In the first figure, the hamstrings are in a mechanical advantage during hip extension when the knee is straight or nearly straight. In the second figure, the hamstring muscles are relaxed when the knee is bent, particularly as the hip is further extended; the gluteus maximus are thereby more exclusively involved in hip extension. See examples of how body seemingly inadvertently compensates for active insufficiency during certain weight training exercises.Passive InsufficiencyThe inability for a biarticulate muscle to stretch enough to complete full range of motion in both joints simultaneously. Also see tension potential above and muscle length-tension relation graph below. The above diagrams also illustrate how flexion at the hip joint is influenced by the position of the knee. In the first figure, the hamstrings are tightly stretched when the knee is straight. In the second figure, the muscles are relaxed when the knee is bent; a greater amount of hip flexion is thereby permitted. When one stretches a biarticulate muscle, they are essentially placing it into a position of passive insufficiency. Although passive insufficiency explains range of motion limitations, it also implies the weaker elongated position in which the muscles placed. See examples of how body seemingly inadvertently compensates for active insufficiency during certain weight training exercises.Greatest tension is developed at point B (slightly stretched) with less tension developed at points A (contracted) and C (stretched).Muscle Fatigue (a) muscle with intact circulation (b) isolate muscle. Note sustained muscular contraction may occlude local vasculature momentarily impeding blood flow to activated muscle. Also see Pump and Burn.Muscular forces can be enhanced when the muscle is stretched (causing eccentric tension) immediately before concentric contraction. This stretch-shorten cycle (SSC) occurs naturally in running, jumping, and all other activities in which muscles are suddenly stretched by impact or other external forces. The stretch-shortening cycle saves energy by temporarily storing potential energy through elastic recoil resulting from an external quick stretching force.Plyometric vertical jumps following quick landings from a 0.4 m height have been found to be higher than made from a semisquat, with or without a dip or countermovement (Asmussen & Bonde-Peterson 1976). Also see Depth Jump Heights and Speed of Contraction.Recoils or windups immediately before throwing, striking, or kicking can augment the muscle contraction forces to come.In running, the shock absorption occurring at foot plant contributes to greater force production at push-off (Cavagna, Dusman & Margaria 1968).In sprint running, the quick stretch (0.15 to 0.1 seconds) applied at ground contact during push-off increased force production (Kreighbaum 1996).In weight training, even a one second delay at the bottom of a bench press would result in a 55% loss of force.Slow Oxidative (SO) fibers have the greater elastic properties than Fast Glycolytic (FG) (Kimi & Bosco 1978, Milner 1988)Musculotendinous ReceptorsMuscle SpindlesMuscle spindles are a type of receptor located throughout the muscle and situated between and parallel to individual muscle fibers. In this position, they are stretched along with adjacent muscle fibers, causing a reflex contraction of their associated host muscle, also known as myotatic or stretch reflex. The knee-jerk reflex is an example. Both the stretch reflex and recoil of stored elastic energy used in striking or throwing movements. Muscle spindles also are involved in motor control, providing constant monitoring and regulation of sensorimotor function, enabling appropriate body movement, both reflective and voluntary (Schmidt 1988, Gregor 1989).Golgi Tendon OrgansGolgi Tendon Organs (GTO) are receptors located in tendon merging with its muscle (myotendinous junction) and positioned in line with the direction of muscle contraction. These receptors are sensitive to both the passive and active pull of muscle tendon (Gregor, 1989). The GTO inhibits the contraction of the associated muscle (autogenic inhibition) and excites the antagonistic muscle group. Also see Golgi Tendon Organs Question/Answer.Slow oxidative (SO)Fast Oxidative Glycolytic (FOG)Fast Glycolytic (FG)Type I (red)Type IIA (white)Type IIX (white)Speed of contractionSlowFastFastForce of contractionLowMediumHighAnaerobic capacityLowMediumHighAerobic capacityHighMediumLowCapillary densityHighMediumLowMitochondrial densityHighHighLowMotor neuron sizeSmallMediumLargeMajor substrateTriglyceridesCP, GlycogenCP, GlycogenActivityProlonged low intenseProlonged high intenseShort high intenseAverage fiber percentage50%35%15%IndividualRatio of both types of muscle fiber varies in each individual, thought to be genetically determined.SexSimoneau, et al. (1985) found differences in ratios of fiber types between sedentary men and women. Other studies suggest fiber type variations may be largely due to differences in physical activity (Miller AEJ et al. 1992).In order from greatest to smallest area occupied in muscleMen: type IIA, I, IIXWomen: type I, IIA, IIXWomen's muscle fiber area of both type I and II are smaller than men'sFiber RatioRatio of both types of muscle fiber varies in each muscle.Eg: Percentage of Type I Fibers: Quadriceps (~52%), Soleus (~80%), Orbicularis Oculi (~15%)Muscles that primarily maintain posture against gravity require more endurance and generally have a higher percentage of slow-twitch fibers.Muscles that produce powerful, rapid, explosive strength movements tend to have a greater percentage of fast-twitch fibers.Recruitment VelocityRecruitment velocity is the rate at which a muscle fiber can achieve maximum tensionRecruitment velociyt varies from 20 milliseconds for white fibers to 65 milliseconds for red fibers.SportSprinters and weight lifters have a large percentage of fast-twitch fibers.Marathon runners generally have a higher percentage of slow twitch fibers.TrainingBoth types of fibers can improve their metabolic capabilities through specific strength and endurance training.NomenclatureEarly researches believed humans possessed type IIb.Later research revealed IIB was in fact IIX in humans.Nonhuman fiber types include true IIb fibers as well as others (IIc, IId, etc.)One end of muscle fiber showing attachment of tendon to sarcolemmaPart of a muscle fiber specially prepared to bring out the numerous nucleiAn artery branching into capillaries between three muscle fibersRecord of successive contractions of elbow flexor musclesAlso see Motor Unit Recruitment and Golgi Tendon Organs Discussion.Muscle as an Endocrine OrganWorking muscle releases myokines, a type of cytokines which regulate the metabolism of muscles and other tissues and organs including the adipose tissue, liver, and brain via their respective receptors. The functions of the various types of myokines vary:IL-6: < Inflammation, > Muscle atrophy, > Fatty acid OxidationBDNF: > Muscle regeneration, > Fatty acid oxidationIL-15: > Fat metabolism, > Myoblast differentiation, > Muscle mass / atrophySPARC: > Muscle repairFGF21: > Muscle Mass, Mitochondrial biogenesisDeorin: > Myhogeneis, < Muscle atrophyMyonectin: < Autophagy, > Mitochondrial biogenesisMyostatin: > Muscle atrophy, < Muscle massIrisin: > Muscle mass, > Muscle hypertrophy, > Fatty acid oxidationLee JH, Jun HS (2019). Role of Myokines in Regulating Skeletal Muscle Mass and Function. Front. Physiol. doi: 10.3389/fphys.2019.00042 At the completion of this chapter, the reader will be able to: Describe the three components of mobility and their differences. Describe the two different types of flexibility. Perform a goniometric assessment of each joint. Describe strategies to increase range of motion (ROM) using different techniques. Describe the indications and contraindications for the various types of ROM exercises. Define active insufficiency and passive insufficiency of a muscle. Outline the indications and contraindications for continuous passive motion (CPM). Define flexibility and describe its importance in rehabilitation. Explain the differences between the various stretching techniques. Describe strategies to increase flexibility using different techniques. Normal mobility is necessary for efficient movement. The terms range of motion (ROM), flexibility, and accessory joint motion are often listed as components of mobility. ROM refers to the distance and direction a joint can move. The direction in which a joint moves is described using terms like flexion, extension, abduction, adduction, internal rotation, and external rotation. Each specific joint has a normal ROM that is expressed in degrees. Within the field of physical therapy, goniometry is commonly used to measure the total amount of available motion at a specific joint. ROM of a joint may be limited by the shape of the articulating surfaces, adaptive shortening of the muscles, and capsular and ligamentous structures surrounding that joint. Under normal circumstances, it is the muscles that move the joints. The full range of extensibility of a muscle is called its functional excursion. The amount of excursion depends on the arrangement of the muscle fibers and whether the muscle is a one-joint or a multi-joint muscle (see later). Flexibility refers to the passive extensibility of connective tissue that provides the ability for a joint or series of joints to move through a full, nonrestricted, injury-free, and pain-free ROM. Flexibility is also dependent upon pain levels and neuromuscular control. Magnusson1 identified three factors that might contribute to improving flexibility: passive tissue properties, segmental reflex excitability, and tolerance of discomfort. When an injury occurs, there is almost always some associated loss of the ability to move normally due to the pain, swelling, muscle guarding, or spasm. The subsequent inactivity results in a shortening of connective tissue and muscle, loss of neuromuscular control, or a combination of these factors.2 Accessory joint motion. Accessory joint motion is the amount of the arthrokinematic glide that occurs at the joint surfaces, termed joint play (see Chapter 1). A number of anatomic factors can limit the ability of a joint to move through a full, unrestricted ROM, including the integrity of the joint surfaces, increasing age, and the mobility and pliability of the soft tissues that surround a joint. Before attempting to improve the arthrokinematic glide at a particular joint, the clinician must always consider the status of the neighboring joints in terms of their hypermobility or hypomobility (see Chapter 2). Joint mobilization is a technique that preserves or increases arthrokinematic motion. Techniques to enhance joint motion are described in Chapter 10. A decrease in accessory joint motion, ROM and/or in the flexibility of one joint can affect the mobility of the kinetic chain. For example, a decreased ROM or flexibility in the shoulder can impact the mobility of the entire arm. In order to provide treatment for a loss of mobility, the clinician must make the determination as to the specific cause, that is, loss of joint motion, ROM, or decreased flexibility. For example, is the specific cause due to joint effusion, adaptive shortening of connective tissue structures, a change in bony architecture, or malalignment of the articular surfaces? Attempting to perform ROM and flexibility techniques in the absence of normal arthrokinematic motion at the joint surface will not result in an improvement in the impaired mobility, but may instead increase the patient's symptoms. Flexibility is the ability to move a single joint or series of joints through an unrestricted and pain-free ROM. Flexibility depends on sound joint arthrokinematics, full ROM (normal osteokinematics), and soft-tissue extensibility. It also depends on the mechanical and neurophysiological properties of the tissues involved and how those tissues react to physical loading (see Chapters 1 and 2). Stretching techniques are designed to improve the extensibility of both contractile and noncontractile tissues, including neural tissues (see Chapter 11). Indications for stretching include those scenarios when ROM is limited due to a loss of extensibility in the soft tissues because of scar tissue formation, adhesions, and contractures that have resulted in functional limitations or participation restrictions. Contraindications for stretching include a bony end feel, an incomplete bony union, recent fracture, acute inflammatory or infectious process, sharp pain with joint movement, or in the presence of hypermobility. It is widely believed that stretching enhances athletic performance. However, a number of studies3,4 have indicated that acute stretching either has no effect or decreases, rather than enhances, muscle performance immediately following the stretching session. In addition, acute stretching has been shown to have no benefit on the performance of activities that require strength, such as jumping or sprinting.5 In contrast, when stretching is performed as part of a regular and comprehensive conditioning program for a number of weeks, beneficial effects on physical performance have been reported.3,6 When referring to flexibility, two types are recognized, static and dynamic. Static flexibility. Static flexibility, also referred to as passive mobility, is defined as the range or motion available to a joint or series of joints.7,8 Increased static flexibility should not be confused with joint hypermobility, or laxity, which is a function of the joint capsule and ligaments. Decreased static flexibility indicates a loss of motion. The end-feel encountered may help the clinician differentiate the cause among adaptive shortening of the muscle (muscle stretch), a tight joint capsule (capsular), and an arthritic joint (hard). Static flexibility can be measured by a number of tests, such as the toe touch and the sit and reach, both of which have been found to be valid and reliable.9,10 Dynamic flexibility. Dynamic flexibility also referred to as active mobility, refers to the ease of movement within the obtainable ROM. Dynamic flexibility is measured actively. The important measurement in dynamic flexibility is stiffness, a mechanical term defined as the resistance of a structure to deformation.11,12 An increase in ROM around a joint does not necessarily equate to a decrease in the passive stiffness of a muscle.13–15 However, strength training, immobilization, and aging have been shown to increase stiffness.16–19 The converse of stiffness is pliability. When soft tissue demonstrates a decrease in pliability, it has usually undergone an adaptive shortening, or an increase in tone, termed hypertonus. There is growing research to suggest that the limiting factors in preventing increases in ROM are not only the connective tissues but are also the result of neurophysiological phenomena controlled by the higher centers of the CNS.20 In addition to those already mentioned, a number of other factors influence connective tissue deformation: Sensory receptors. Two sensory receptors that monitor muscle activity, the muscle spindle, and Golgi tendon organs (GTOs) (see Chapter 3), play an important role when attempting to increase flexibility through stretching. These two receptors can activate both spinal reflexes and long-loop pathways involving supraspinal centers. When a muscle is stretched, both the muscle spindles and the GTOs immediately begin sending a stream of sensory impulses to the spinal cord. Initially, impulses coming from the muscle spindles notify the CNS that the muscle is being stretched. Impulses return to the muscle from the spinal cord, causing the muscle to reflexively contract, thus resisting the stretch.2 The GTOs respond to the change in length and the increasing tension by firing off sensory impulses of their own to the spinal cord and, if the stretch of the muscle continues for an extended period of time (at least 6 seconds), impulses from the GTOs begin to override muscle spindle impulses and cause a reflex relaxation of the antagonist muscle (autogenic inhibition).2 In any synergistic muscle group, a contraction of the agonist causes a reflex relaxation of the antagonist muscle, allowing it to stretch and protecting it from injury—this phenomenon is referred to as autogenic inhibition.2 Tissue temperature. At temperatures above 37°C (98.6°F), the cross-links between collagen fibrils are broken more easily and more rapidly, with the most profound changes occurring between 40 and 45°C (104–113°F).21,22 A number of key points must be remembered by the clinician in order to effectively manipulate temperature:23 The amount of force required to attain/maintain a desired deformation decreases as temperature increases. The time required to deform collagen to the point of failure is inversely related to temperature. The higher the temperature, the greater the load collagen is able to tolerate before failure. The higher the temperature, the greater the amount of deformation possible before failure. It is important to make a distinction between stretching and warm-up as the two are not synonymous but are often confused by the layman. While stretching places neuromusculotendinous units and their fascia under tension, a warm-up requires the performance of an activity that raises total body and muscle temperatures to prepare the body for exercise.24 Research has shown that warm-up prior to stretching results in significant changes in joint ROM.25 Anecdotally, it would make sense not to perform stretching at the beginning of the warm-up routine because the tissue temperatures are too low for optimal muscle–tendon function, and are less compliant and less prepared for activity. Some advocate stretching after an exercise session, citing that the increased musculotendinous extensibility leads to the potential for improved joint flexibility.26 In one study, static stretching was done before, after, and both before and after each workout. All produced significant increases in ROM.27 The amount of force used. Viscoelastic changes are not permanent, whereas plasticity changes, which are more difficult to achieve, result in a residual or permanent change in length. The key factor for any change in connective tissue length is the deforming force, in particular, the magnitude and velocity applied. The application of low-load, long duration forces is recommended, although a muscle may require a greater stretching force initially, possibly to break up adhesions or cross-linkages, and to allow for viscoelastic and plastic changes to occur in the collagen and elastin fibers.28 The direction of the stretch. To stretch a muscle appropriately, the stretch must be applied parallel to the muscle fibers. The orientation of the fibers can be determined by palpation. Typically, in the extremities, the muscle fibers run parallel to the bone. The duration and frequency of the stretch. The duration refers to how long the clinician applies the stretching force. The frequency refers to the number of times or repetitions the stretch is performed. There continues to remain a lack of agreement on the ideal combination of either the duration of a single stretch or the number of repetitions of a stretch in a single session that is necessary to achieve the best results. Researchers have reported that techniques utilizing cyclic and sustained stretching for 15 minutes on 5 consecutive days increased hamstring muscle length and that a significant percentage of the increased length was retained 1 week posttreatment.29 Other researchers have reported that after using four consecutive knee flexor static stretches of 30 seconds, the new knee ROM was maintained for 3 minutes but had returned to prestretch levels after 6 minutes.30 A similar study using a sequence of five modified hold–relax stretches reported producing significantly increased hamstring flexibility that lasted 6 minutes after the stretching protocol ended.31 Frequent stretching ensures that the lengthening is maintained before the muscle has the opportunity to recoil to its shortened state.32 Frequency of stretching needs to occur at a minimum of two times per week.33,34 In contrast, it has been determined that 80% of the length changes occur in the first four stretches of 30 seconds each.26 It is important for the clinician to remember that any gains in flexibility and ROM achieved from a stretching program are only temporary.35 Thus, it is important to integrate functional activities such as reaching, bending, squatting, twisting, and pushing into the patient's exercise program that utilize the regained range on a regular basis. The speed of the stretch. Two common stretching techniques, static and ballistic, use different speed parameters. The static stretch allows for a steady speed to allow lengthening of the entire myotendinous unit, and a hold or delay at the end of the available motion.36 The ballistic stretch uses various speeds of singular or repetitive bouncing at the end of motion to stretch a particular muscle. The muscle is stretched by the momentum created from the bouncing movements supplying the tensile force used for the stretch.26 The patient quickly relaxes the muscle when reaching the end of ROM. This is performed in a cyclical bouncing motion and repeated several times, thus engaging a neurological component called active resistance—the contraction of muscles that resist elongation in the form of muscle reflex activity.26,37 In comparisons of the ballistic and static methods, two studies38,39 have found that both produce similar improvements in flexibility. However, the ballistic method appears to cause more residual muscle soreness or muscle strain, than those techniques that incorporate relaxation into the technique and are therefore not appropriate for elderly or sedentary individuals.39,40 Instead, the application of any stretch should be applied and released gradually to minimize muscle activation and injury to tissues. Positioning and stabilization of the structure being stretched. As described in Chapter 10, when performing any manual technique, correct positioning of the patient is essential both to help the patient relax and to ensure safe body mechanics from the clinician. For example, when stretching the hip musculature, it is important to protect the lumbar spine by maintaining it in a neutral position. When patients feel relaxed, their muscle activity is decreased, reducing the amount of resistance encountered during the technique. Accurate hand placement is essential for efficient stabilization and for the accurate transmission of force. The clinician can stabilize either the proximal or distal attachment site of the muscle tendon unit being stretched, although it is more common to stabilize the proximal attachment and move the distal segment. The type of stretch. The type of stretch refers to the method by which the stretch is imparted. Stretching can be applied manually or mechanically. A variety of stretching techniques can be used to increase the extensibility of the soft tissues. Static stretching involves the application of a steady force for a sustained period. The stretch should be performed at the point just shy of the pain, although some discomfort may be necessary to achieve results.28 Small loads applied for long periods produce greater residual lengthening than heavy loads applied for short periods.41 Restoration of the normal length of the muscles may be accomplished using the guidelines outlined in Table 13-1. Weighted traction or pulley systems may be used for this type of stretching. It is important for the patient to realize that the initial session of stretching may increase symptoms.42 However, this increase in symptoms should be temporary, lasting for a couple of hours, at most.32,43 TABLE 13-1 Static Stretching Guidelines Heat should be applied to increase intramuscular temperature prior to, and during, stretching.a–d This heat can be achieved with either through low-intensity warm-up exercise, or through the use of thermal modalities. The application of a cold pack following the stretch is used to take advantage of the thermal characteristics of connective tissue, by lowering its temperature and thereby theoretically prolonging the length changes—the elasticity of a muscle diminishes with cooling.a–d Effective stretching, in the early phase, should be performed every hour, but with each session lasting only a few minutes. With true muscle shortness, stronger resistance is used to activate the maximum number of motor units, followed by vigorous stretching of the muscle. Stretching should be performed at least two times a week using: Low force, avoiding pain Prolonged duration Rapid cooling of the muscle while it is maintained in the stretched position Dynamic stretching involves stretching by a muscular contraction to increase or decrease the joint angle where the muscle crosses, thereby elongating the musculotendinous unit as the end ROM is obtained26 Dynamic stretching is a specific warm-up using activity-specific movements to prepare the muscles by taking them through the movements used in a particular sport.26 Dynamic stretching does not incorporate end-range ballistic movements, as in ballistic stretching, but rather the use of controlled movements through a normal ROM.26 There is some debate as to whether the static or dynamic method is better to stretch a muscle. Static stretching is considered the gold standard in flexibility training.44 However, recent studies have found that static stretching is not an effective way to reduce injury rates,45,46 and may actually inhibit athletic performance.6 This is likely because the nature of static stretching is passive and does nothing to warm a muscle.47 More dynamic methods of stretching involve either a contraction of the antagonist muscle group, thus allowing the agonist to elongate naturally in a relaxed state, or eccentrically training a muscle through its full ROM.44 The latter method would appear to address the problem that most injuries occur during the eccentric phase of activity.45 A study by Nelson44 that compared the immediate effect of static stretching, eccentric training, and no stretching/training on hamstring flexibility in high school and college athletes (75 subjects) found the flexibility gains in the eccentric training group to be significantly greater than the static stretch group. This type of stretching refers to the use of techniques that rely on the neurophysiological changes that occur in contractile tissues. The goal of these techniques is to reduce the sensory-motor feedback and thereby increase relaxation. Such techniques include proprioceptive neuromuscular facilitation (PNF) and muscle energy (see Chapter 10). The majority of studies have shown the PNF techniques to be the most effective for increasing ROM through muscle lengthening when compared to the static or slow sustained, and the ballistic or bounce techniques,48–58 although one study found it to be not necessarily better.59 The PNF techniques of contract–relax (CR), hold–relax (HR), an agonist contraction (AC), or a hold–relax–agonist contraction sequence (HR–AC) can be used to actively stretch the soft tissues:2 CR and HR. HR and CR stretching techniques begin as per the static stretching techniques in that the clinician supports the patient and brings a limb (and the targeted muscle to be stretched) to the end of ROM until gentle stretching is felt. At that point, the clinician asks the patient to provide a prestretch, end range, isometric contraction of the muscle being stretched for approximately 5 seconds after which the patient is asked to relax the muscle. The clinician then moves the limb passively into the new range until a limitation is again felt and repeats the procedure two to four times. The only difference between the HR technique and the CR technique is that in the former technique the prestretch isometric contraction occurs in all muscles of the diagonal pattern, whereas in the latter technique the rotators of the limb contract concentrically while all of the muscle groups of the diagonal pattern contracts isometrically during the prestretch phase of the procedure.60 AC. AC stretching uses the principle of reciprocal inhibition, and the term agonist refers to the muscles opposite the range limiting target muscle, which can be confusing. The clinician moves the limb to the position of gentle stretch and asks the patient for a contraction of the muscle opposite the muscle being stretched (the antagonist) for about 5 seconds, and for the patient to hold the end range position for another 5 seconds. For example, when stretching the hamstring muscles, a simultaneous contraction of the quadriceps muscles can facilitate the stretch of the hamstrings. The technique is repeated two to four times. HR–AC. This technique, also referred to as the CR–AC or slow reversal HR technique, combines the HR and AC procedures. The clinician takes the limb to the point of gentle stretch and performs a CR sequence (i.e., resistance applied against the muscle being stretched). After contracting the muscle being stretched, the patient is asked to relax this muscle while contracting the opposing muscle group (antagonist), thus facilitating the stretch. For example, when stretching the hamstring muscles, the hamstrings are brought to a stretched position, the hamstrings are then contracted against resistance, and then relaxed, and then the quadriceps are contracted. Each contraction is held for approximately 5 seconds, and the technique is repeated two to four times. Other techniques that can assist in lengthening of contractile tissue through relaxation include the following: The application of heat, which increases the extensibility of the shortened tissues, will allow the muscles to relax in length and more easily, reducing the discomfort of stretching. Heat without stretching has little or no effect on long-term improvement in muscle flexibility, whereas the combination of heat and stretching produces greater long-term gains in tissue length than stretching alone. Massage and other soft-tissue techniques (see Chapter 10), which increase local circulation to the muscle and reduce muscle spasm and stiffness. Biofeedback, which teaches the patient to reduce the amount of tension in a muscle. Relaxation training. Following each stretching session, the stretched tissues must be allowed to cool in a lengthened position. This can be facilitated by using cold packs. Once gains in motion have been achieved, it is important for the patient to gain neuromuscular control of the agonists in the new range. This can be accomplished with low load resistance exercises throughout the newly acquired range. For example, after having stretched the hamstrings to reduce a knee flexion contracture, the patient is encouraged to activate the quadriceps in the new range. Once the ROM approaches what is normal for the patient, the muscles that were shortened and then stretched must also be strengthened. Any given muscle, crossing a single joint, is normally capable of shortening sufficiently to permit a full ROM at that joint. The functional excursion of a one-joint muscle is limited by the ROM at the joint it crosses. For example, the hip abductors are limited by the range available at the hip joint. For two-joint or multi-joint muscles, the functional excursion goes beyond the limits of any one joint that they cross. For example, the sartorius muscle can flex, abduct, and externally rotate the hip as well as being able to flex the knee. The absolute amount by which any muscle can shorten depends on: The length of, and arrangement of, the fibers Structure and design of the joint. The number of joints traversed. Resistance of antagonist muscle or muscles The presence of any load that opposes the muscle. If a muscle that crosses two or more joints produces simultaneous movement at all of the joints that it crosses, it soon reaches a length at which it can no longer generate a functional amount of tension. This is referred to as active insufficiency (e.g., attempting to achieve maximal hip flexion with the knee fully extended). In contrast, when the full ROM at any joint, or joints, that the muscle crosses is limited by the muscle's own length, it is referred to as passive insufficiency (e.g., attempting to fully extend the elbow, while simultaneously pronating the forearm and extending the shoulder places the brachialis muscle in a position of passive insufficiency). From a rehabilitation viewpoint, to maintain or improve the amount of ROM at a joint or kinematic chain, each joint must be moved through its available ROM at regular intervals. Continuous immobilization of skeletal muscle tissues can cause some undesirable consequences, including weakness or atrophy of the muscles.61 Muscle atrophy is an imbalance between protein synthesis and degradation. After modest trauma, there is a decrease in whole-body protein synthesis62 rather than increased breakdown. With more severe trauma, major surgery, or multiple organ failures, both synthesis and degradation increase, the latter being more enhanced.63,64 When referring to ROM techniques used in rehabilitation, three major movements are recognized:2 Passive range of motion (PROM). PROM refers to the degree to which a joint can be passively moved to the endpoint in the ROM. PROM exercises are performed by the clinician, family member, caregiver without any muscular activation by the patient. In some cases, the patient is able to perform PROM on one part of their body using another part (using the left arm to flex the right elbow). In addition, pulleys, continuous passive motion (CPM) devices, or various household objects, such as a counter or chair, can be used to assist in the performance of PROM. PROM is indicated when the patient's own muscle force is inadequate to produce sufficient motion at a joint, when active contraction of the muscle would be harmful, or as a means of educating a patient about a particular movement. PROM is contraindicated during any stage of tissue healing in which motion could prevent or inhibit tissue repair, in the presence of muscle guarding, or in the presence of increasing pain. Factors that can limit PROM about a joint include the joint capsule, periarticular connective tissue, adaptive shortening of the musculotendinous unit, bone on bone approximation, loose bodies, pain, and scarring of the overlying skin. If overpressure is applied at the end of the available PROM, a stretching force is imparted, and the clinician can determine the end feel. Patient handling and positioning are critical to allow the patient to relax during treatment by decreasing apprehension. For example, adequate stabilization and the use of a smooth and steady pace. Although PROM is important to enhance vascular dynamic and synovial diffusion, maintain joint motion, ROM, and flexibility, it does not prevent muscle atrophy, increase strength or endurance, or assist circulation to the same extent that active, voluntary muscle contraction does. The use of a CPM device has been promoted as a means to facilitate a more rapid recovery by improving ROM, decreasing the length of hospital stay, and lowering the amount of narcotic use. However, studies have shown that the effect of CPM devices on analgesia consumption, ROM, hospital stay, and complications has been variable: Data support the use of CPM to decrease the rate of manipulation for poor ROM after total knee arthroplasty (TKA). Although it appears that the use of a CPM device does help regain knee flexion quicker post TKA, it is not as effective in the enhancement of knee extension. Knee impairment or disability is not reduced with the use of a CPM at discharge from the hospital. Because of standardized inpatient hospital clinical pathways, the length of hospital stay is not decreased by the use of a CPM device but, depending on the hospital involved, the overall cost is not increased. Wound complications probably are not increased with the use of CPM, provided good technique is used in wound closure. Active-assisted range of motion (AAROM). AAROM occurs when ROM of the joint occurs actively but where the effect of gravity has been removed or when manual assistance is necessary to complete the motion due to weakness resulting from trauma, pain, neurologic injury, or postsurgical recovery. AAROM involves some muscle activation and is advocated when some muscle activation through the ROM is permitted or desired. For example, performing shoulder abduction while lying supine, which uses the bed surface for support. The amount of assistance needed varies from minimal or no assistance in some ranges to maximal assistance in other parts of the range. AAROM is important to enhance vascular dynamic and synovial diffusion, maintain joint motion, ROM, and flexibility, and may help prevent muscle atrophy. Active range of motion (AROM). AROM refers to the degree to which a joint can be moved by a muscle contraction, usually through the mid-range of movement. AROM exercises are typically used following any passive technique to reinforce proper movement or as part of a warm-up routine. AROM is indicated when the patient is able to perform a movement safely, effectively, and with minimum pain. AROM is contraindicated in the acute stage of healing (12–48 hours after the trauma) or in the presence of any adverse response to the motion (pain that persists more than 2 hours after the activity, an undesired cardiopulmonary response, or an increase in effusion/information). AROM does not maintain or increase strength or develop skill or coordination except in the movement patterns used. In the early stages of the rehabilitation process, ROM exercises are performed in the following sequence: Passive ROM → AAROM → AROM. It is important to remember when making the transition from PROM to AAROM or AROM, that gravity has a significant impact especially in individuals with weak musculature. These individuals may require assistance when the segment moves up against gravity, or moves downward, with gravity. The term goniometry is derived from two Greek words, gonia meaning angle and metron, meaning measure. Thus, a goniometer is an instrument used to measure angles. Within the field of physical therapy, a goniometer is used to measure the total amount of available motion at a specific joint. Goniometry can be used to measure both active and passive ROM, PROM, AAROM, and AROM. Goniometers are produced in a variety of sizes and shapes and are usually constructed of either plastic or metal (Fig. 13-1). The two most common types of instruments used to measure joint angles are the bubble inclinometer and the traditional goniometer. FIGURE 13-1 The various types of goniometers. Bubble goniometer (Fig. 13-2). The bubble goniometer, which has a 360-degree rotating dial and scale with fluid indicator can be used for flexion and extension; abduction and adduction; and rotation of the neck, shoulder, elbow, wrist, hip, knee, ankle, and the spine. FIGURE 13-2 Bubble goniometer. Traditional goniometer. The traditional goniometer, which can be used for flexion and extension; abduction and adduction; and rotation of the shoulder, elbow, wrist, hip, knee, and ankle, consists of three parts: A body. The body of the goniometer is designed like a protractor and may form a full or half circle. A measuring scale is located on the body. The scale can extend either from 0 to 180 degrees and 180 to 0 degrees for the half circle models or from 0 to 360 degrees and from 360 to 0 degrees on the full circle models. The intervals on the scales can vary from 1 to 10 degrees. A stationary arm. The stationary arm is structurally a part of the body and, therefore, cannot move independently of the body. A moving arm. The moving arm is attached to the fulcrum in the center of the body by a rivet or screw-like device that allows the moving arm to move freely on the body of the device. In some instruments, the screw-like device can be tightened to fix the moving arm in a certain position or loosened to permit free movement. The length of the stationary and moving arms varies among instruments (Fig. 13-1). Extendable goniometers (Fig. 13-3) allow varying ranges in arm length from 9½ to 26 in. FIGURE 13-3 Extendable goniometer. The correct selection of which goniometer device to use depends on the joint angle to be measured. The longer-armed goniometer, or the bubble inclinometer, are recommended when the landmarks are further apart, such as when measuring spine, hip, knee, elbow, and shoulder movements. In the smaller joints, such as the wrist and hand and foot and ankle, a traditional goniometer with a shorter arm is used. The general procedure for measuring ROM involves the following: The patient is positioned in the recommended test position and should be correctly draped. While stabilizing the proximal joint component, the clinician gently moves the distal joint component through the available ROM until the end feel is determined (see Chapter 4). An estimate is made of the available ROM, and the distal joint component is returned to the starting position. The clinician palpates the relevant bony landmarks and aligns the goniometer. A record is made of the starting measurement. The goniometer is then removed, and the joint is moved through the available ROM. Once the joint has been moved through the available ROM, the goniometer is replaced and realigned, and a measurement is read and recorded. The standard testing procedures for each of the upper and lower extremity joints are outlined in Tables 13-2 and 13-3. TABLE 13-2 Goniometric Techniques for the Upper Extremity TABLE 13-3 Goniometric Techniques for the Lower Extremity The following sections describe in detail how to perform a goniometric measurement of the major joints of the upper extremity. Shoulder motion occurs at the glenohumeral, scapulothoracic, acromioclavicular, and sternoclavicular joints. In addition, for full shoulder motion to occur, they must also be available motion in the cervical and upper thoracic spine. For the following measurements, the patient is positioned in supine with both hips and knees flexed and the feet placed on the bed to flatten the lumbar spine unless otherwise stated. Shoulder Flexion. When measuring glenohumeral flexion, allowing the motion to occur at the other joints provides a more functional reading. However, if the clinician requires a measurement of pure glenohumeral motion, the other joints must be manually blocked. This is best achieved by stabilizing the scapula to prevent it from elevating, upwardly rotating, and posteriorly tilting. In the following description, the scapular is not stabilized; instead the thorax is stabilized to prevent extension of the spine. Upper Extremity Position. The glenohumeral joint is initially positioned at 0 degrees of abduction, adduction, and rotation, and the forearm is positioned in 0 degrees of supination and pronation so that the palm of the hand faces the body. Goniometer Placement. The fulcrum is centered close to the acromion process, the proximal arm is aligned with the midaxillary line of the thorax, and the distal arm is aligned with the lateral midline of the humerus, using the lateral epicondyle of the humerus as a landmark. Technique. The shoulder is moved passively or actively to the end range of available shoulder flexion (Fig. 13-4), and a measurement is made (Fig. 13-5). FIGURE 13-4 Passive shoulder flexion. FIGURE 13-5 Goniometric measurement of shoulder flexion. Shoulder Extension. The patient is positioned in prone. Upper Extremity Position. The glenohumeral joint is positioned at 0 degrees of abduction and rotation, the elbow is positioned in slight flexion, and the forearm is positioned in 0 degrees of supination and pronation. If a measurement of pure glenohumeral extension is required, the scapula must be stabilized to prevent elevation and anterior tilting. Goniometer Placement. The fulcrum is centered close to the acromion process, the proximal arm is aligned with the midaxillary line of the thorax, and the distal arm is aligned with the lateral midline of the humerus, using the lateral epicondyle of the humerus as a landmark. Technique. The shoulder is moved passively or actively to the end range of available shoulder extension (Fig. 13-6). The clinician can take a measurement of AROM (Fig. 13-7) or PROM, or both if a comparison is to be made. FIGURE 13-6 Passive shoulder extension. FIGURE 13-7 Goniometric measurement of shoulder extension. Shoulder Abduction. Although measured here with the patient positioned in supine, shoulder abduction can be measured with the patient in sitting or prone, which has the advantage of allowing free motion of the scapula. Upper Extremity Position. The glenohumeral joint is positioned at 0 degrees of flexion and extension, and full external rotation so that the palm of the hand faces anteriorly to prevent the greater tubercle of the humerus impacting on the upper portion of the glenoid fossa or acromion process. Pure glenohumeral abduction can be measured by stabilizing the scapula to prevent its upward rotation and elevation. Goniometer Placement. The fulcrum is centered close to the anterior aspect of the acromion process, the proximal arm is aligned so that it is parallel to the midline of the anterior aspect of the sternum, and the distal arm is aligned with the medial midline of the humerus using the medial epicondyle as a landmark. If shoulder abduction is measured with the patient in the seated position, the fulcrum is centered close to the posterior aspect of the acromion process, the proximal arm is aligned parallel to the spinous processes of the vertebral column, and the distal arm is aligned with the lateral midline of the humerus, using the lateral epicondyle as a landmark. Technique. The shoulder is moved passively or actively to the end range of available shoulder abduction (Fig. 13-8), and a goniometric measurement is made (Fig. 13-9). FIGURE 13-8 Passive shoulder abduction. FIGURE 13-9 Goniometric measurement of shoulder abduction. Shoulder adduction is not typically measured as it represents the patient's arm by the side. Further motion toward the patient's midline is considered horizontal adduction. Only gold members can continue reading. Log In or Register to continue

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