STRETCHING

- *A*ny therapeutic maneuver designed to *increase the extensibility of soft tissues, thereby improving* flexibility by elongating (lengthening) structures that have adaptively shortened and have become hypomobile over time.
- Early in the rehabilitation process manual "hand on techniques" stretching and joint mobilization, passive stretching.
- Later, self-stretching exercises performed independently by a patient

DEFINITIONS

- **Flexibility……**
- *Ability to move a single joint or series* of joints smoothly and easily through an unrestricted, pain-free ROM.
- **DEPEND ON:**
- Muscle length, joint integrity, extensibility of periarticular soft tissues.
- Extensibility of musculotendinous units baesd on
- soft tissues relax or deform and yield to a stretch force.
- The arthrokinematics of the moving joint
- as well as periarticular connective tissues

Dynamic and Passive Flexibility

- ***Dynamic flexibility.***
- active mobility or active ROM, is the degree to which active muscle contraction moves a body segment through the available ROM of a joint.

- ***Passive flexibility.***
- Passive mobility or passive ROM, degree to joint can be passively moved through the available ROM
- Factors affect or depend on extensibility
- It is prerequisite for but does not ensure dynamic flexibility.

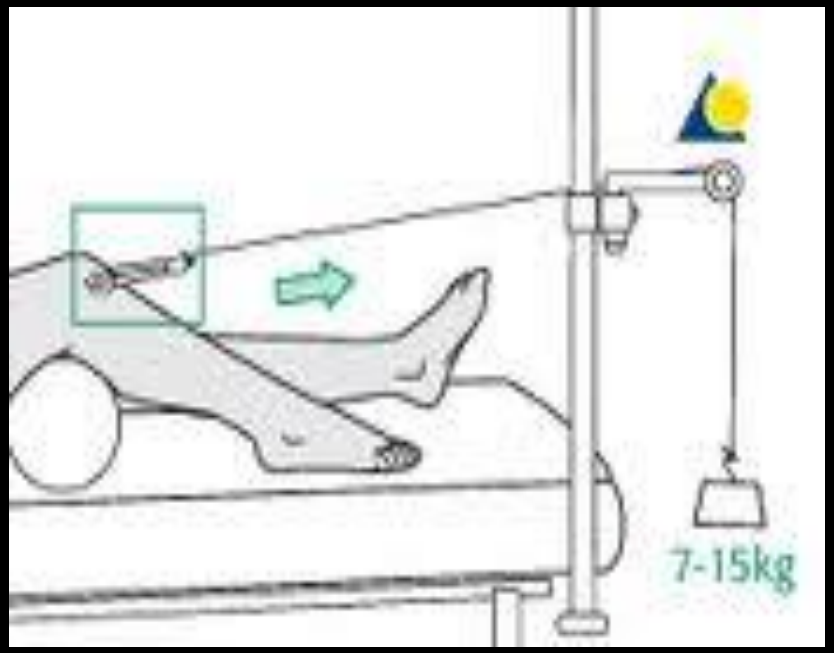
Hypomobility

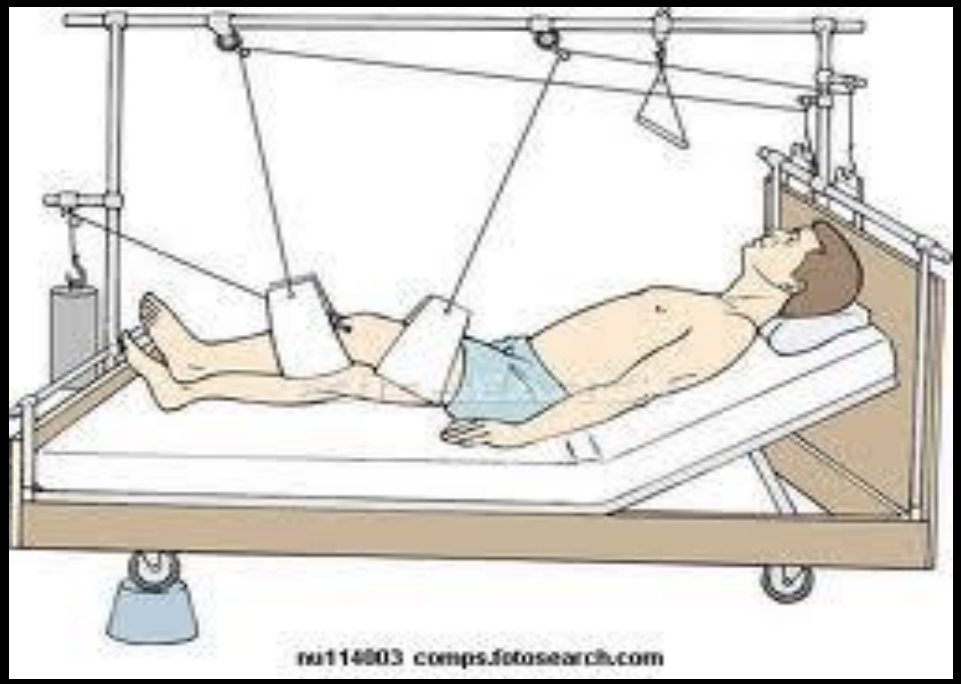
- *Decreased mobility or restricted* motion.

- wide range of pathological processes restrict movement and impair mobility.
- Many factors contribute hypomobility, stiffness of soft tissues, the potential loss of ROM, and the development of contractures.

Factors That Contribute to Restricted Motion

Contributing Factors	Examples
Prolonged immobilization	Fractures, osteotomy, soft tissue trauma or repair
Extrinsic	
Casts and splints	
Skeletal traction	
Intrinsic	Microtrauma or macrotrauma; degenerative diseases
Pain	
Joint inflammation and effusion	Joint diseases or trauma
Muscle, tendon, or fascial disorders	Myositis, tendonitis, fasciitis
Skin disorders	**Burns, skin grafts, scleroderma**
Bony block	**Osteophytes, ankylosis, surgical fusion**
Vascular disorders	Peripheral lymph-edema
Sedentary lifestyle and habitual faulty or asymmetrical postures	Confinement to bed or a wheelchair; prolonged positioning associated with occupation or work environment
Paralysis, tonal abnormalities, and muscle Imbalances	Neuromuscular disorders and diseases: CNS or PNS dysfunction (spasticity, rigidity, flaccidity, weakness, muscle guarding, spasm)
Postural malalignment: congenital or acquired	Scoliosis, kyphosis


7-15kg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Indications for Use of Stretching

- • limited ROM because of soft tissues extensibility loss,
- due to adhesions,
- contractures,
- and scar tissue formation, causing functional limitations or disabilities.
- • Restricted motion may lead to structural deformities.
- • Muscle weakness and shortening of opposing tissue.
- • May be used as part of a total fitness program designed to prevent musculoskeletal injuries.
- • May be used prior to and after vigorous exercise potentially to minimize postexercise muscle soreness.

Contraindications to Stretching

- • A bony block limits joint motion.
- • Recent fracture, and incomplete bony union.
- • Evidence of acute inflammatory or infectious process (heat and swelling) .
- • Sharp, acute pain with joint movement or muscle elongation.
- • A hematoma or other indication of tissue trauma is observed.
- • Hypermobility.
- • Shortened soft tissues provide necessary joint stability…
- • Shortened soft tissues enable a patient with paralysis or severe muscle weakness to perform specific functional skills otherwise not possible.

Contracture

- **" Adaptive shortening of the muscle-tendon unit and other soft tissues that cross or surround a joint that results in significant resistance to passive or active stretch and limitation of ROM, and it may compromise functional abilities.**
- Mild muscle shortening to irreversible contractures.
- No description how much limitation of motion from loss of soft tissue extensibility.

Designation of Contractures by Location

- Contractures are described by action of the shortened muscle.
- E.g. elbow flexion contracture.
- Hip adductors contracture.

Contracture Versus Contraction…

Types of Contracture

- Described as, contractures by the pathological changes in the different types of soft tissues involved.
- **Myostatic Contracture/myogenic**
- musculotecndinous unit has adaptively shortened,
- significant loss of ROM,
- no specific muscle pathology present.
- Morphological perspective
- Resolved short time with stretching exercises

Pseudomyostatic Contracture

- Central nervous system disorders (CVA, C.P, Spinal cord injuries, traumatic brain injuries)
- Hypertonicity (spasticity, rigidity)
- Muscle spasm or guarding and pain may also cause a pseudomyostatic contracture. Muscles in a constant state of contraction, giving rise to excessive resistance to passive stretch.
- **Hence, the term *pseudomyostatic contracture or apparent contracture is used*.**
- *inhibition procedures* applied, ……..full, passive elongation of the apparently shortened muscle is then possible

Arthrogenic and Periarticular Contractures

- **intra-articular pathology.**
- adhesions, synovial proliferation, joint effusion, irregularities in articular cartilage, or osteophyte formation.
- **A periarticular soft tissue lose mobility**
- joint capsule, ligaments etc lose mobility,
- Restricted arthrokinematic motion.

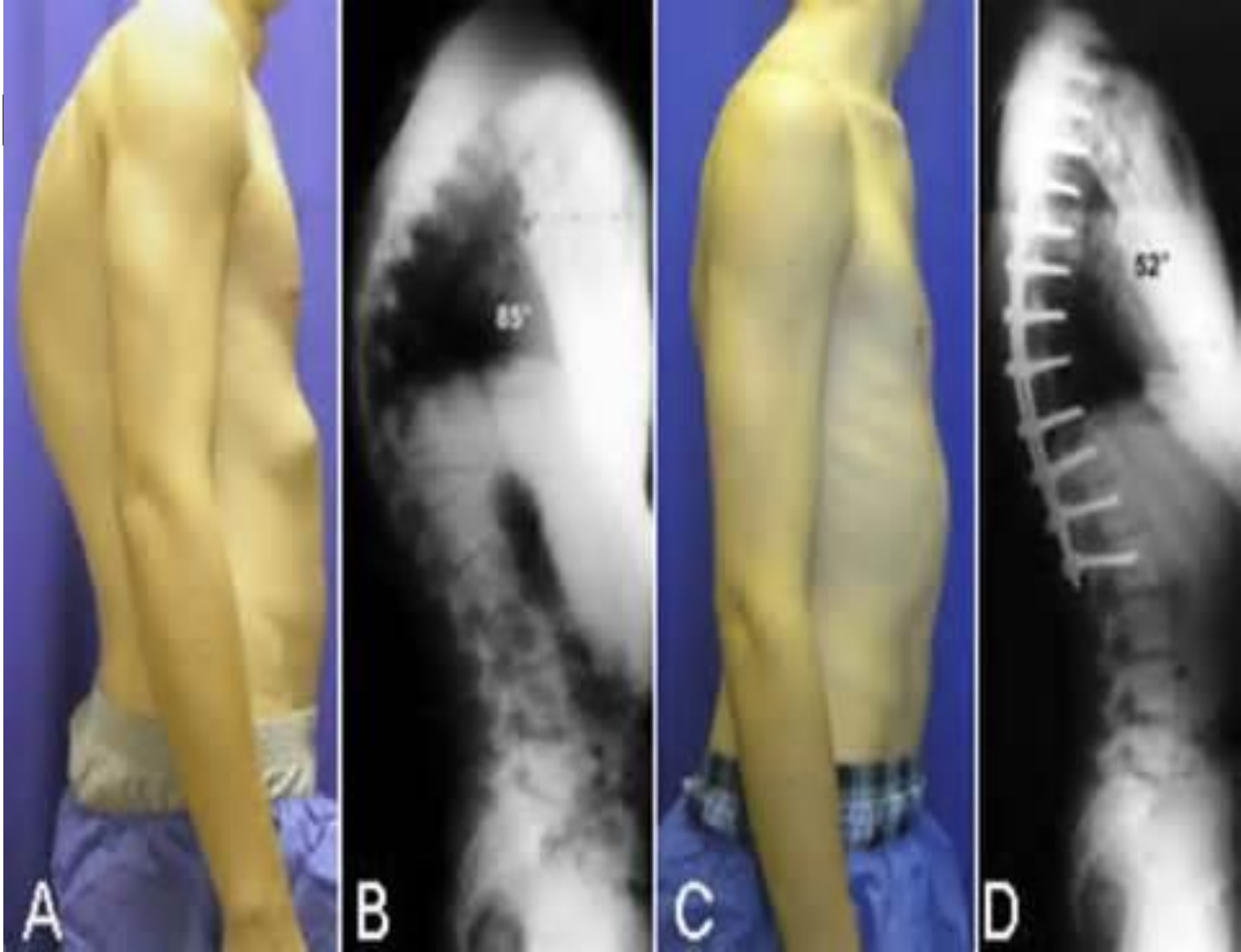
Figure 1

Figure 2

Fibrotic Contracture/Irreversible Contracture

- Fibrous changes in muscle and periarticular structures can cause adherence of tissues and development of a fibrotic contracture.
- stretch a fibrotic contracture and increase ROM possible, often difficult to re-establish optimal tissue length.
- Permanent /Irreversible contractures form…….
- Replaced with a large amount of relatively non-extensible, fibrotic adhesions and scar tissue or even heterotopic bone…..(**surgery)**
- Immobilization in a shortened position…or ..
- The longer a fibrotic contracture **or** greater replacement ..with nonextensible adhesions and scar tissue or bone, **more difficult** to regain mobility--→more likely contracture will become irreversible.


L5

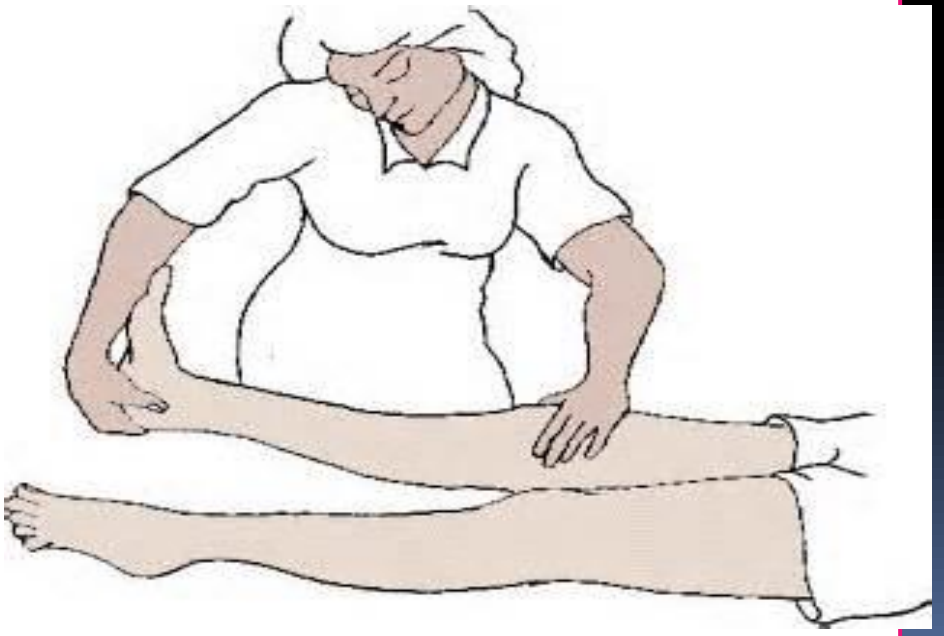

A
B
85°
C
D
52°

Interventions to Increase Mobility of Soft Tissues

- Stretching and mobilization

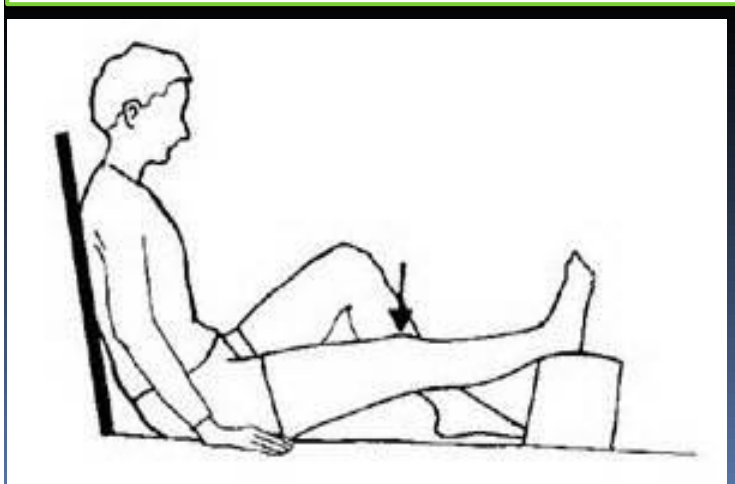
Manual or Mechanical/Passive or Assisted Stretching

- **Passive stretching:**
- A sustained or intermittent external, end-range stretch force, applied with overpressure and by manual contact or a mechanical device, elongates a shortened muscle-tendon unit and periarticular connective tissues by moving a restricted joint just past the available ROM.
- ***Assisted stretching…***



Self-Stretching

- independently by a patient after instruction and supervision by a therapist.
- *The terms self-stretching* and *flexibility exercises*
- *Active stretching is another term sometimes used to denote* self-stretching procedures. **OR**
- stretching exercises incorporate inhibition or facilitation techniques.



Neuromuscular Facilitation and Inhibition Techniques

- Relax tension in reflexively prior to or during muscle elongation.
- *PNF stretching*, active inhibition, active stretching, or facilitated stretching
  - **Muscle Energy Techniques**
- manipulative procedures evolved out of osteopathic medicine and are designed to **lengthen muscle and fascia and to mobilize joints.**
- **Techniques……**
- principles of neuromuscular inhibition are incorporated……. Another term used *post-isometric relaxation.*

Joint Mobilization/Manipulation

- Applied……used to stretch capsular restrictions or reposition a subluxed or dislocated joint.

Soft Tissue Mobilization and Manipulation

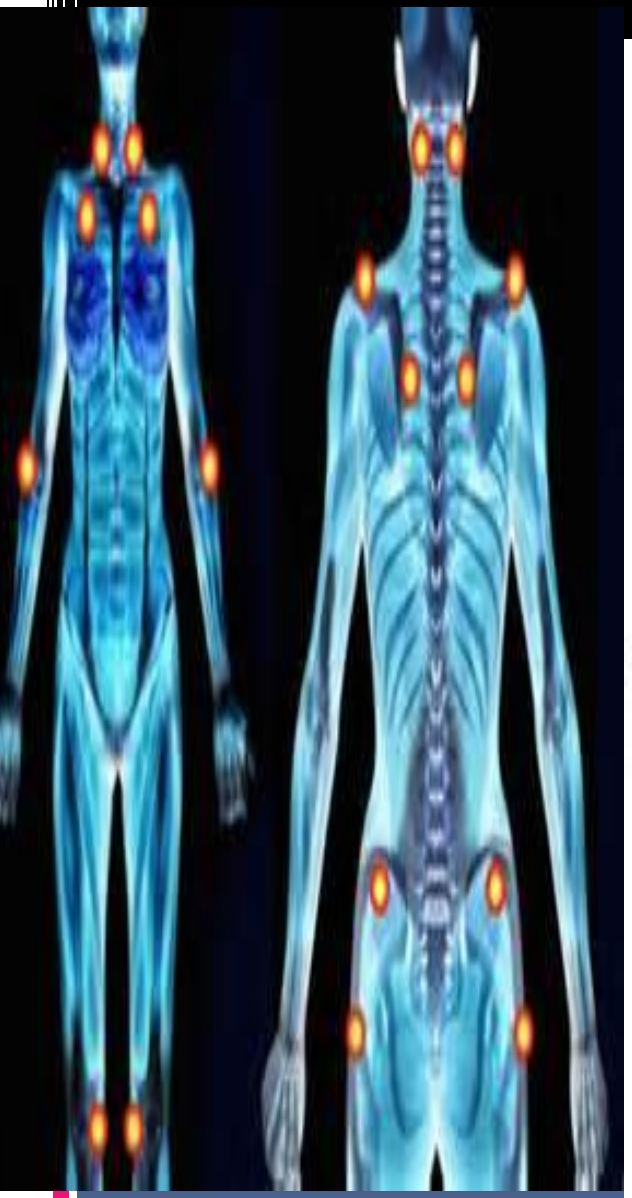
- Improve muscle extensibility and involve the application of specific and progressive manual forces (e.g., by means of sustained manual pressure or slow, deep stroking) to effect change in the myofascial structures that can bind soft tissues and impair mobility.
- deep ***Friction, myofascial release acupressure***, *and* ***trigger point therapy,*** mobilizing and manipulating connective tissue that binds soft tissues.
- Adjuncts to manual stretching procedures,

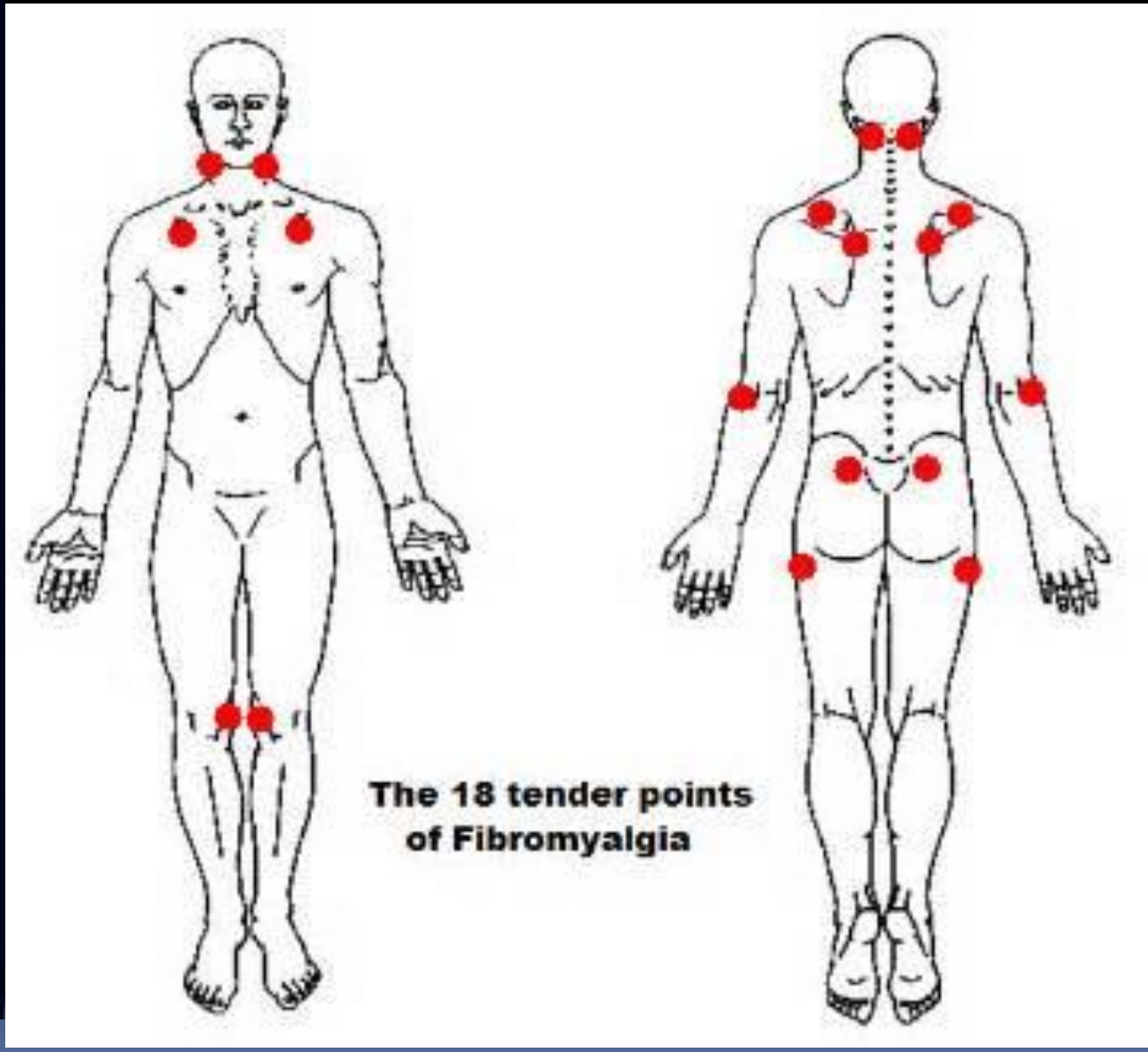
Neural Tissue Mobilization (Neuromeningeal Mobilization)

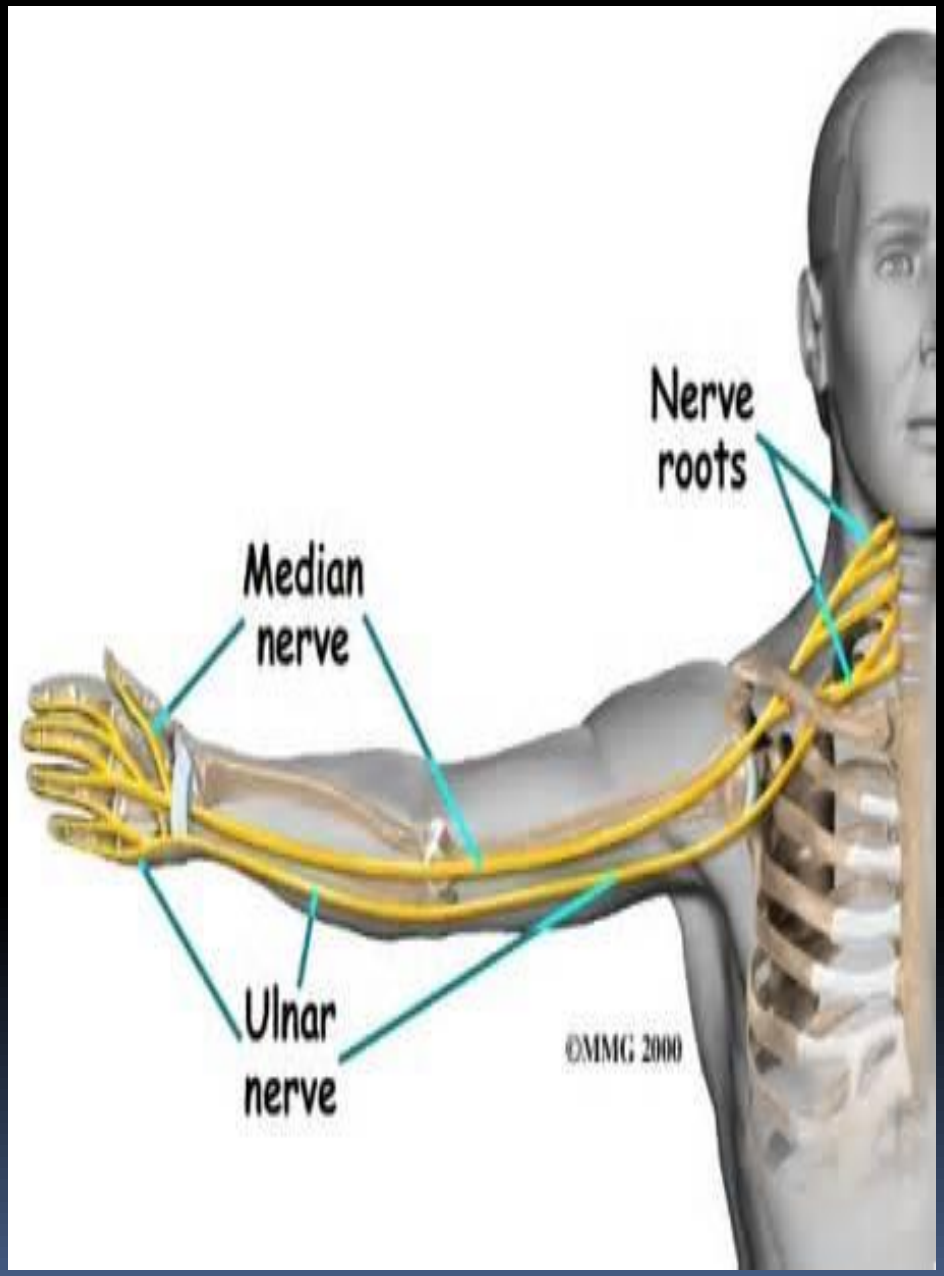
- After trauma or surgical procedures, adhesions or scar tissue may form around the meninges and nerve roots or at the site of injury at the plexus or peripheral nerves.
- Tension placed on the adhesions or scar tissue leads to pain or neurological symptoms.
- After **tests** to determine neural tissue mobility are conducted, mobilization done.

COMMON TRIGGER POINTS

Fibromyalgia trigger points






Nerve roots
Median nerve
Ulnar nerve
©MMG 2000

Selective Stretching

- stretching techniques selectively to some muscles and joints…
- Balance between mobility and stability…..incase of parlysis patients
- **Example:** spinal cord injury,….
- Too much limitation of motion in the low back can decrease function.
- Allowing slight hypomobility in long flexors of the fingers while maintaining flexibility of the wrist enables the patient to develop grasp

Overstretching and Hypermobility

- *A stretch well beyond the normal length* of muscle and ROM of a joint and the surrounding soft tissues, resulting in *hypermobility (excessive mobility).*
- Individuals in sports that require extensive flexibility.
- ***Instability…….***
- causes pain and musculoskeletal injury.

PROPERTIES OF SOFT TISSUE– RESPONSE TO IMMOBILIZATION AND STRETCH

PROPERTIES OF SOFT TISSUE– RESPONSE TO IMMOBILIZATION AND STRETCH

- Mechanical and neurophysiological characteristics
- **Stretched soft tissue:** elastic, viscoelastic, or plastic changes occur.
- ***Elasticity***
- ***Prestrech resting position,….short duration force***
- ***Viscoelasticity :*** time-dependent→initially resists deformation, stretch sustained….>change in the length of the tissue→ tissue return gradually to its prestretch state-→stretch force removed.
- ***Plasticity : new greater length.***
- elasticity & plasticity contractile and noncontractile tissues.
- Viscoelasticity only in connective tissues

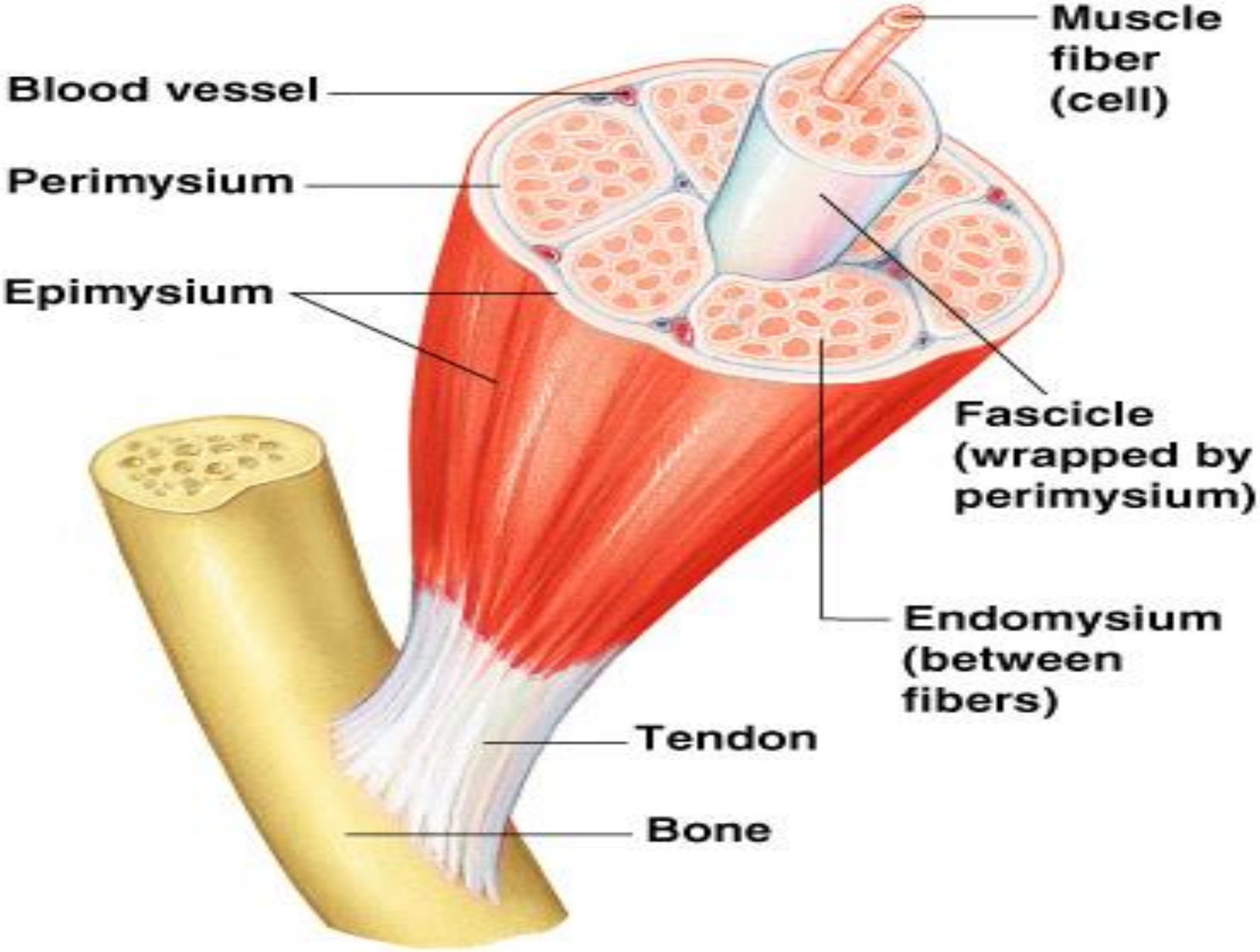
Mechanical Properties of Contractile Tissue

- Muscle both contractile and non-contractile connective tissues. The contractile characteristics of contractility and irritability.
- The non-contractile connective tissue in and around resist deforming forces.
- The connective tissue structures,

endomysium, perimysium, epimysium.

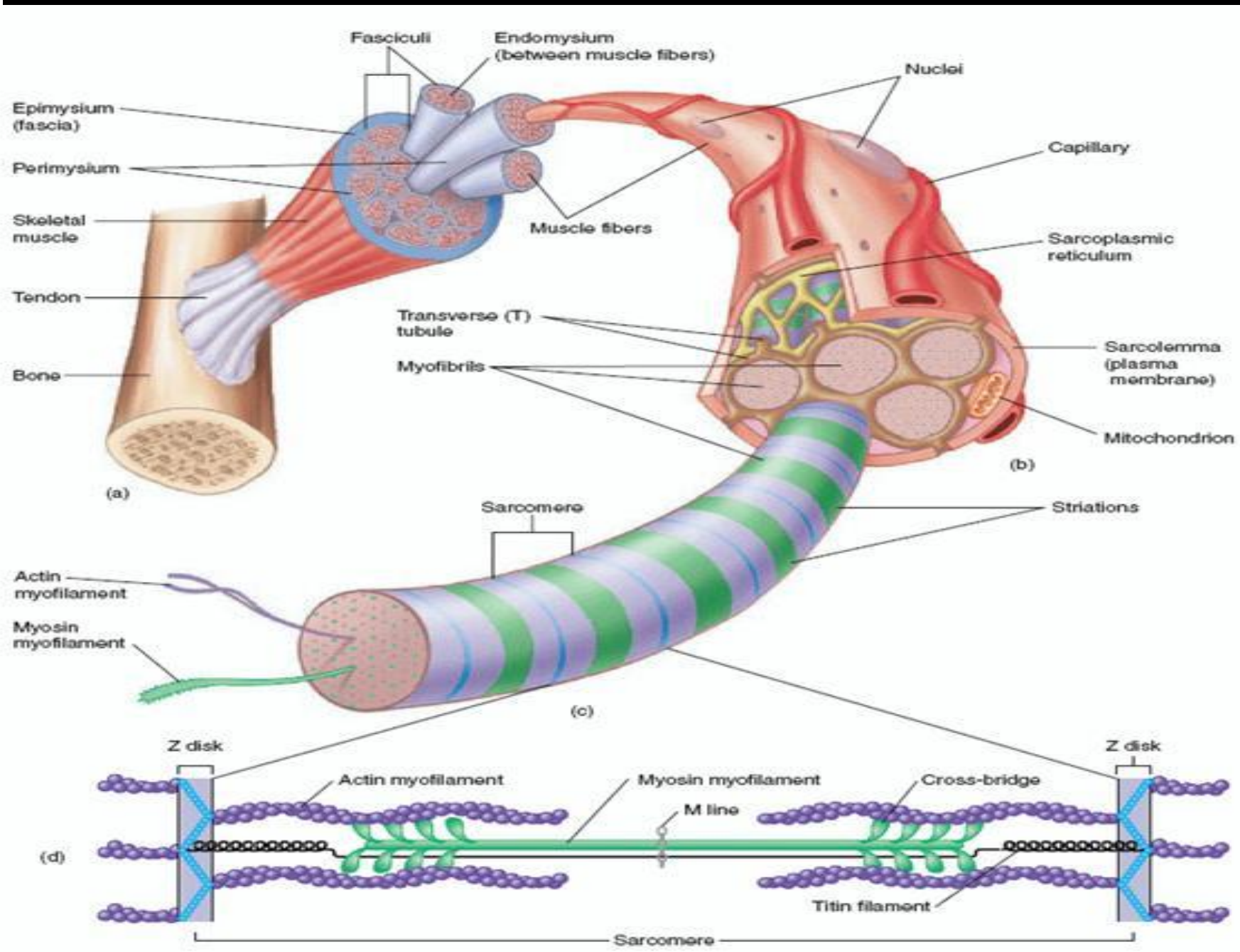
Framework… primary source of a muscle's resistance to passive elongation.

When contractures develop, adhesions in and between collagen fibers resist and restrict movement.


Muscle fiber (cell)
Blood vessel
Perimysium
Epimysium
Fascicle (wrapped by perimysium)
Endomysium (between fibers)
Tendon
Bone

Contractile Elements of Muscle

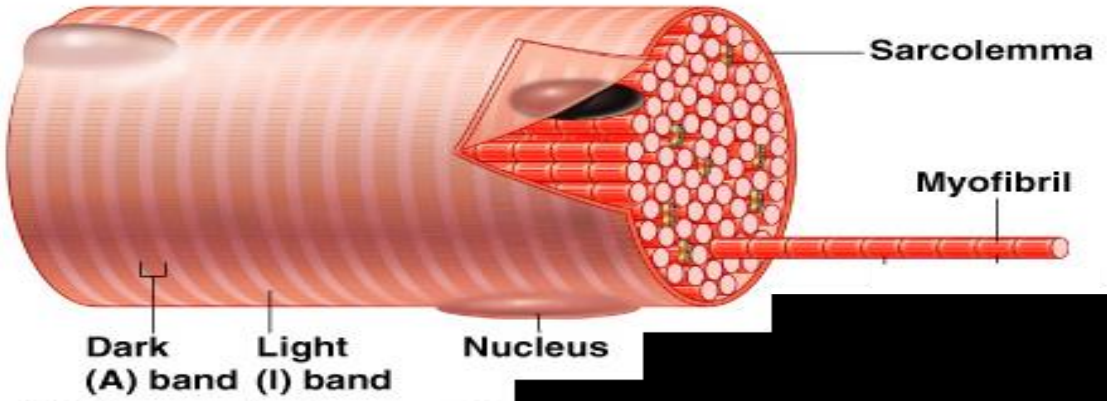
- **many *muscle fibers*** *that lie in parallel with one another.*
- *A single* muscle fiber is made up of many *myofibrils.*
- Composed of even smaller structures called ***sarcomeres****, which lie in series within a myofibril.*
- The sarcomere is the contractile unit, composed of overlapping *myofilaments* of actin form cross-bridges.
- The sarcomere::contract and relax.
- When a motor unit stimulates a muscle to contract, the actin-myosin filaments slide together, and the muscle actively shortens.
- When a muscle relaxes, the cross-bridges slide apart slightly, and the muscle returns to its resting length .


Fasciculi
Endomysium
(between muscle fibers)
Nuclei
Epimysium
(fascia)
Capillary
Perimysium
Skeletal
muscle
Muscle fibers
Sarcoplasmic
reticulum
Tendon
Transverse (T)
tubule
Sarcolemma
(plasma
membrane)
Myofibrils
Bone
Mitochondrion
(a)
(b)
Sarcomere
Striations
Actin
myofilament
Myosin
myofilament
(c)
Z disk
Z disk
Actin myofilament
Myosin myofilament
Cross-bridge
M line
(d)
Titin filament
Sarcomere

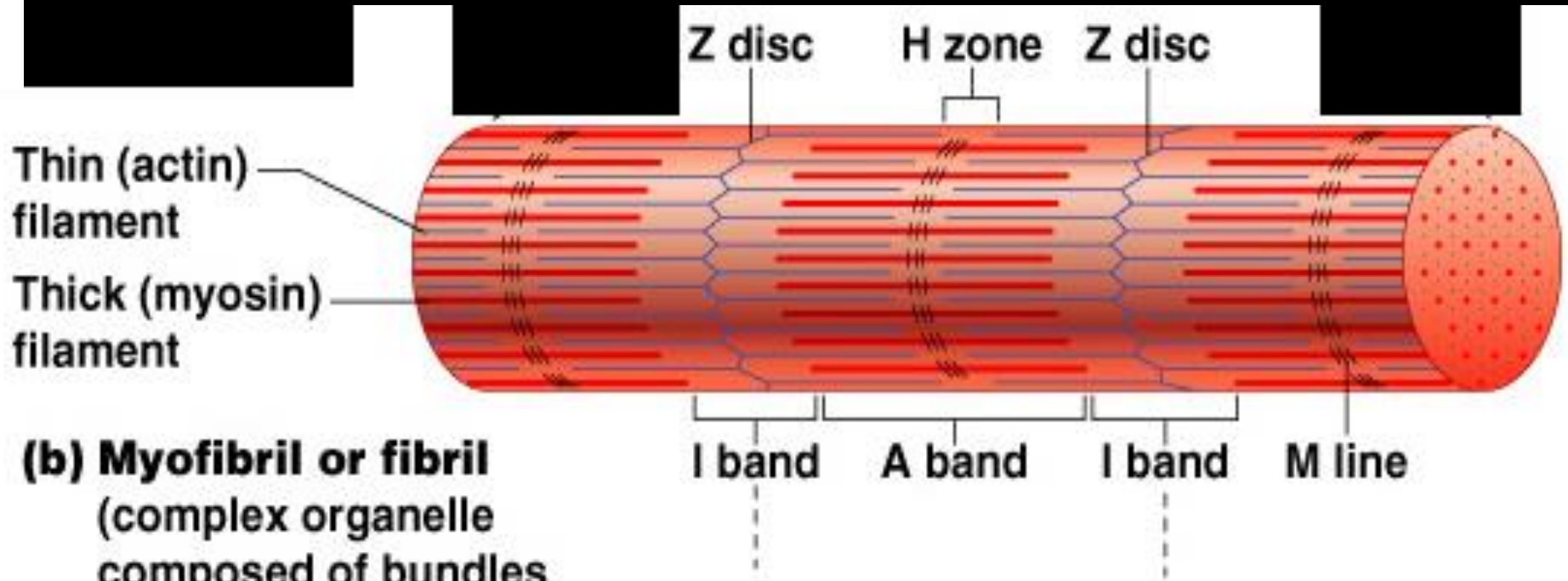
- Myofibrils are aligned to give distinct bands
- **I band =**
- light band

A band =

dark band



(a) Segment of a muscle fiber (cell)



(b) Myofibril or fibril (complex organelle composed of bundles of myofilaments)

Mechanical Response of the Contractile Unit to Stretch and Immobilization

Response to Stretch

- Muscle stretched and elongates, the stretch force is transmitted to the muscle fibers via connective tissue (endomysium and perimysium) in and around the fibers.
- Molecular interactions b/w noncontractile elements to the contractile unit of muscle, the sarcomere.
- During passive stretch both longitudinal and lateral force transduction occurs…… tension rises sharply.
- ***Mechanical disruption……sarcomere give.***
- *When the stretch force* is released, the individual sarcomeres return to their resting length……called elasticity.
- For plastic changes…. the stretch force extended period of time.

Response to Immobilization and Remobilization

Morphological changes.:

Muscle immobilize long period of time, physical stresses on the muscle diminished.

Decay of contractile protein-→**a decrease fiber diameter**, number of myofibrils-→intramuscular capillary density,-→ muscle *atrophy and weakness.*

Muscle atrophied---→fibrous and fatty tissue in muscle.

- **The composition of muscle affects its response to immobilization,**
- slow twitch fibers atrophied more quickly and more extensively than in phasic (fast-twitch) fibers.
- **The duration and position affect atrophy** and loss of strength and power. …can begin within a few days to a weeks. significant deterioration in motor unit recruitment affect functional activity.

Immobilization in a shortened position.

- immobilization in a shortened position for several weeks…… ***sarcomere absorption occur……***
- *This absorption occurs* at a faster rate than the muscle's ability to regenerate sarcomeres.
- The decrease in the overall length of the muscle fibers and number in series sarcomeres, muscle atrophy, weakness.
- Muscle immobilized in a shortened position atrophies and weakens at a faster rate than if it is held in a lengthened position over time.
- There is a shift to the left in the **length–tension curve** of a shortened muscle, which decreases the muscle's capacity to produce maximum tension at its normal resting length as it contracts.
- Increase fibrous tissue and fat in muscle with immobilization further decreased extensibility of muscle.

Immobilization in a lengthened position.

- muscle is immobilized in a position of maximum available length prolonged period of time. (serial casts) or the use of a dynamic splint……
- Muscle lengthened extended time period,(*myofibrillogenesis)…… to maintain the greatest functional* overlap of actin and myosin filaments.
- Permanent (plastic) form of muscle lengthening, …
- Myofibrillogenesis require several weeks to occur.
- Same results gained by stretching exercises
- But are transient, lasting only 3 to 5 weeks…
- need for patients to use full-range motion……

Neurophysiologic Properties of Contractile Tissue

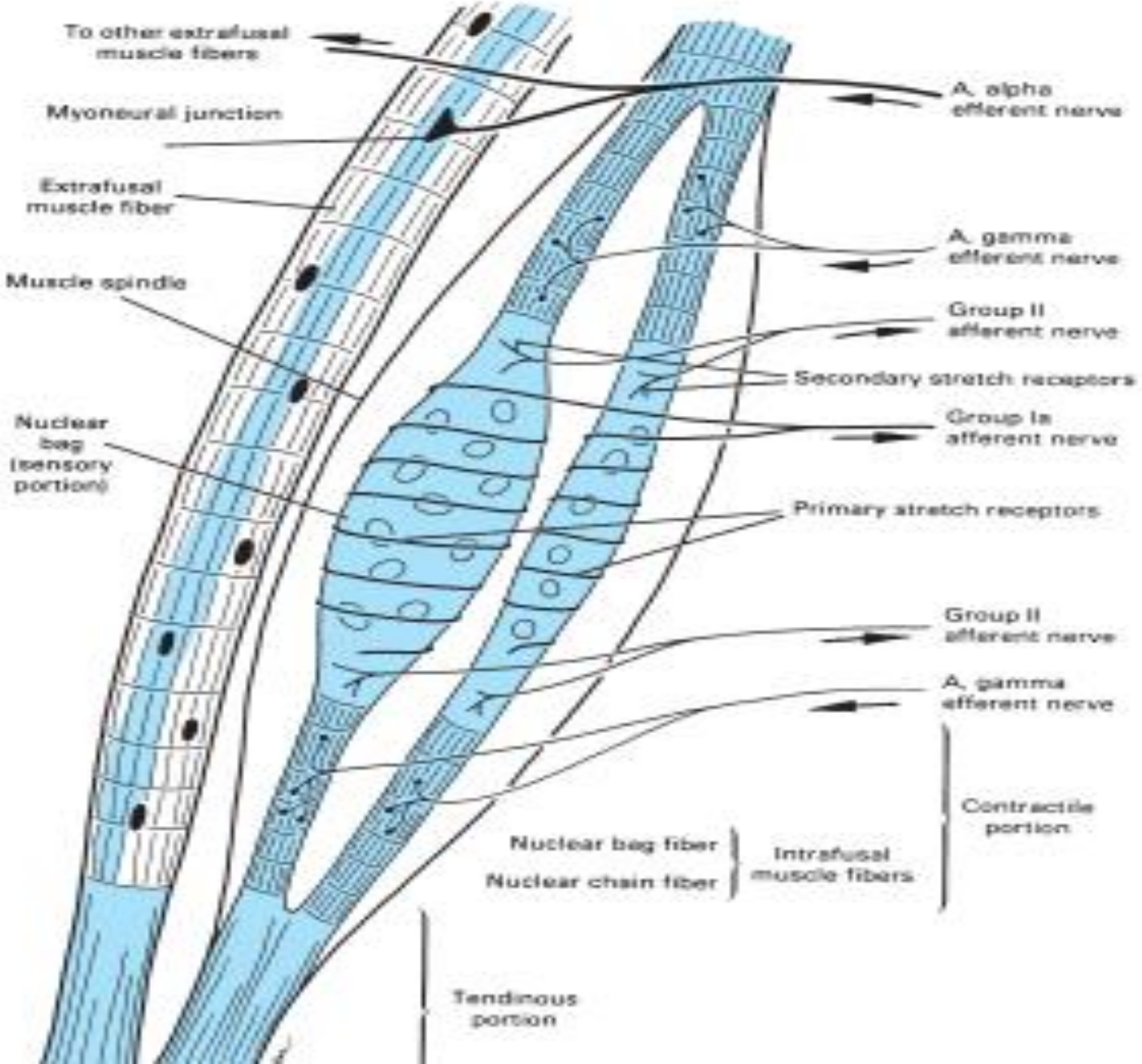
- Influence a muscle's response to stretch
- Two sensory organs,… the *muscle spindle and the Golgi tendon organ,* are mechanoreceptors…….> convey information central nervous system…..> affect a muscle's response to stretch.

Muscle Spindle

- The major sensory organ and senstive to quick and sustained (tonic) stretch .
- Receive and convey information… length and velocity of length changes.
- Muscle spindles are small, encapsulated receptors composed of afferent, efferen fiber endings, and specialized muscle fibers called *intrafusal fibers.*
- *Intrafusal muscle fibers are bundled together* and lie between and parallel to extrafusal muscle fibers that make up the main body of a skeletal muscle.
- intrafusal fiber: *nuclear bag fibers and nuclear chain fibers……*
- Primary (type Ia fiber) afferent endings, which arise from nuclear bag fibers, sense & response to quick and sustained (tonic) stretch.
- **secondary (type II)** afferents from the **nuclear chain** fibers are sensitive only to tonic stretch.

Muscle Spindle

- Intrafusal muscle fibers connect at their ends to extrafusal muscle fibers, when a muscle is stretched, intrafusal fibers are also stretched.
- Only the ends (polar regions),…of an intrafusal fiber is contractile. Consequently, when an intrafusal muscle fiber is stimulated and contracts, it lengthens the central portion.
- Small-diameter motor neurons, known as ***gamma motor*** *neurons, innervate the contractile polar* regions of intrafusal muscle fibers and **adjust the sensitivity of muscle spindles**. Large-diameter *alpha motor neurons* innervate extrafusal fibers.
- Primary and secondary fibers synapse on the alpha or gamma motoneurons, which when stimulated cause excitation of their own extrafusal and intrafusal fibers, respectively.
- two ways to stimulate these sensory fibers by means of stretch; **one is by overall lengthening** of the muscle, and the other is by **stimulating contraction of intrafusal** fibers via the gamma efferent neural pathways.

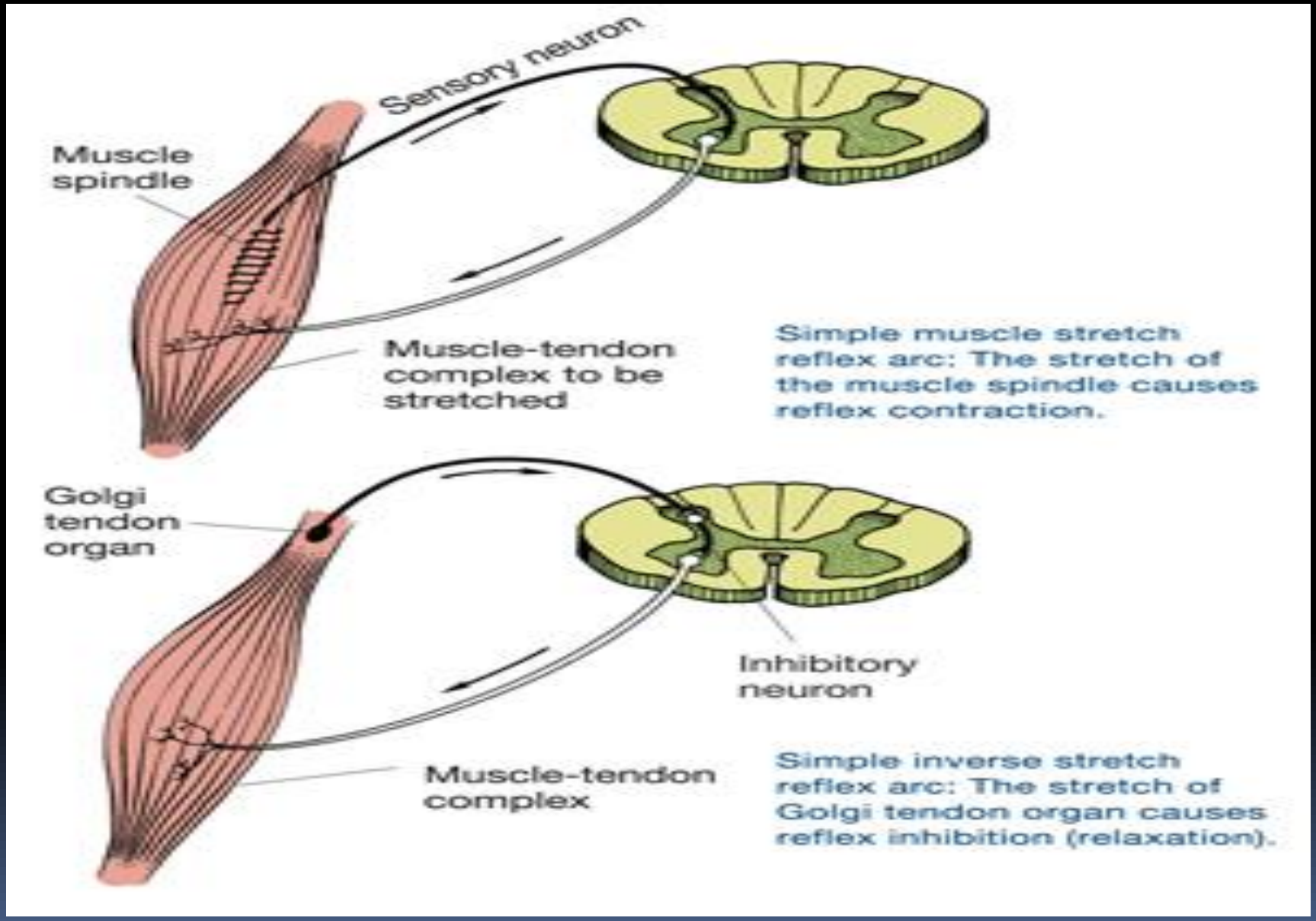

To other extrafusal muscle fibers
Myoneural junction
Extrafusal muscle fiber
Muscle spindle
Nuclear bag (sensory portion)
A. alpha efferent nerve
A. gamma efferent nerve
Group II afferent nerve
Secondary stretch receptors
Group Ia afferent nerve
Primary stretch receptors
Group II afferent nerve
A. gamma efferent nerve
Contractile portion
Nuclear bag fiber
Nuclear chain fiber
Intrafusal muscle fibers
Tendinous portion

Golgi Tendon Organ

- The Golgi tendon organ (GTO) is a sensory organ located near the musculotendinous junctions of extrafusal muscle fibers.
- **Monitor changes in tension of muscle-tendon units**. These encapsulated nerve endings in collagen strands of a tendon and transmit sensory information via Ib fibers.
- These sensory organs are sensitive to even slight changes of tension on a muscle-tendon unit as the result of passive stretch of a muscle or with active muscle contractions during normal movement.
- When tension develops in a muscle, the GTO fires, inhibits alpha motoneuron activity, and decreases tension in the muscle-tendon unit being stretched.
- At neuromuscular system, *inhibition is a state* of decreased neuronal activity and altered synaptic potential, which reflexively diminishes the capacity of a muscle to contract.
- Originally, the GTO was thought to fire and inhibit muscle activation only in the presence of high levels of muscle tension as a protective mechanism. However, the GTO has since been shown to have a low threshold for firing (fires easily) so it can continuously monitor and adjust the force of active muscle contractions during movement or the tension in muscle during passive stretch

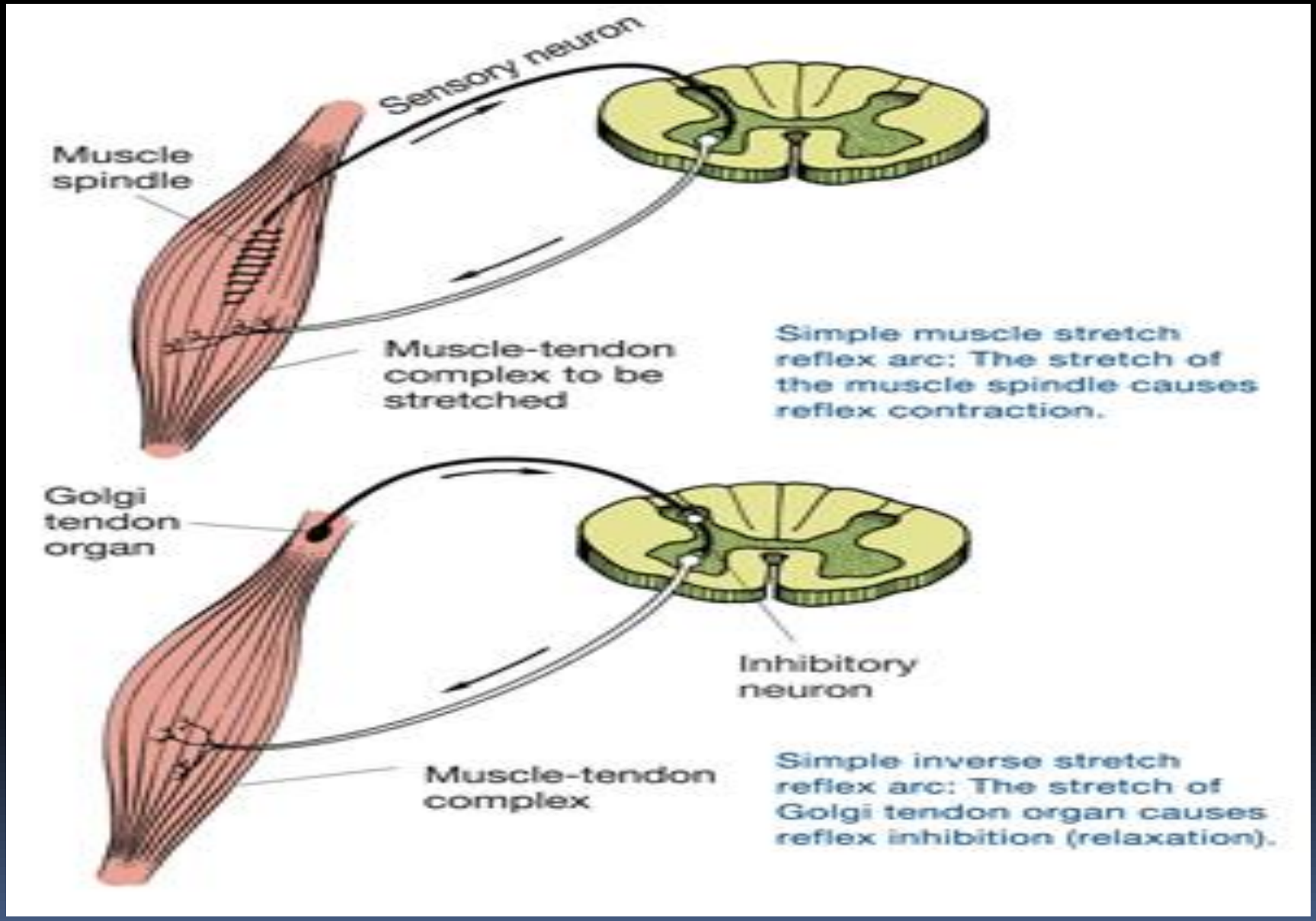
Neurophysiological Response of Muscle to Stretch

- stretch applied to a muscle-tendon unit either quickly or over a prolonged period of time, the primary and secondary afferents of intrafusal muscle fibers **sense** the length changes and activate extrafusal muscle fibers via alpha motor neurons in the spinal cord, thus activating the stretch reflex and increasing (facilitating) tension in the muscle being stretched.
- The increased tension causes resistance to lengthening and, in turn, is thought to compromise the effectiveness of the stretching procedure.


Sensory neuron
Muscle spindle
Muscle-tendon complex to be stretched
Simple muscle stretch reflex arc: The stretch of the muscle spindle causes reflex contraction.
Golgi tendon organ
Inhibitory neuron
Muscle-tendon complex
Simple inverse stretch reflex arc: The stretch of Golgi tendon organ causes reflex inhibition (relaxation).

Neurophysiological Response of Muscle to Stretch……..

- When the stretch reflex is activated in a muscle being lengthened, decreased activity (inhibition) in the muscle on the opposite side of the joint, referred to as ***reciprocal inhibition,*** may also occur.
- To minimize activation of the stretch reflex and the subsequent increase in muscle tension and reflexive resistance to muscle lengthening during stretching procedures, a slowly applied, low-intensity, prolonged stretch is considered preferable to a quickly applied, short-duration stretch.


Sensory neuron
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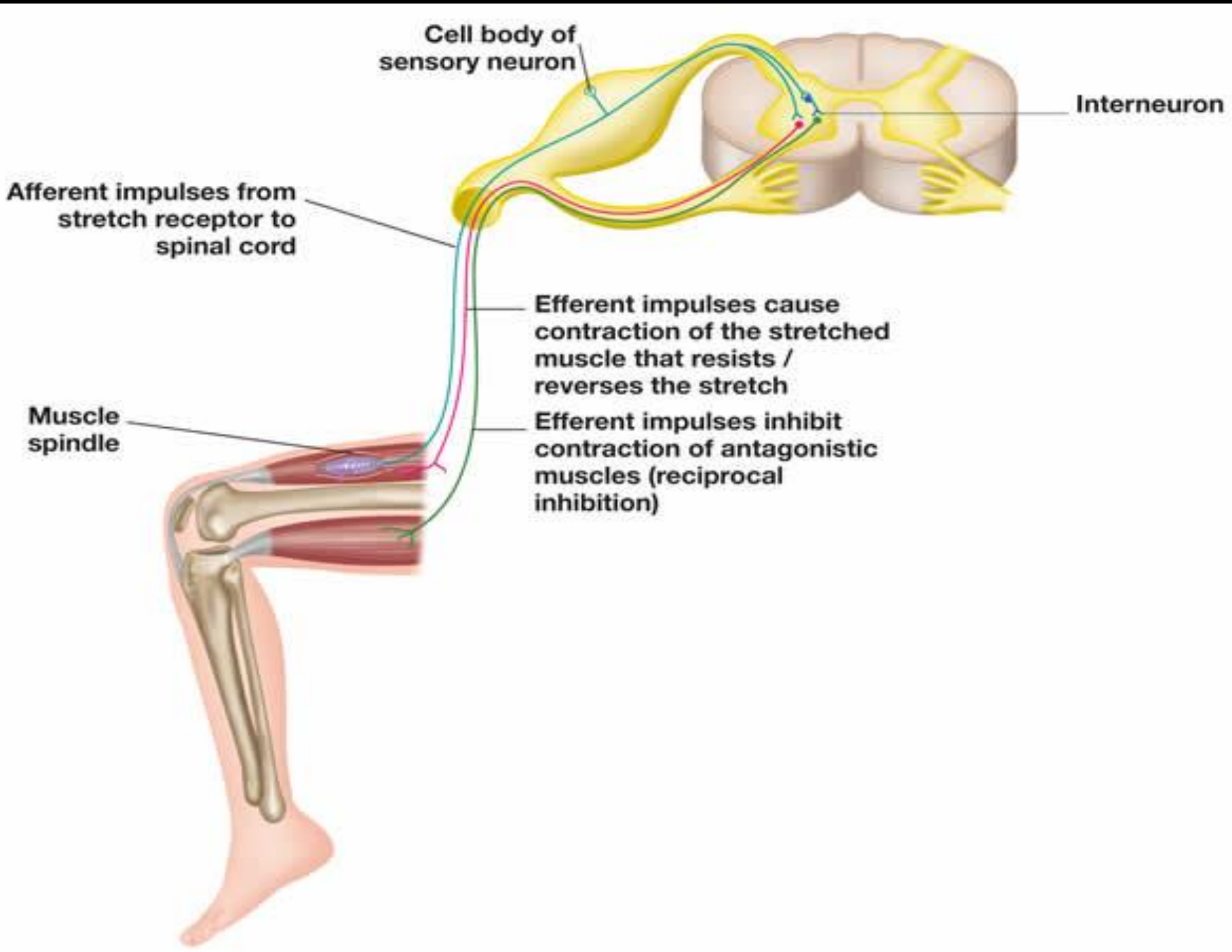
Inhibitory neuron
Muscle-tendon complex
Simple inverse stretch reflex arc: The stretch of Golgi tendon organ causes reflex inhibition (relaxation).


Cell body of sensory neuron
Interneuron
Afferent impulses from stretch receptor to spinal cord
Efferent impulses cause contraction of the stretched muscle that resists / reverses the stretch
Muscle spindle
Efferent impulses inhibit contraction of antagonistic muscles (reciprocal inhibition)

Continue……..

- In contrast, the GTO, as it monitors tension in the muscle fibers being stretched,.. inhibit level of muscle tension in the muscle-tendon unit in which it lies, particularly if the stretch force is prolonged……called ***autogenic inhibition.***
- *Inhibition* of the contractile components contributes to reflexive muscle relaxation during a stretching maneuver, enabling a muscle to be elongated against less muscle tension.
- A low-intensity, slow stretch force is applied to muscle, the stretch reflex is less likely to be activated….. as the GTO fires and inhibits tension in the muscle, allowing the parallel elastic component (the sarcomeres) of the muscle to remain relaxed and to lengthen…. Improvement in muscle extensibility.

Reciprocal & autogenic inhibition

	Autogenic inhibition	Reciprocal inhibition
Agonist Muscle Group	Relaxation	Contraction
Anta-gonist Muscle Group	contraction	Relaxation

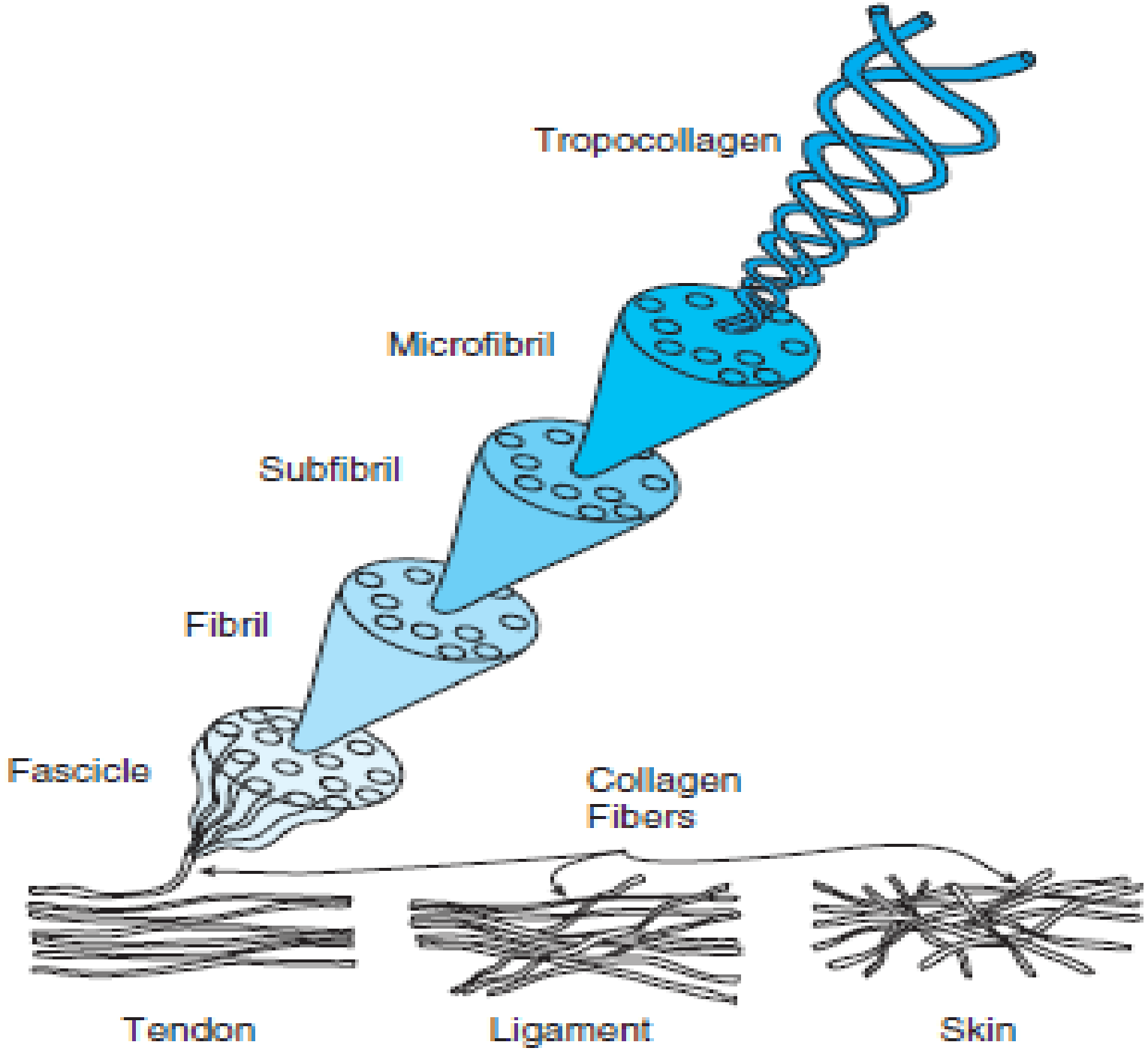
Mechanical Properties of Noncontractile Soft Tissue

- non-contractile tissue develop adhesions and contractures affect the flexibility tissues crossing joints.
- Response to stretch force depends its basic architecture.
- **Composition of Connective Tissue:**

Fibers: collagen, elastin and reticulin, and non-fibrous ground substance.

- ***Collagen fibers:***
- strength and stiffness of tissue ….resist tensile deformation.
- Tropocollagen crystals form the building blocks of collagen….
- 6 six classes with 19 types of collagen; the fibers of tendons and ligaments mostly contain type I collagen, which is highly resistant to tension.
- As collagen fibers develop and mature, they bind together, initially with unstable hydrogen bonding, which then converts to stable covalent bonding.

The stronger the bonds, more mechanical stability of the tissue.


Tropocollagen
Microfibril
Subfibril
Fibril
Fascicle
Collagen
Fibers
Tendon
Ligament
Skin

Elastin fibers.

- ***extensibility.***
- Great elongation with small loads…. Fail abruptly without deformation at higher loads.
- Tissues with greater amounts of elastin have greater flexibility.

Reticulin fibers; bulk.

Ground substance: ***proteoglycans*** (PGs) and glycoproteins.

- The PGs hydrate the matrix, stabilize the collagen networks, and resist **compressive forces.** (cartilage and intervertebral discs.
- **The glycoproteins** provide linkage between the matrix components and between the cells and matrix opponents.
- **The ground substance** organic gel containing water reduces friction between fibers, transports nutrients and metabolites,
- prevent excessive cross-linking between fibers…maintaining space between fibers.

Mechanical Behavior of Noncontractile Tissue

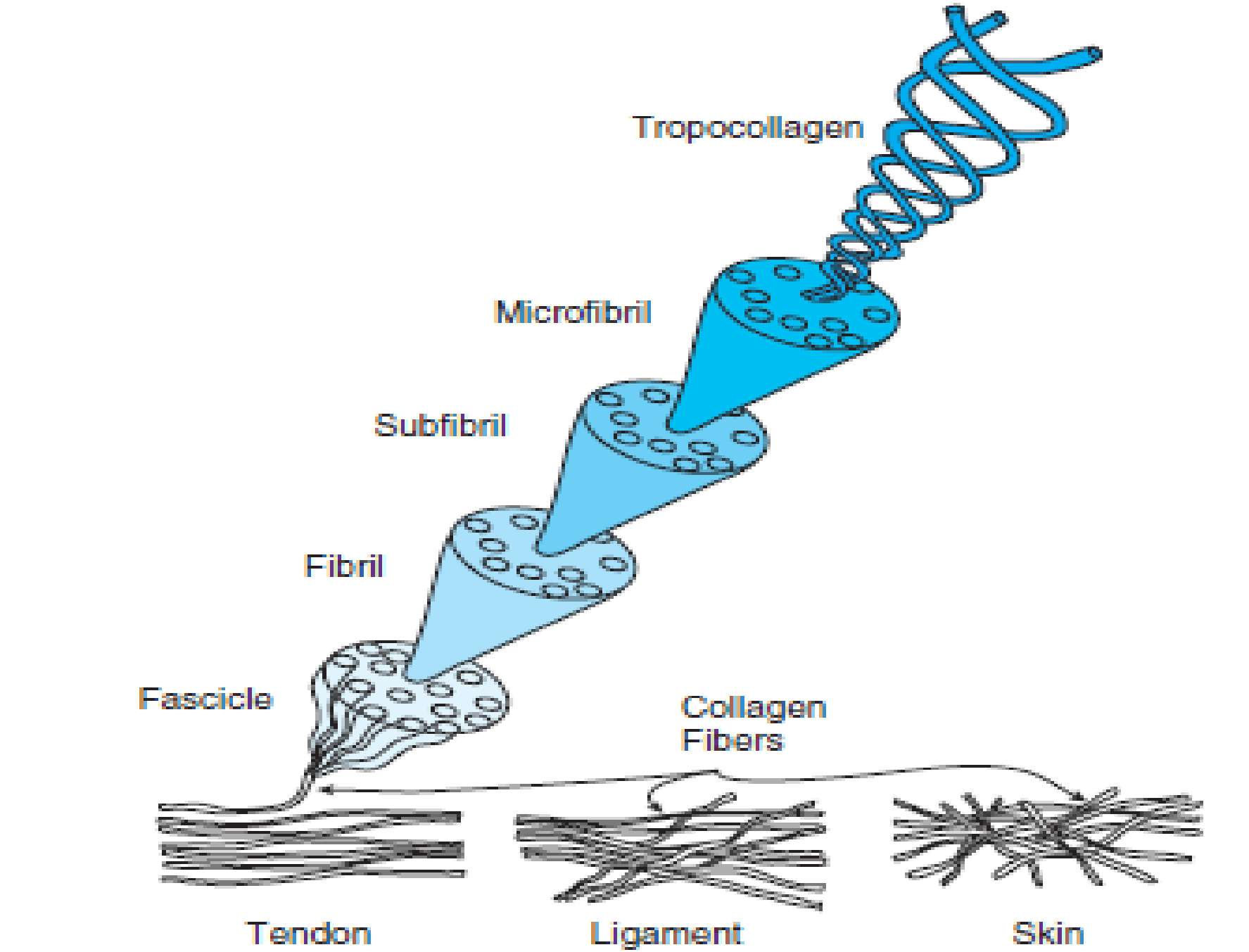
- Depend on proportion of collagen and elastin fibers and structural orientation of fibers.
- The proportion of proteoglycans (PGs) also influences the mechanical properties of connective tissue.
- Those high in collagen and low in PGs resist high tensile loads;
- Tissues have greater concentrations of PGs withstand greater compressive loads.

Collagen behavior to stress:

- Collagen absorbs most of the tensile stress. Collagen fibers elongate quickly under light loads (wavy fibers align and straighten).
- With increased loads, tension increases, fibers stiffen.
- fibers strongly resist the tensile force, but with continued loading the bonds between collagen fibers begin to break.
- substantial number of bonds are broken, the fibers fail.

Continue……

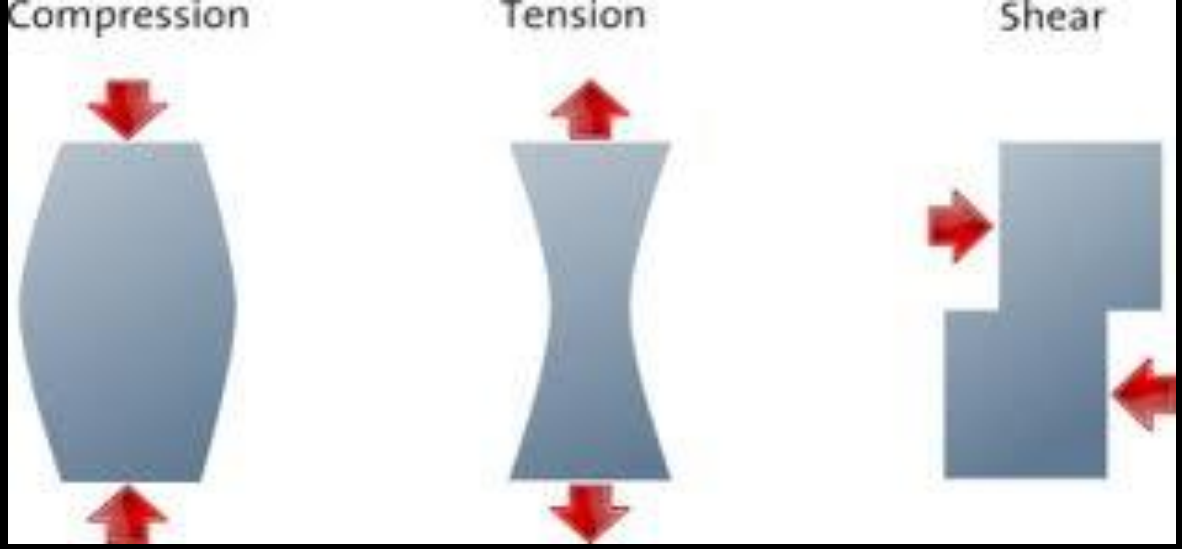
- Applied tensile forces elongation of collagen is less than 10%, elastin lengthen 150% and return to its original length. Collagen is five times as strong as elastin.
- The alignment of **collagen fibers** reflects tensile forces:
- **In tendons**, parallel and can resist the greatest tensile load. They transmit forces to the bone created by the muscle.
- **In skin**, collagen fibers are random and weakest in resisting tension.
- **In ligaments, joint capsules, and fasciae**, collagen fibers vary between the two extremes, **resist** multidirectional forces.
- Ligaments that resist major joint stresses have a more parallel orientation of collagen fibers and a larger cross-sectional area.

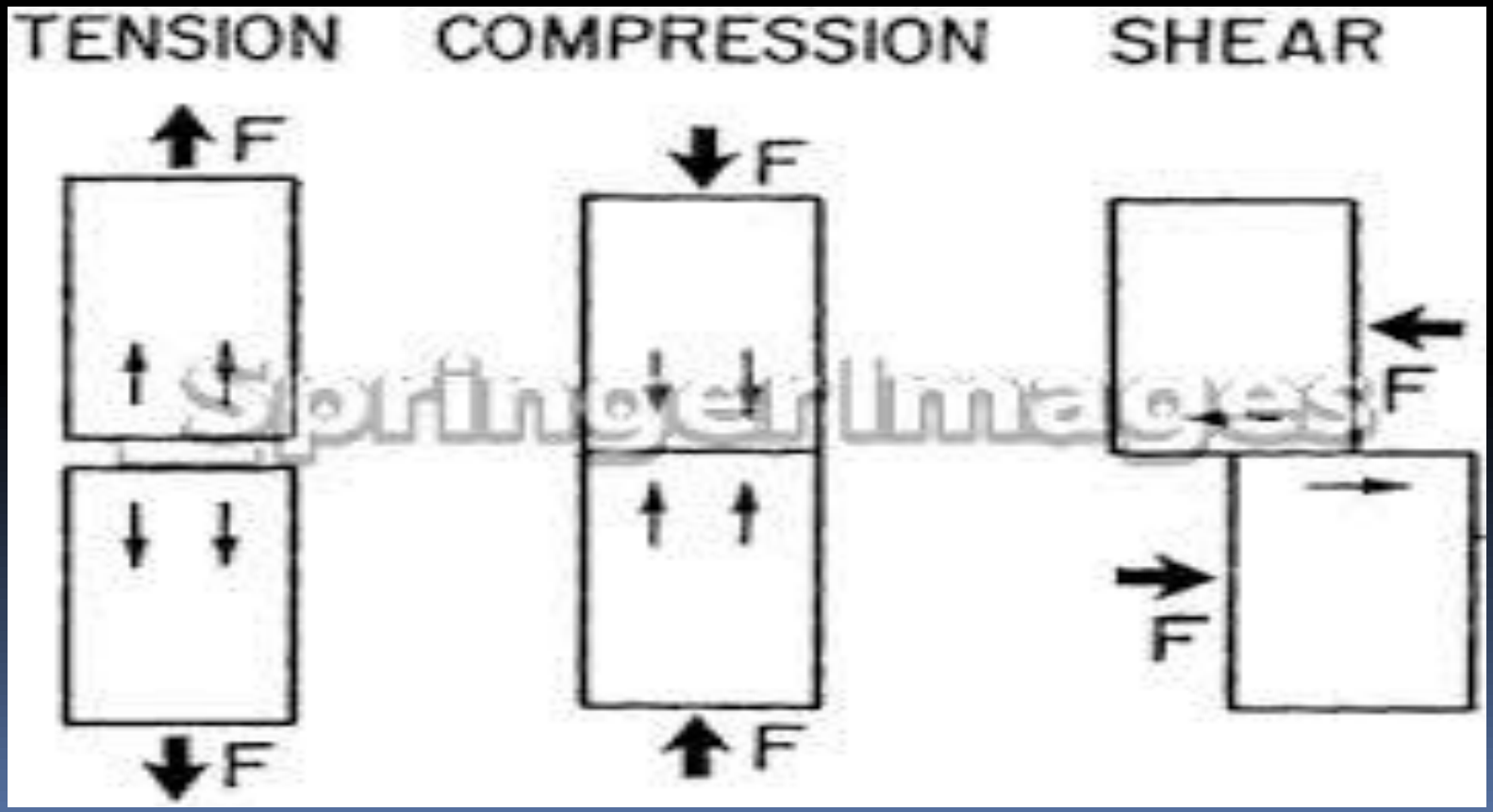

Tropocollagen
Microfibril
Subfibril
Fibril
Fascicle
Collagen
Fibers
Tendon
Ligament
Skin

Interpreting Mechanical Behavior of Connective Tissue:

- **The Stress–Strain Curve……..**
- ***Stress*** *is force per unit area. …..internal* reaction or resistance to an external load. **Types**
- ***Tension:*** *force perpendicular to the cross sectional* area in a direction away from the tissue. **stretching**
- ***Compression:*** *force perpendicular to the crosssectional* area of the tissue in a direction toward the tissue.

  (Muscle contraction and joint loading)
- ***Shear:*** *force parallel to the cross-sectional area* of the tissue.
- ***Strain:*** the amount of deformation or lengthening that occurs when a load (stress) or stretch force is applied


Compression
Tension
Shear


TENSION
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Regions of the Stress-Strain Curve

- ***Toe region.***
- Fibers at rest are wavy, straightening and aligning the fibers.
- *Area* considerable deformation. ….most functional activity.
- ***Elastic range/linear phase:***
- *Strain is directly proportional tissue resistance.*
- Tissue is taken to the end of its ROM, and gentle stretch is applied.
- bonds between fibers and between the surrounding matrix strained, some microfailure between the collagen bonds begins, and some water may be displaced from the ground substance.
- Complete recovery,…….

Elastic limit.

- ***Plastic range;***
- ***The range beyond the elastic limit*** to the point of rupture.
- Tissue strained has permanent deformation.
- sequential failure of the bonds between collagen fibrils and eventually of collagen fibers.
- Heat is released and absorbed in the tissue.
- Fibers rupture that results in increased length.

Ultimate strength/necking:

- ***The greatest load the tissue sustain*** is ultimate strength.
- Then increased strain (deformation) without an increase in stress required.
- The *region of necking is reached in which there is* considerable weakening of the tissue, and it rapidly fails.
- **Therapist role** to recognize necking region

Failure: ***Rupture of the integrity of the tissue is called*** failure.

- ***Structural stiffness :*** Tissues with greater stiffness have a
- higher slope in the elastic region of the curve, indicating
- that there is less elastic deformation with greater stress.
- Contractures and scar tissue have greater stiffness, probably because of a greater degree of bonding between collagen fibers and their surrounding matrix

Connective Tissue Responses to Loads

- ***Creep.***
- ***load is applied for an extended period of*** time, the tissue elongates, permanent **deformation**.
- It is related to the viscosity of the tissue and is therefore time-dependent.
- depends on the amount of force and the rate at which the force is applied.
- Low-magnitude loads, usually in the elastic range and applied for long periods, increase the deformation of connective tissue and allow gradual rearrangement of collagen fiber bonds (remodeling) and redistribution of water to surrounding tissues.
- Increasing the temperature of the part increases the creep and therefore the dispensability of the tissue.
- Complete recovery from creep may occur over time, but not as rapidly as a single strain.

Stress-relaxation.

- ***Load is applied to stretch*** a tissue and the length of the tissue is kept constant, after the initial creep there is a decrease in the force required to maintain that length, and the tension in the tissue decreases.
- Related to viscoelastic qualities and redistribution of the water content.
- **Principle:** prolonged stretching for several hours or days.
- **Recovery** (i.e., no change) versus permanent changes in length,,,, depend on amount of deformation and duration of deformation is maintained.

Cyclic loading and connective tissue fatigue.

- Repetitive loading of tissues increases heat production and cause failure below yield point.
- The greater applied load, the few cycles needed for failure.
- can be used for stretching by applying repetitive loads at a sub maximal level on successive days.
- The intensity determined by the patient's tolerance.
- ***endurance limit***. A minimum load is required for this failure.
- Below the minimum load an apparently infinite number
- of cycles do not cause failure
- **Example:** stress fractures and overuse syndromes…. Not required……
- Therefore, periodically, time is allowed between bouts of cyclic stretching to allow for remodeling and healing in the new range.

Changes in Collagen Affecting Stress–Strain Response

- **Effects of Immobilization:**
- weakening of the tissue -→ collagen turnover and weak bonding between the new, non-stressed fibers.
- Disorganized collagen-→ greater cross linkage-→ adhesion formation……> due to decreased effectiveness of the ground substance maintaining space and lubrication between the fibers.
- Elasticity reduced-→return to normal tensile strength is slow.
- **ACL For example**, after 8 weeks of immobilization, the anterior cruciate ligament in monkeys failed at 61% of maximum load; after 5 months of reconditioning, it failed at 79%; after 12 months of reconditioning, it failed at 91%
- **Recovery** follow same 5-months and 12-months pattern

Changes in Collagen Affecting Stress–Strain Response

- **Effects of Inactivity (Decrease of Normal Activity)**

Decrease size and amount of collagen fibers--------

- Increase in the predominance of elastin fibers------→
- Recovery 5 months….regular cyclic loading. Physical activity beneficial on the strength of connective tissue
- **Effects of Age:**
- Decrease maximum tensile strength, elastic modulus, rate of adaptation to stress.
- increase tendency of overuse syndromes, fatigue failures, and tears with stretching.
- **Effects of Corticosteroids:**
- On the mechanical properties of collagen with a decrease in tensile strength.
- fibrocyte death at injection site delay in reappearance up to 15 weeks.

Changes in Collagen Affecting Stress–Strain Response

- **Effects of Injury**
- Excessive tensile loading can lead to rupture of ligaments and tendons at musculotendinous junctions. Healing follows a predictable pattern, with bridging of the rupture site with newly synthesized type III collagen.
- This is structurally weaker than mature type I collagen. Remodeling progresses, and eventually collagen matures to type I.
- Remodeling begins about 3 weeks post injury and continues for several months to a year, depending on the size of the connective tissue structure and magnitude of the tear.

Determinants of Stretching Interventions

Alignment: *positioning a limb or the body……*

- ***Stabilization:*** *fixation of one site of attachment of the* muscle as the stretch force is applied to the other bony attachment
- ***Intensity of stretch:*** *magnitude of the stretch force*
- ***Duration of stretch:*** *length of time the stretch force*
- ***Speed of stretch:*** *speed of initial application*
- ***Frequency of stretch:*** *number of stretching sessions per* day or per week
- ***Mode of stretch:*** *form or manner..*(static, ballistic, cyclic); degree of patient participation (passive, assisted, active); or the source of the stretch force (manual, mechanical, self)

DETERMINANTS, TYPES, AND EFFECTS OF STRETCHING INTERVENTIONS

Alignment and Stabilization

- **Alignment**
- patient comfort and stability during stretching.
- Influences amount of tension in soft tissue and consequently affects the ROM available…
- muscles and joint alignment….as well as the alignment of the trunk and adjacent joints must all be considered.
- Eg. RF muscle & shoulder extensors
- Sources of **stabilization** include manual contacts, body weight, or a firm surface such as a table, wall, or floor.
- Eg. Quards manual & self (prox. & dist., stabilization)
- when stretching the iliopsoas, the pelvis and lumbar spine must maintain a neutral position as the hip is extended to avoid stress to the low back region

Intensity of Stretch

- the load placed on soft tissue to elongate it.
- ***low intensity*** *by means* of a *low load..High by high loads.*
- ***Low-intensity*** **compare to high-intensity:…..**
- **Low-intensity long duration of stretch:** improvement in ROM without exposing tissues, weakened by immobilization and potential injury.
- Elongate dense connective tissue,…component of chronic contractures, less soft tissue damage and post-exercise soreness…..

Duration of Stretch

- Period single stretch force applied or shortened tissues are held in a lengthened position.
- *If more than one* repetition of stretch (*stretch cycle)…*, cumulative time……
- In general, the shorter the duration of a single stretch cycle, the greater the number of repetitions applied during a stretching session.
- Any number of combinations have been studied….
- For example, in a study by Cipriani et al., two repetitions of 30-second hamstring stretches were found to be equally effective compared to six repetitions of 10-second stretches.
- However, Roberts and Wilson found that over the course of a 5-week period three 15-second hamstring stretches each day yielded significantly greater stretch-induced gains in ROM than nine daily 5-second stretches

Intensity, Duration, Frequency, Mode of Stretch– Interrelationships & Impact on Stretching Outcomes

- • Inverse relationship between intensity and duration as well b/w intensity and frequency.
- • lower the intensity of stretch, the longer time….
- • The higher the intensity, the less frequency…..
- • A low-load (low-intensity), long-duration stretch most significant, elastic deformation and long-term, plastic changes in soft tissues.
- • Manual stretching and self-stretching in hypomobile but healthy subjects
- prolonged mechanical stretching in patients with chronic contractures gains in ROM.

Continue……

- **Elderly,** stretch cycles of 15, 30, and 60 seconds applied for four repetitions… significant gains in ROM with the greatest and longest-lasting improvements occurring with the use of 60-second stretch cycles.
- • In **healthy young and/or middle-age adults** • 15, 30, 45, or 60 seconds or 2 minutes to lower extremity musculature produced significant gains in ROM.
- static, cyclic stretch same duration….same results….
- 2 session of 30-second static stretch similar with 6 repetitions of 10-second static stretches daily.
- **chronic, fibrotic contractures:……manual vs splintss**

1) Static Stretching

- *commonly used method …*elongate beyond point of tissue resistance…held in the lengthened position with a sustained stretch force over a period of time.
- sustained, maintained, or prolonged stretching.
- predetermined duration…..
- A single stretch cycle 5 seconds to 5 minutes per repetition…manual stretch or self-stretching.
- Mechanical device provides static stretch, from almost an hour to several days or weeks.

Static Stretching

- Best considered increase flexibility and a safer form of stretching than ballistic…less tissue trauma and less post-exercise muscle soreness than ballistic stretching.

1. Tension half than ballistic…which is consistent with viscoelastic properties of connective tissue, around muscles, as well as the neurophysiological properties.

2. non-contractile soft tissues yield more in static stretching & Contractile through GTO

2) Static Progressive Stretching

- Describes how static stretch is applied for maximum effectiveness……
- Involves continuous displacement of a limb by varying the stretch force (stretch load).
- capitalizes on the stress-relaxation properties of soft tissue.
- Can compare effect with dynamic splint effect
- Manual stretching and self-stretching procedures are also routinely applied in this manner.

3) Cyclic (Intermittent) Stretching

- A repeated, short-duration stretch force but gradually applied, released, and then reapplied….. multiple repetitions (stretch cycles) during a single treatment session.
- *Repititive, slow velocity, in a controlled manner, and* relatively low intensity.
- Cyclic stretching each cycle of stretch is held between 5 and 10 seconds……
- Static stretch more than 30 seconds…. Better to apply cyclic stretching…same result…

Speed of Stretch

- **Slowly Applied Stretch:**

optimal muscle relaxation, prevent injury to tissues, *easy control*…….less increase tensile stresses on connective tissues **or** to activate the stretch reflex and increase tension in the contractile structures of the muscle being stretched…..

- a slow rate stretch affects the viscoelastic properties of connective tissue, making them more compliant.

4) Ballistic Stretching

- A *rapid, forceful intermittent stretch— OR*
- *A high-speed and high-intensity stretch, short duration— characterized* quick, bouncing movements.....
- Improve flexibility equally,.... greater trauma to stretched tissues and greater residual muscle soreness than static stretching.
- **Recomendations:;;**
- increase ROM safely in young, healthy subjects participating in a conditioning program, it is, for the most part, **not recommended for elderly or sedentary individuals or patients with musculoskeletal pathology or chronic contractures.**

High-Velocity Stretching in Conditioning Programs and Advanced-Phase Rehabilitation

- high-velocity stretching is appropriate for carefully selected individuals……
- Following safe transition and progression from static stretching to ballistic
- **stretching to improve dynamic flexibility.:**
- Static stretching → Slow, short end-range stretching → Slow, full-range stretching → Fast, short end-range stretching → Fast, full-range stretching.
- Antagonists contract…..

Frequency of Stretch

- *Number of bouts (sessions) per day or per week a patient carries out a stretching r*egimen.
- ranges from 2-5 sessions/week,……
- aware of any breakdown of tissues with repetitive stretch.
- Balance between collagen tissue breakdown and repair is needed to allow an increase in soft tissue lengthening.

Mode of Stretch

- Form of stretch or the manner of exercise…….. OR
- who or what is applying the stretch force or whether the patient is actively participating in the stretching maneuver.
- *manual and mechanical stretching or self-stretching* as well as *passive, assisted, or active stretching.*
- stretching procedures should be **preceded** by either low intensity active exercise or therapeutic heat to warm up the tissues that are to be lengthened.

Manual Stretching

- A therapist ….an external force to move body segment *slightly beyond the point of tissue* resistance and available ROM.
- Therapist manually controls the site of stabilization as well as the direction, speed, intensity, and duration of stretch.
- ***ROM exercises* stay within the limits of tissue extensibility to *maintain* the available length of tissues.**
- Manual stretching usually employs a controlled, end-range, static, progressive stretch applied at an intensity consistent with the patient's comfort level, held for 15 to 60 seconds and repeated for at least several repetitions.

When compared to mechanical stretching, manual stretching could be categorized as a high-intensity, short-duration stretch.

The following are points to consider about the use of manual stretching.

- Most appropriate in the early stages of a stretching program…. determine how patient responds varying intensities or durations of stretch.
- Performed *passively is an appropriate* choice for a therapist or caregiver if a patient cannot perform self-stretching…
- If a patient has control of the body segment, ask the patient to assist the therapist with the manual stretching maneuver, (in PNF method)

Mechanical Stretching

- increase ROM.
- A cuff weight or weight-pulley system or some adjustable orthosis or automated stretching machines.*
- **constant load with variable displacement or constant displacement with variable loads.**
- **Efficacy of device**: soft tissue properties of either creep or stress-relaxation, occur in short period of time, as well as plastic deformation,
- **Best:** low intensity stretch force (low load) over a prolonged period of time, plastic deformation.

An effective stretch load applied with a cuff weight can be as low as a few pounds.

Some devices, such as the Joint Active Systems™ adjustable orthosis, allow a patient to control and adjust the load (stretch force) during a stretching session.

With other devices the load is preset prior to the application of the splint, and the load remains constant while the splint is in place.

Duration of Mechanical Stretch

- Longer overall duration of stretch ……..
- Rang **from 15 to 30 minutes** to as long as 8 to 10 hours at a time **or** continuous throughout the day except for time out of the device for hygiene and exercise.
- Serial casts are worn for days or weeks at a time before being removed and then reapplied. dependent on the type of device, cause and severity of impairment, and patient tolerance.
- Chronic contractures as neurological or musculoskeletal disorders….

Special Considerations for Use of Mechanical Stretching Devices

- manufacturer's product information.
- stretching protocols recommended by the manufacturer;
- provide evidence of the efficacy of the equipment or protocols.
- • modifying a suggested protocol
- Check fit of a device before sending it home with a patient.
- Teach how to apply and safely adjust the device and how to maintain it in good working order.
- patient knows who to contact if the equipment appears defective.
- Teach the patient to inspect the skin areas of excessive pressure from the stretching device and potential skin irritation.
- "homemade equipment"…check equipment is safe and effective.
- keep a daily record of using the stretching device.
- Re-examine and re-evaluate the patient and equipment periodically to determine the effectiveness of the mechanical stretching program and to modify and progress the program as necessary..

Proprioceptive Neuromuscular Facilitation Stretching Techniques

- Described by Knott and Voss, adjunct to manual stretching or self-stretching.
- (*PNF stretching*), *active stretching or facilitative stretching*,
- *integrate* active muscle contractions to facilitate or inhibit muscle activation, muscle to be lengthened remains as relaxed as possible as it is stretched.
- autogenic or reciprocal inhibition, less resistance.

Types of PNF Stretching

- **Hold–relax (HR) or contract–relax (CR)**
- **Agonist contraction (AC)**
- **Hold–relax with agonist contraction (HR-AC).**
- **Hold–Relax and Contract–Relax**
- The range limiting muscle lengthened to the point of limitation or to the extent that is comfortable for the patient.
- *pre-stretch, end-range, isometric contraction (for 5 to 10 seconds) followed by voluntary* relaxation of the tight muscle.
- The limb passively moved into the new range.
- More comfortable for a patient than manual passive stretching.

Agonist Contraction

The "agonist" muscle *opposite the range-limiting muscle.*

- "Antagonist," therefore, refers to the range-limiting muscle.
- *Dynamic range of motion (DROM) and active stretching are terms that have been used to describe the* AC procedure.
- To perform the AC procedure the patient *concentrically contracts (shortens) agonist muscle… and then holds the end-range position for* at least several seconds.
- Effective in muscle guarding, less effective chronic contractures……
- Useful for initiating neuromuscular control in the newly gained range to re-establish dynamic flexibility.

- **P R E C A U T I O N S : Avoid full-range, balllistic movements** when performing concentric contractions of the agonist muscle group.
- Rest after each repetition to avoid muscle cramping when the agonist is contracting in the very shortened portion of its range.

Hold–Relax with Agonist Contraction

- combines the HR and AC procedures…..**reversal hold–relax technique.**
- Move the limb to the point that tissue resistance is felt in the tight (range-limiting) muscle;
- then have the patient perform a resisted, prestretch isometric contraction of the range-limiting muscle ***followed*** *by* relaxation of that muscle and an immediate concentric contraction of the muscle *opposite the tight muscle.*
- *Hold new range for several seconds.*
- knee joint, elbow flexor contracture….
- **Integration of Function into Stretching**
- **Importance of Strength and Muscle Endurance**

PROCEDURAL GUIDELINES FOR APPLICATION OF STRETCHING INTERVENTIONS

- **Examination and Evaluation:**
- **R**eview the patient's history and perform a thorough systems review.
- tests and measurements.
- ROM involved and adjacent joints…..
- hypomobility or other impairments causing functional limitations or disability.
- source of impaired mobility. joint capsule, peri-articular non-contractile tissue, and muscle length restrictions.
- patient's extremities or spine moving, pay attention to the patient's reaction to movements…..dosage (such as intensity and duration) stretch.
- Analyze any factors adversely affect outcomes.

Preparation for Stretching

- Review goals and desired outcomes, patient's consent to initiate treatment.
- Select the stretching techniques……
- Warm up the soft tissues……
- Patient comfortable, stable position……
- **Procedure:**
- *The direction of stretch is exactly opposite the direction of the joint or muscle restriction.*
- Pre-stretch explanation,……
- Free area,….restrictive clothing, bandages, or splints.
- patient to be as relaxed as possible or assist when requested……

Application of Manual Stretching Procedures

- Move the extremity slowly through the free range to the point of tissue restriction.
- Grasp the areas proximal and distal to the joint in which motion is to occur.
- Force comfortable…..Use padding, if necessary, in areas with minimal subcutaneous tissue, reduced sensation, or over a bony surface.
- Use the broad surfaces of your hands to apply all forces.
- Stretch the muscle over one joint at a time and then over all joints simultaneously until the optimal length of soft tissues is achieved.

Continue……..

Consider pre-stretch, isometric contraction(The hold–relax procedure), relax muscle reflexively prior to stretching it.

- To avoid joint compression…. apply gentle (grade I) distraction.
- **Apply a low-intensity stretch in a slow, sustained manner…..experience pulling sensation not pain….**
- Ask to assist….
- Enough force to tension on soft tissue structures but not cause pain or injure the structures.
- Stress relaxation in new length…gain more length.
- soft tissue mobilization procedures, such as fascial or crossfiber friction, at or near the sites of adhesion during the stretching maneuver.

After Stretching

- Apply cold to allow these structures to cool in a lengthened position.
- minimize post-stretch muscle soreness that can occur as the result of microtrauma during stretching.
- After stretching, patient perform active ROM and strengthening exercises through the gained range immediately after stretching.
- Develop a balance in strength in the antagonistic muscles in the new range so there is adequate neuromuscular control and stability as flexibility increases.

PRECAUTIONS FOR STRETCHING

- **General Precautions**
- Do not passively force a joint beyond its normal ROM. Remember, normal (typical) ROM varies among individuals.
- In adults, flexibility is greater in women than in men. When treating older adults, be aware of age related changes in flexibility.

PRECAUTIONS FOR STRETCHING

- Care…. suspected osteoporosis due to disease, prolonged bed rest, age, or prolonged use of steroids.
- Protect newly united fractures;.
- Avoid vigorous stretching of muscles and connective tissues immobilized extended time……..(high intensity short duration)
- Progress the gradually……..
- joint pain or muscle soreness lasting more than 24 hours after stretching,……
- Avoid stretching edematous tissue, as it is more susceptible to injury than normal tissue. Continued irritation of edematous tissue usually causes increased pain and edema.

Precautions for flexibility programs

- **Common Errors and Potential Problems**
- ***1) Nonselective or poorly balanced stretching activities.***
- General flexibility programs body areas…usually stretch.. already mobile or even hypermobile but may neglect regions that are tight from faulty posture or inactivity.
- E.g…..in the sedentary population,….
- Yet many **commercially available** flexibility routines overemphasize exercises that stretch posterior muscle groups, already overstretched, and fail to include exercises to stretch the tight anterior structures…..faulty postures may worsen rather than improve.
- ***2) Insufficient warm-up. Individuals involved in flexibility…***programs often fail to warm up prior to stretching

Common Errors and Potential Problems

- ***3) Ineffective stabilization.***
- ***4) Use of ballistic stretching.***
- ***5) Excessive intensity. "The phrase "no pain, no gain" is*** often used inappropriately.(hurdelers'strecth)
- ***6) biomechanics.***
- ***7) Insufficient information about age-related differences.***


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Strategies for Risk Reduction

- appropriateness and safety of exercises in a "prepackaged" flexibility program.
- Community exercise program monitor closely to patient….
- **home exercise videotapes**.
- Group of same pathology…
- Eliminate or modify those exercises that are inconsistent with the intervention
- Balance b/w stretching and strengthening,……e.g….Teach your patient basic principles of self-stretching
- importance of warming up prior to stretching.
- Teach effective self-stabilization to isolate stretch to specific muscle groups.
- Teach your patient how to determine the appropriate intensity of stretch;……**soreness**….?

ADJUNCTS TO STRETCHING INTERVENTIONS

Relaxation Training:

- *General relaxation* (total body relaxation), reduce pain, muscle tension, anxiety or stress, **AND**
- **Associated physical impairments:** including tension headaches, high blood pressure, and respiratory distress.

Common Elements of Relaxation Training:

- Involves a reduction in muscle tension in the entire body or the region that is painful or restricted by ***conscious effort and thought***
- ***environment***
- The patient performs deep breathing exercises or visualizes a peaceful scene.
- Instructions the therapist uses a soft tone of voice.

Examples of Approaches to Relaxation Training

Autogenic training:

- ***By Schultz*** and colleagues,
- involves conscious relaxation through autosuggestion and a progression of exercises as well as meditation.

Progressive relaxation:

- By Jacobson;
- uses systematic, distal to proximal progression of voluntary contraction and relaxation of muscles. .
- ***Awareness through movement:***
- ***By* Feldenkrais:;**
- Involve Sensory awareness, movements of the limbs and trunk, deep breathing, conscious relaxation procedures, self-soft tissue mobilization to alter muscle imbalances and abnormal postural alignment to remediate muscle tension and pain.

Sequence for Progressive Relaxation Techniques

- In quiet area and comfortable position, restrictive clothing loosened.
- Breathe in a deep, relaxed manner.
- Contract the distal musculature in hands or feet voluntarily for several (5 to 7) seconds and consciously relax those muscles for 20 to 30 seconds.
- Feel sense of heaviness in the hands or feet and a sense of warmth in the muscles just relaxed.
- Progress to a more proximal area of the body as above…….at end isometrically contract and relax the whole area……
- Feel sense of relaxation and warmth throughout the entire limb and eventually throughout the whole body.

Indicators of Relaxation

- • Decreased muscle tension
- • Lowered heart and respiratory rates and blood pressure
- • Increased skin temperature in the extremities associated with vasodilation
- • Constricted pupils
- • Little to no body movement
- • Eyes closed and flat facial expression
- • Jaw and hands relaxed with palms open
- • Decreased distractibility

Heat

- increases extensibility…
- amount of force and time the stretch force…….decreased
- Decrease firing of the type II efferents from the muscle spindles and an increase in the sensitivity of the GTO…….easily lengthen, with less muscle guarding……
- poste-xercise muscle sorenesss and the risk of injury to soft tissues.

Methods of Warm-up

- Superficial heat ……or deep-heating modalities….
- used on areas as individual joints, muscle groups, or tendons and may be applied prior to or during the stretching procedure……
- Low-intensity, active exercises, warm up large muscle groups prior to stretching.
- brief walk, non-fatiguing cycling on a stationary bicycle, use of a stair-stepping machine, active heel raises, or a few minutes of active arm exercises.

EFFECTIVENESS OF WARM-UP……

- The use of heat alone without, stretching--- min or no imp in **flexibility**……
- heat combined with stretching, **flexibility**……
- stretching, inflammation…..
- After stretching, cold……

Relaxation

- Local muscle relaxation…..light or deep stroking techniques.
- stress and anxiety or pain management, using light stroking techniques (effleurage), is performed during the relaxation process.
- In sports and conditioning programs, general relaxation or to enhance recovery after strenuous physical activity,

Soft Tissue Mobilization Techniques

- various forms of soft tissue mobilization, purpose not relaxation, rather, increasing the mobility of adherent or shortened connective tissues including fascia, tendons, and ligaments.

- With *myofascial massage,..... friction ,*

deep circular or cross-fiber .....

- Increase the mobility of scar tissue....

Biofeedback

- Help patient learn and practice process of relaxation.
- A patient, if properly trained, can electronically monitor and learn to reduce the amount of tension in muscles, as well as heart rate and blood pressure, through biofeedback instrumentation.
- Through visual or auditory feedback, a patient can begin to sense or feel what muscle relaxation.
- By reducing muscle tension, pain can be decreased and flexibility increased.
- **UNITS:**
- 1) Periphral skin temperature unit
- 2) skin conductance activity
- 3) finger photo-transmission
- 4) EMG Biofeedback
- **N O T E : Biofeedback is also a useful means to help a** patient learn how to activate a muscle, rather than relax it,


STRESS THERMOMETER


76.6°F
84.0°F


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Joint Traction or Oscillation

- Slight manual distraction of joint surfaces prior to or in conjunction….. inhibit joint pain and spasm of muscles around a joint.
- Pendular motions of a joint use the weight of the limb to distract the joint surfaces and simultaneously oscillate and relax the limb.
- The joint may be further distracted by adding a 1- or 2-lb weight to the extremity, which causes a stretch force on joint tissues.

End