Lecture 1:
Foundations of Structural Kinesiology and Analysis

COURSE: Introduction to Exercise Science Level I (Kinesiology)

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Class Objectives

To learn about:

- the terms Kinesiology and understand the importance of human motion.
- five Components of teaching and analyzing a movement
- anatomy of the skeletal and muscle systems.
- planes of motion axes of rotation
- allowable joint movements.
- muscle contractions and how muscles function in joint movement.

Definition Kinesiology

- The study of human movement from three fields of physical sciences:
  - Mechanics: Biomechanics
  - Anatomy: Musculoskeletal anatomy
  - Physiology: Neuromuscular Physiology
- Personal Trainers must view human & exercise movements through new eyes

Reasons to Study Kinesiology

- Practitioners of movement who study Kinesiology include Physical therapy, athletic training, orthopedic medicine, physical ed. & personal training
- Teaches *Safety, Effectiveness, & Efficiency*
- Study and teach gait, posture, ergonomics, exercise movements, etc.

Five Components to Teaching and Analyzing a Movement

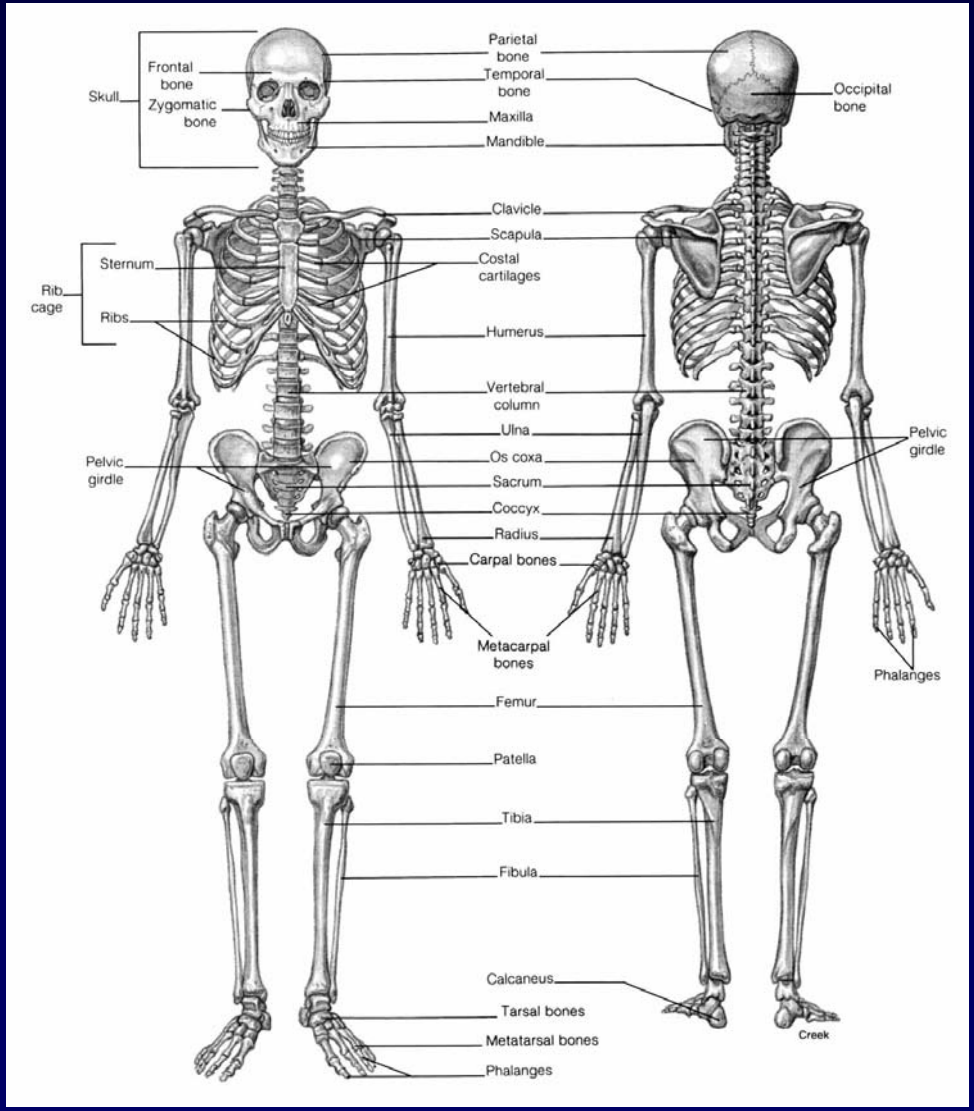
1. Describing-logical and systematic
a. Preparatory
b. Central
c. Terminal
2. Performing- PFT performs movement
3. Practicing-Client practices
4. Evaluating-PFT observes and evaluates
5. Prescribing-corrects and recommends

3 Key Musculoskeletal Structures

- Skeletal/Bones
- Joints-articulation between bony structures
- Muscles-attach to bones

THE BONES

- Skeleton: provides protection, muscle attachment, & lever system
- Axial: skull, spinal column, sternum, and Ribs
- Appendicular: upper & lower extremities, & shoulder/pelvic girdle



Skeletal Changes

- Skeletal Changes: Epiphyseal plate –strength training for youth, slow, controlled, and structured
- Osteoporosis: loss of calcium & other minerals; resistance training reduces chances of developing osteoporosis

Types of Bones

- Long: shaft or body with a medullary canal, a
  - Femur, tibia, humerus, ulna, radius, etc.
- Short: relatively small, chunky, solid
  - Carpals and tarsals
- Flat: flat & plate like
  - Sternum, scapulae, ribs, pelvis, & patella
- Irregular: bones of spinal column
  - Vertebrae, sacrum, & coccyx

Sesamoid:

- patella

Terms and Make-up of Joint Structure

- bony structures & articulations- bone to bone meetings,
- Joint Stability-resistance to displacement; ligaments, muscular arrangements, fascia, & atmospheric pressure
- ligaments- ligaments stabilize joints by connecting bones to bones.

Terms and Make-up of Joint Structure

- Tendon- Collagen fibers in parallel arrangement
- cartilage- meniscus, shock absorbers, & reduces friction
- joint capsule- ligamentous structure that surrounds a joint. Ex. Shoulder
- synovial fluid- produced within joint capsule, its like WD-40=lubricates the joint
- Bursae-pad that allows for structure to move smoothly

Two Categories of Joints

- Based on presence or absence of a joint cavity
  - Synarthrodial or Diarthrodial (Synovial)
- Further classified either by shape or nature of the tissues that connect the bones

Synarthrodial: Characteristics

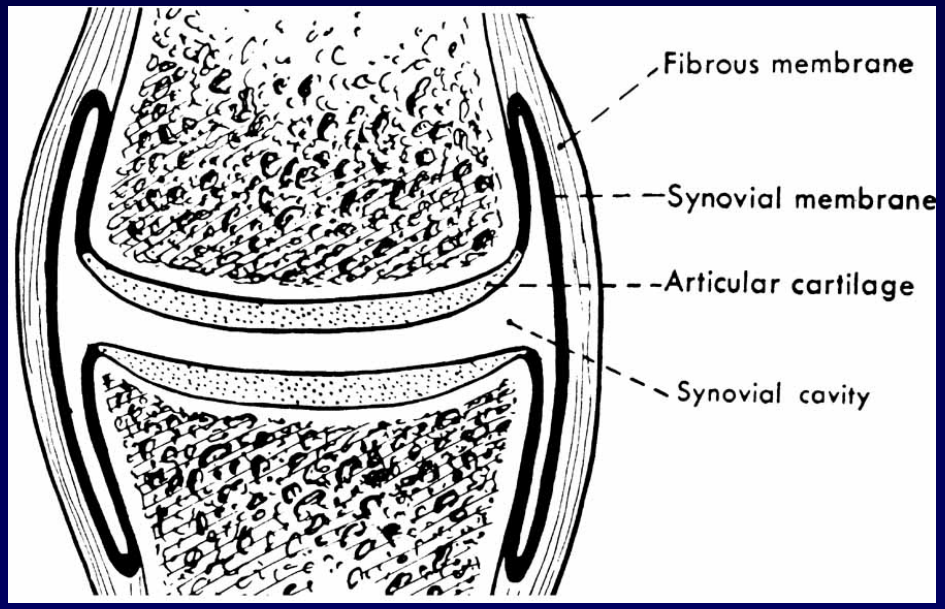
- No articular cavity, capsule, synovial membrane or synovial fluid
- In two types, bones are united by cartilage or fibrous tissue
- Third type, not a true joint, but is a ligamentous connection between bones

Synarthrodial Joints: Classification

- Fibrous joint (immovable): edges of bone are united by a thin layer of fibrous tissue, Sutures of the Skull & sockets in teeth
- Sydesmosis (ligamentous) (slightly moveable): two bodies are tied together by ligaments, Radius & Ulna, Tibia/fibula
- Synchondrosis (cartilageous) (slightly moveable)joint: united by fibrocartilage permits bending & twisting motions, Vertebral bodies & Symphysis Pubis & ribs artic. w/ sternum

Diarthrodial: Characteristics

- Articular cavity
- Joint capsule
- Synovial membrane
- Synovial Fluid
- Surfaces are smooth
- Surfaces covered with hyaline cartilage
- Fibro disc sometimes present



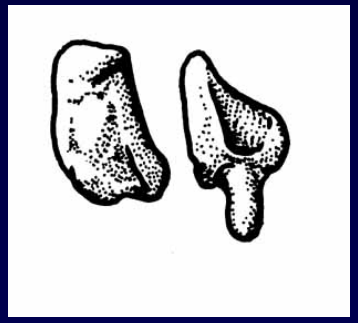
Diathrodial Joint Descriptions

- Gliding/Plane joint: irregular surfaces, flat or slightly curved
- Hinge joint: convex/concave surfaces, uniaxial, permits flexion/extension
- Pivot joint: a peglike pivot, permits rotation
- Condyloid joint: oval or egg-shape convex surface fits into a reciprocal concave surface, biaxial, permits flexion/extension, Ab & adduction, and circumduction

Diathrodial Joint Descriptions

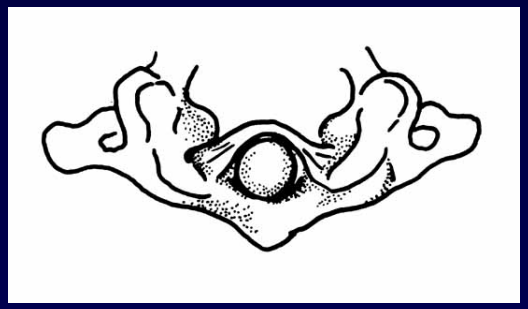
- Saddle: modification of condyloid, both surfaces are convex and concave, biaxial, permits flexion/extension, Ab & adduction, and circumduction
- Ball-and-socket: head of one bone fits into the cup of the other bone , movement in all 3 a planes

Types of Diathrodial Joints

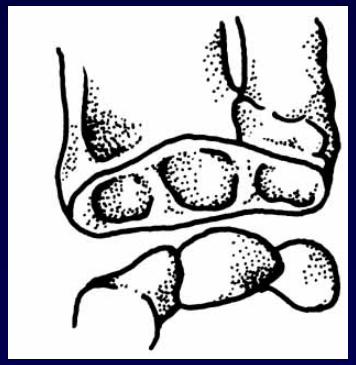


Plane
Intercarpal

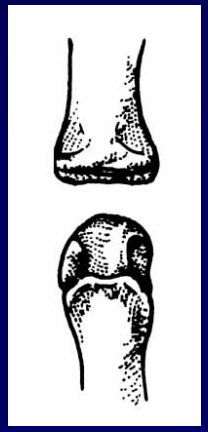
Hinge
Elbow



Pivot
Atlantoaxial

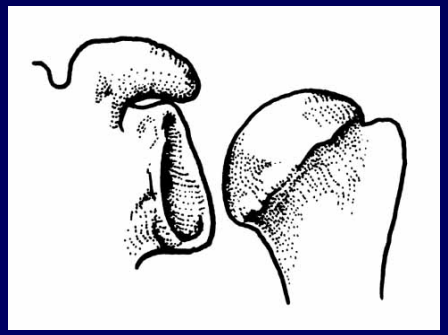


Condyloid
Radiocarpal

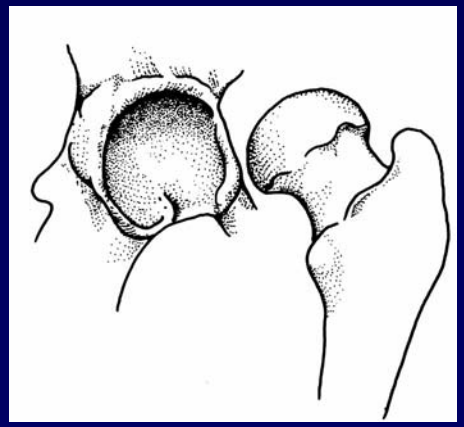


Condyloid
MCP joint

Saddle
Thumb



Ball & Socket
Shoulder



Ball & Socket
Hip

Joint Stability

- Function of joints is to provide a means of moving or, rather, of being moved
- Secondary functions is to provide stability without interfering with the desired motions
- All joint do not have the same degree of stability
- Movement is gained at the expense of stability

Joint Stability

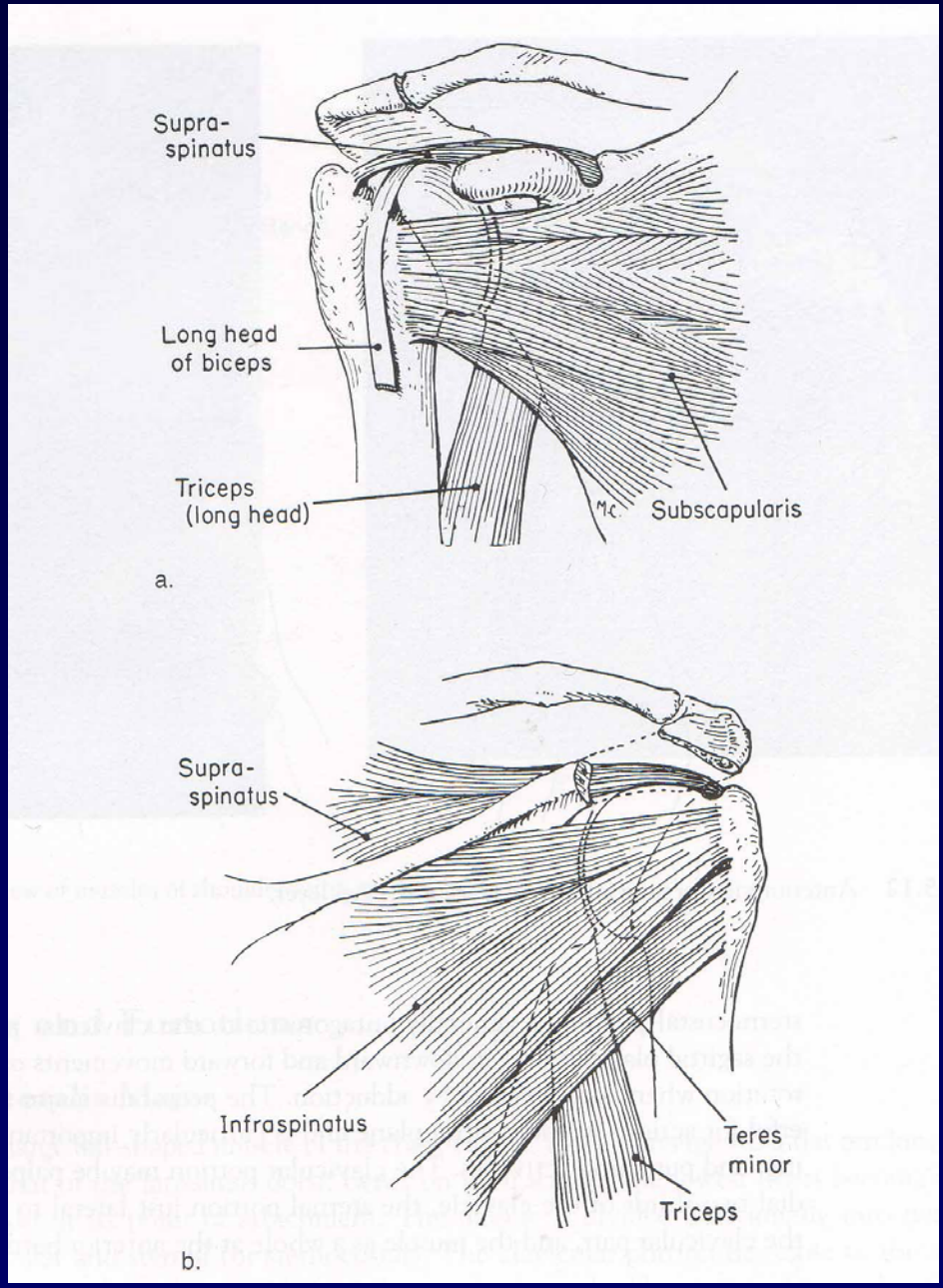
- Resistance to displacement
- Factors responsible for stability
  1. Ligaments-Collateral Ligaments, Knee
  2. Muscle tension-Shoulder joint
  3. Fascia-Iliotibial tract of fascia lata
  4. Atmospheric pressure-Hip joint
  5. Bony structure-Shoulder & hip

Ligamentous Arrangements

- Ligaments are strong, flexible, stress-resistant, somewhat elastic, fibrous tissues that form bands or cords
- Check normal movement & Resist movements for stress joint
- Prolonged stress may stretch ligament affecting stability

Muscular Arrangement

- Muscle and tendons that span joints aid in stability
- Especially when bony structure contributes little to stability
- Ex. shoulder



Fascia and Skin

- Fascia consist of fibrous connective tissue to support joint structure
- Intense or prolonged stress may cause permanent stretch
- Iliotibial tract and thick skin covering the knee joint are examples

Atmospheric Pressure

- Atmospheric pressure pushes on the outside of the joint with a greater force that the outward pushing force within the joint cavity
- The suction created is am important factor in resisting dislocation of a joint

Joint Function

- Kinematic Chains- Linking chains/segments in movement
- Open Chain- Distal segment of chains moves in space
- Closed Chain- Distal segment of the chain is fixed and proximal part moves

Joint Motions

A. Arthokinematics-movement of joint surfaces
- combination of rolling, sliding, and spinning
- Closed pack position
- Open (loose) pack position
- Hypermobility- excess movement
- Hypomobility – decrease movement

Muscular system

- More than 600 muscles; 100 primary movement muscles personal trainers should know
- Exercise movements: large muscle groups activate smaller ones
- Muscles move joints and skeletal structure.
- Superficial & Deeper muscles (Both strengthen and stabilize)
- Primary Muscles: Origins and insertions, better understanding of how movements occur.
- Muscular Fiber Arrangement
- Practical application in designing exercise prescriptions.

Muscular Attachments

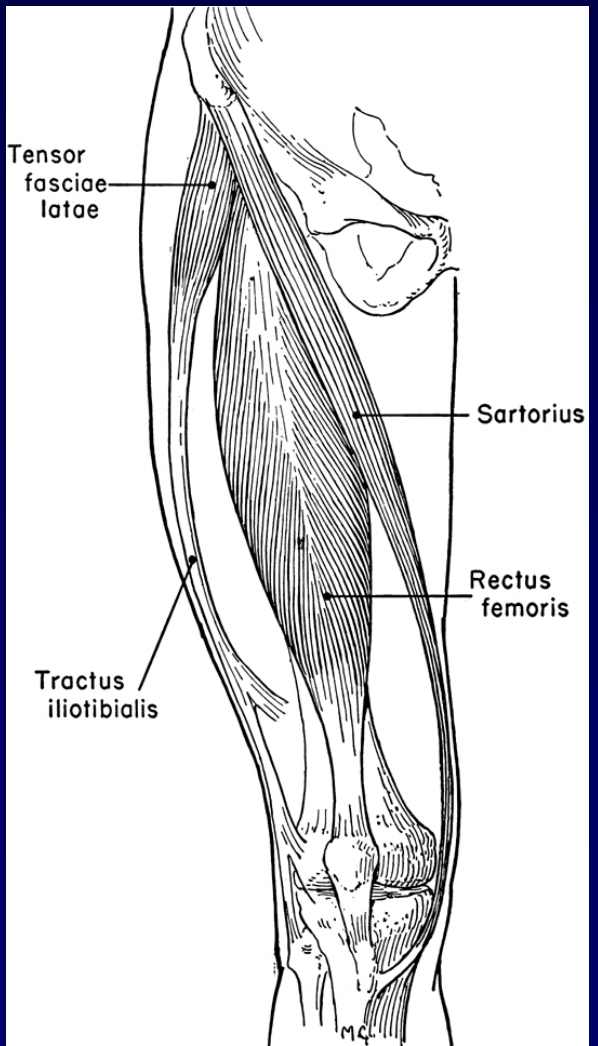
- Muscle attach to bone by connective tissue, which continues beyond the muscle belly to form a tendon
- Origin: usually more proximal
- Insertion: usually more distal
- Contraction produces equal force on the two attachments
- Origin usually stabilized by other muscles

Classification of Muscles

- Longitudinal- straplike muscle whose fibers run parallel,
- Quadrate- 4 sided muscle- ex. Pronator quadratus
- Fan shaped- small to wide muscle-ex. Pectoralis
- Fusiform/spindle shaped- rounded;ex.brachialis
- Unipenniform- parallel fibers that run along a tendon, ex. Tibialis posterior
- Bipenniform- One long central tendon with fibers lined on both sides;ex. Rectus femoris
- Multipenniform

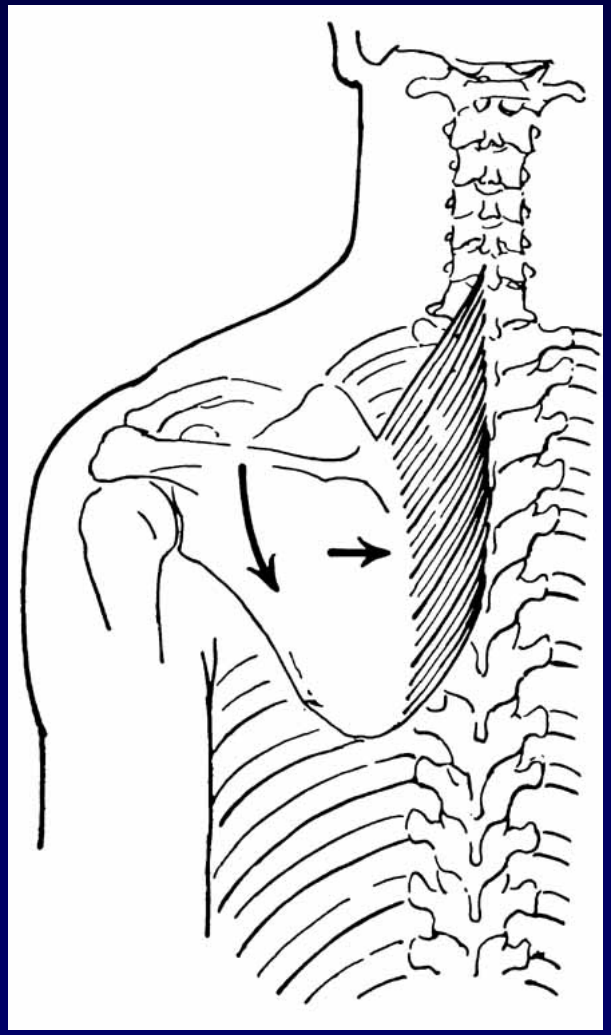
Structural Classification of Muscles on the Basis of Fiber Arrangement

- Longitudinal: long, strap like muscle with fibers in parallel to its long axis
- Sartorius



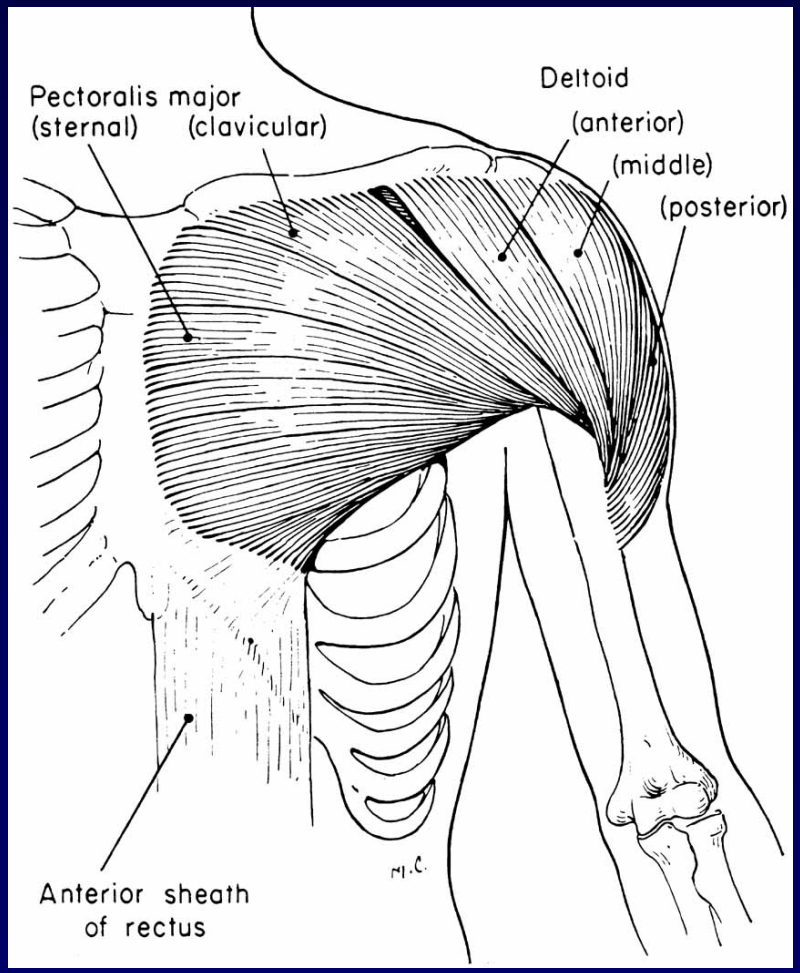
Structural Classification of Muscles on the Basis of Fiber Arrangement

- Quadrate or Quadrilateral: four sided and usually flat
- Consist of parallel fibers
- Rhomboids



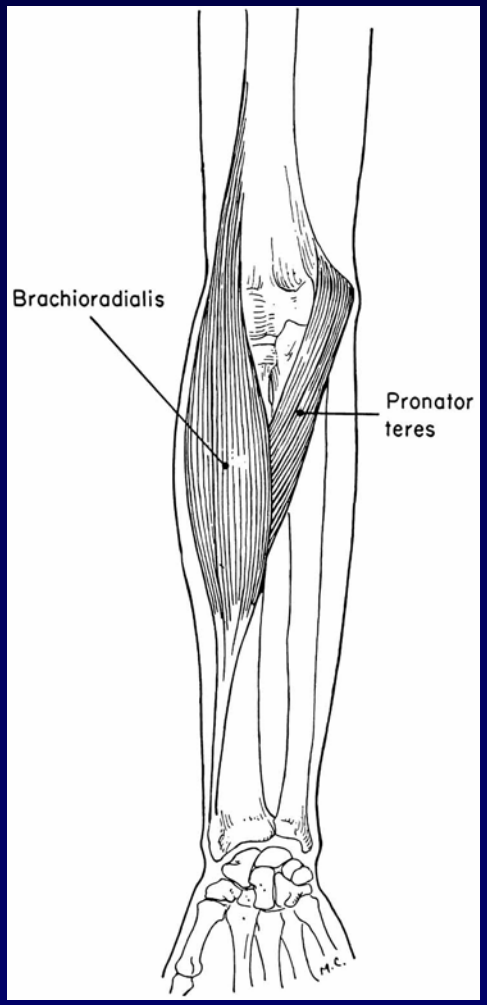
Structural Classification of Muscles on the Basis of Fiber Arrangement

- Triangular or Fan-Shaped: fibers radiate from a narrow attachment at one end to a broad attachment at the other
- Pectoralis major



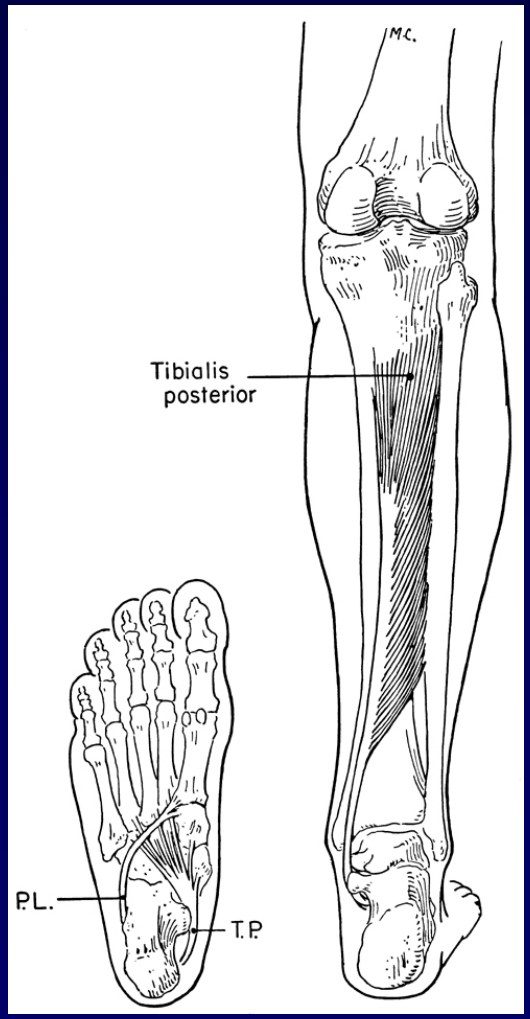
Structural Classification of Muscles on the Basis of Fiber Arrangement

- Fusiform or Spindle-Shaped: rounded muscle that tapers at either end
- Brachioradialis



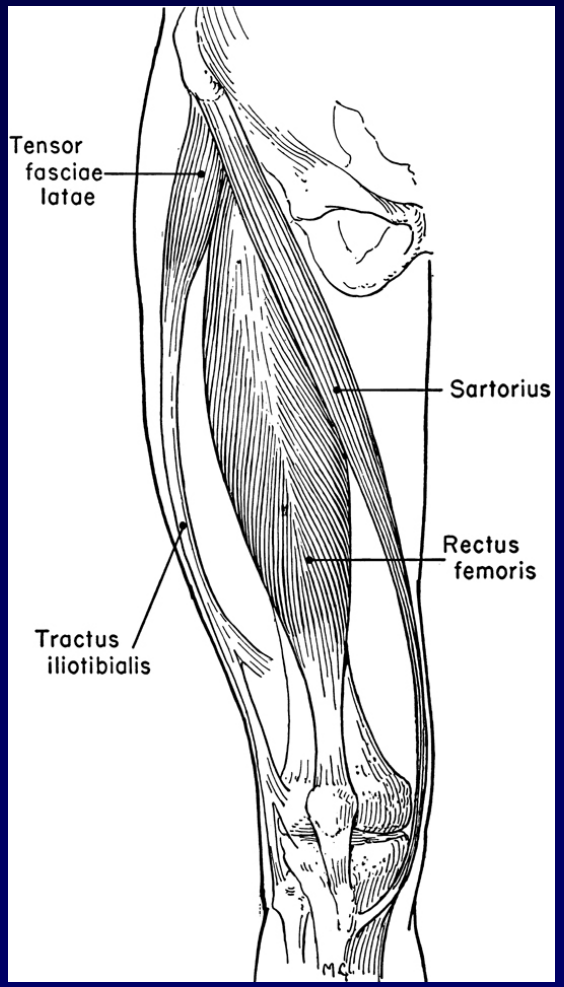
Structural Classification of Muscles on the Basis of Fiber Arrangement

- Unipenniform: a series of short, parallel, feather like fibers extends diagonally for side of a long tendon
- Tibialis posterior



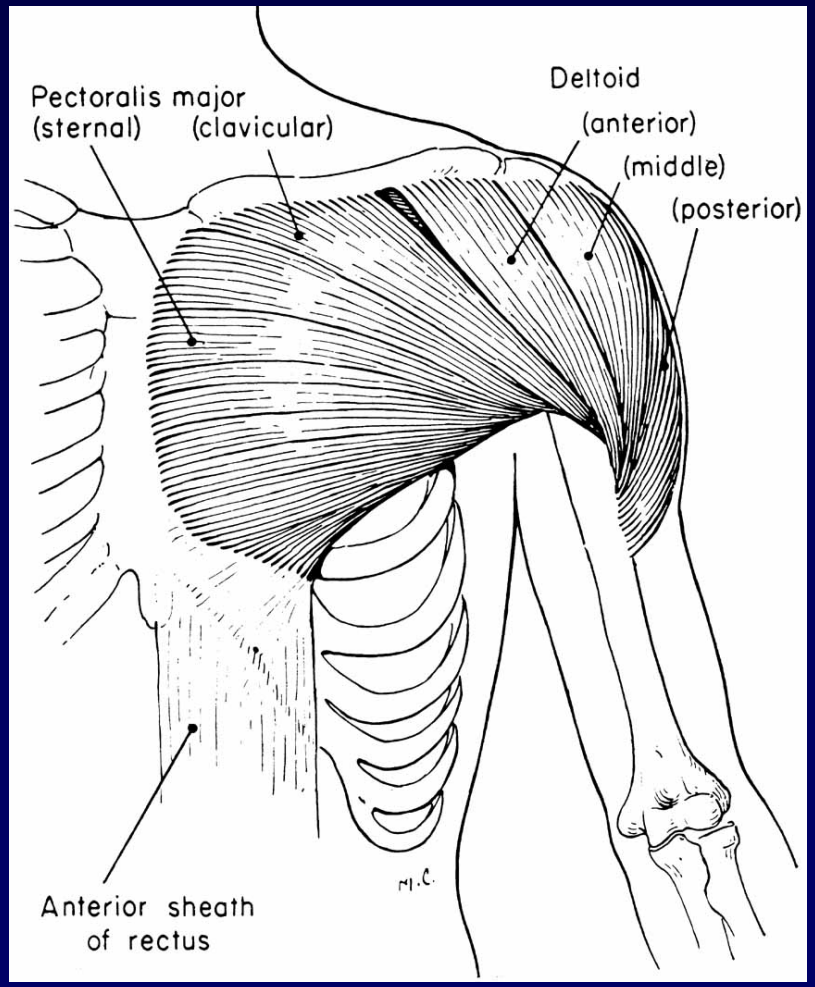
Structural Classification of Muscles on the Basis of Fiber Arrangement

- Bipenniform: A long central tendon with fibers extending diagonally in pairs form either side of the tendon
- Rectus femoris



Structural Classification of Muscles on the Basis of Fiber Arrangement

- Multipenniform: Several tendons are present, with fibers running diagonally between them
- Middle deltoid



Skeletal Muscle Function Terminology

- Effects of muscle structure on forces and range of motion
- Line of Pull to a muscle in relation to exercises chosen
- Angle of Attachment for a muscle
- Reverse Muscle Actions

Effect of Muscle Structure on Force

- Force a muscle can exert is proportional to its physiological cross section
- A broad, thick, longitudinal muscle exerts more force than a thin one
- A penniform muscle of the same thickness as a longitudinal muscle can exert greater force
- The oblique arrangement of fiber allows for a larger number of fibers than in comparable sizes of other classifications

Effect of Muscle Structure on ROM

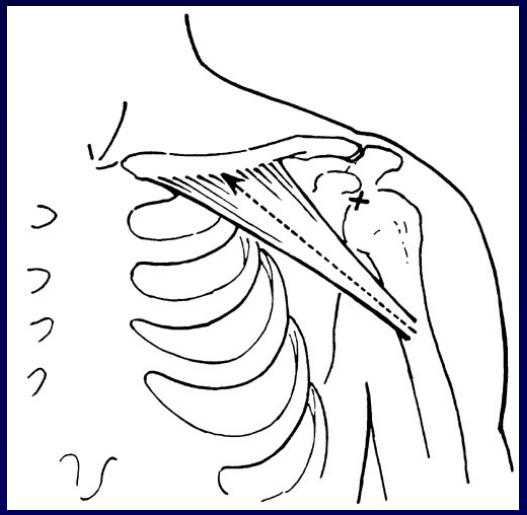
- Long muscles with fibers longitudinally arranges along the long axis, can exert force over a longer distance
- Pennate muscles with their oblique fiber arrange and short fibers, can exert superior force through only a short range

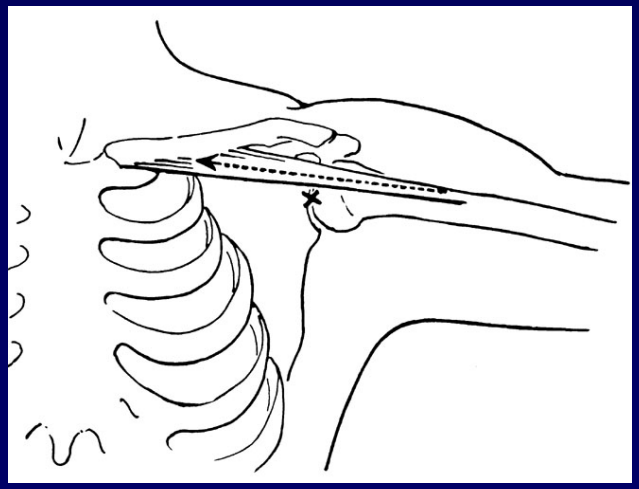
SKELETAL MUSCLE FUNCTION
Line of Pull

- Movement that the contracting muscle produces is determined by two factors
  - Type of joint that is spans
  - The relation of the muscle's line of pull to the joint

Line of Pull

- Pectoralis major (clavicular) is primarily a flexor, but it also adducts the humerus
- When humerus is abducted, line of pull moves above axis of rotation and contributes to abduction of humerus





Angle of Attachment

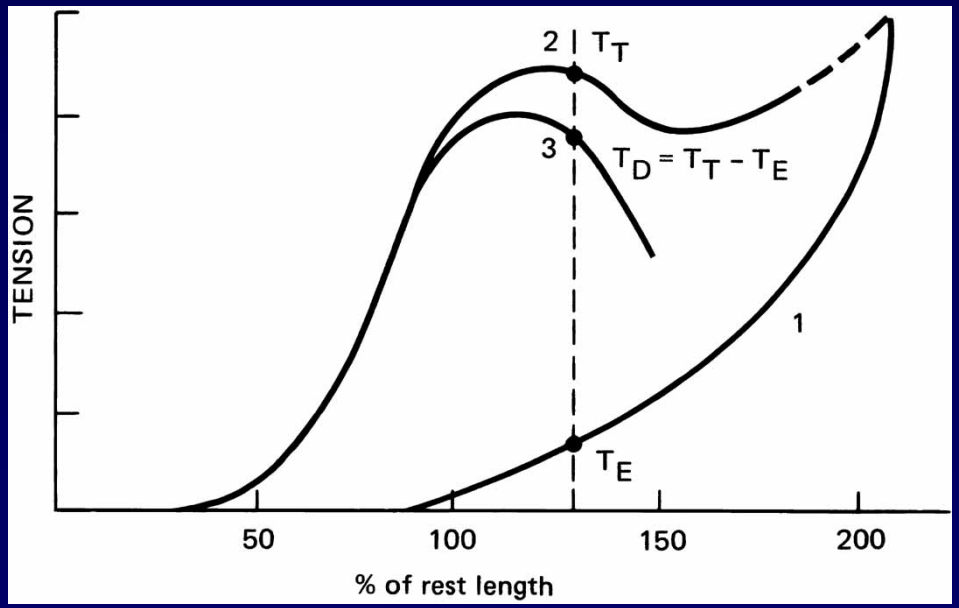
- If very shallow, most of the tension will produce a force pulling along the bone
- Will tend to stabilize joint
- Many muscles, angle changes throughout ROM
- When muscle generates tension at a 90^0 angle to the bone, it is the most efficient at producing joint motion

Skeletal Muscle Function Terminology

- Spurt and Shunt Muscles
- Length-Tension Relationship
- Force-Velocity Relationship
- Categories of Muscle Contractions (2 Types)
- Influences of Gravity
- and Coordination of Movements in the Muscular System

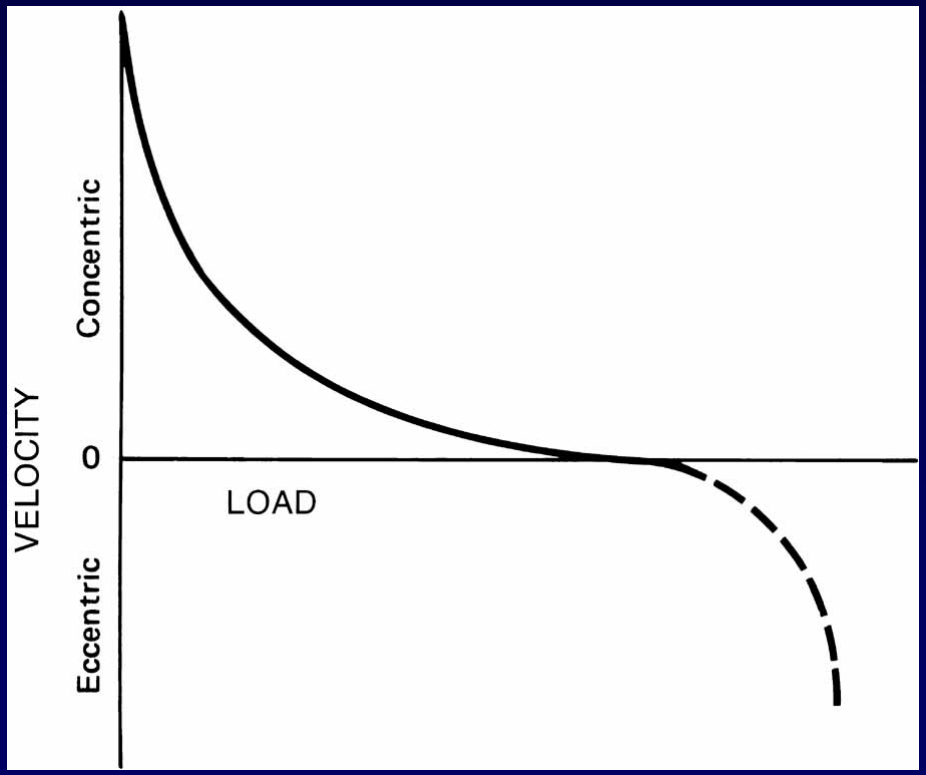
Length-Tension Relationship

- Optimum length is the length at which a muscle can exert maximum tension
- Passive insufficiency
- Active insufficiency



Force-Velocity Relationship

- As speed of contraction increases, the force it is able to exert decreases
- At maximum velocity of contraction the load is zero



3 Types of Contraction

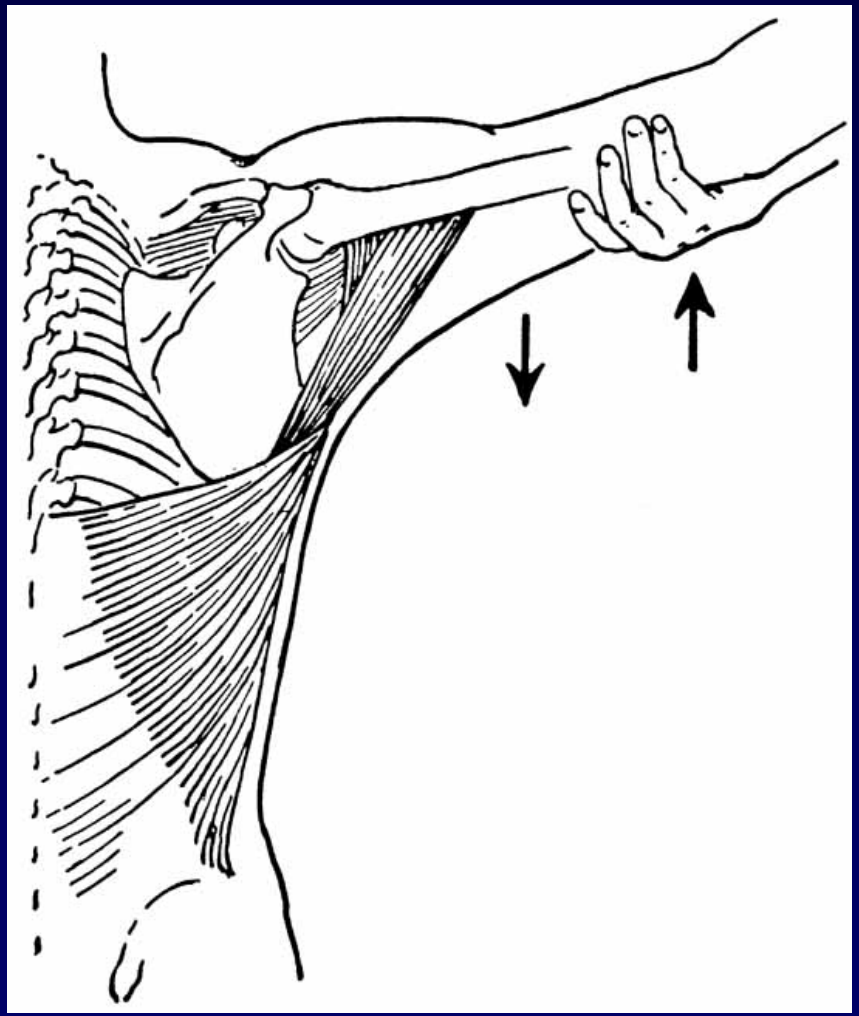
- Contract literally means to “draw together”
- Muscle contraction occurs whenever muscle fibers generate tension which may occur while the muscle is actually shortening, remaining the same length, or lengthening

Isometric or Static Contraction

- Isometric means “equal length”
- Tension of the muscle without any appreciable change in muscle length or joint angle
- Isometric sometimes called Static Contraction

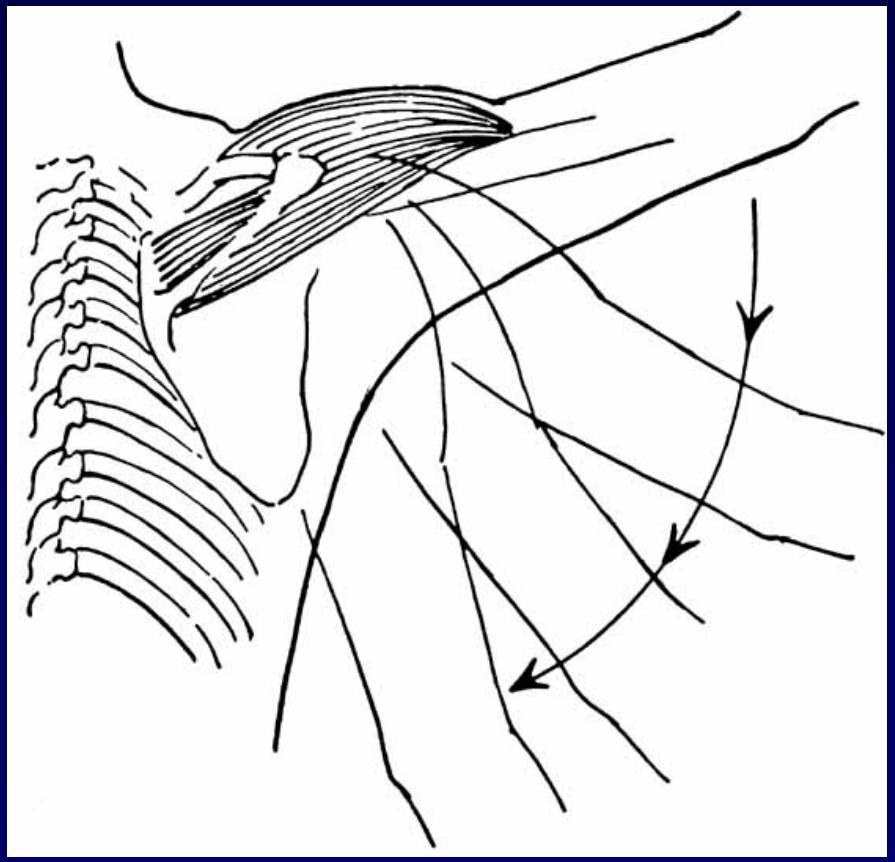
Concentric or Shortening Contraction

- When tension by the muscle is sufficient to overcome a resistance and move the body segment
- The muscle actually shortens



Eccentric or Lengthening Contraction

- When a muscle slowly lengthening as it gives in to an external force that is greater than the contractile force it is exerting
- Muscle is acting as a “brake”



Influence of Gravity

- Movements may be in the direction of gravitational forces (downward), opposing gravity (upward), or perpendicular to gravity (horizontal)
- Horizontal motion is not affected by gravity
- Lifting against gravity is a concentric contraction of the agonist
- Slower lowering with gravity is eccentric contraction of the same muscle

COORDINATION OF THE MUSCULAR SYSTEM

- Movements of the body considerable muscular activity in addition to those muscles directly responsible for the movement itself
- Muscles causing the movement must have a stable base
- Bones not engages in the movement must be stabilized by other muscles

Roles of Muscles

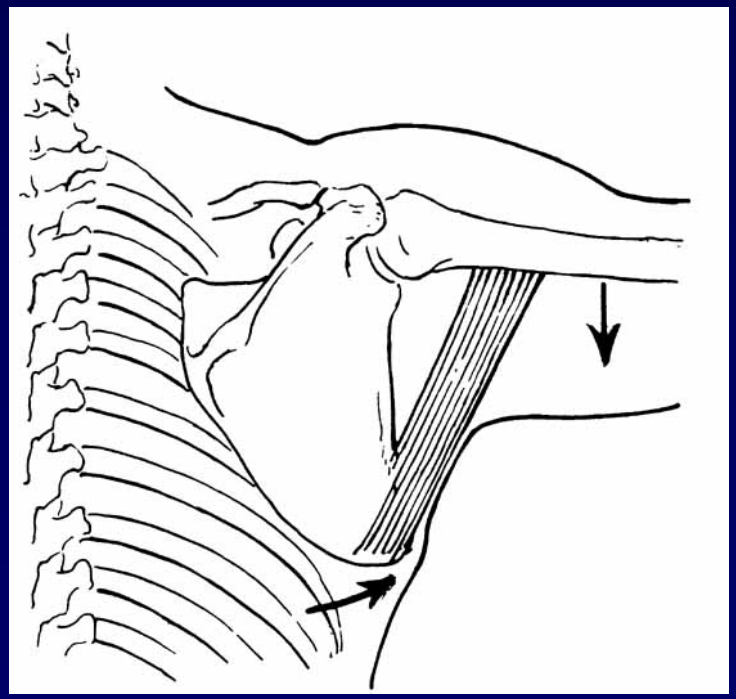
- Agonists (Movers): directly responsible for producing a movement
  - Prime movers: large impact on movement
  - Assistant movers: only help when needed

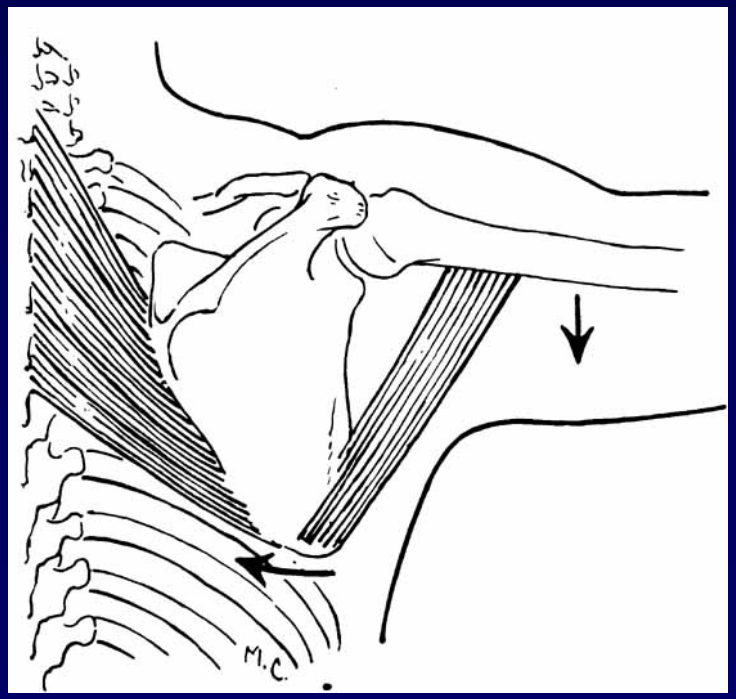
Roles of Muscles

- Antagonists: have an effect opposite to that of movers, or agonists
  - Check ballistic movements
- First antagonists must relax to permit movement
- Second it acts as a brake at completion of movement

Roles of Muscles

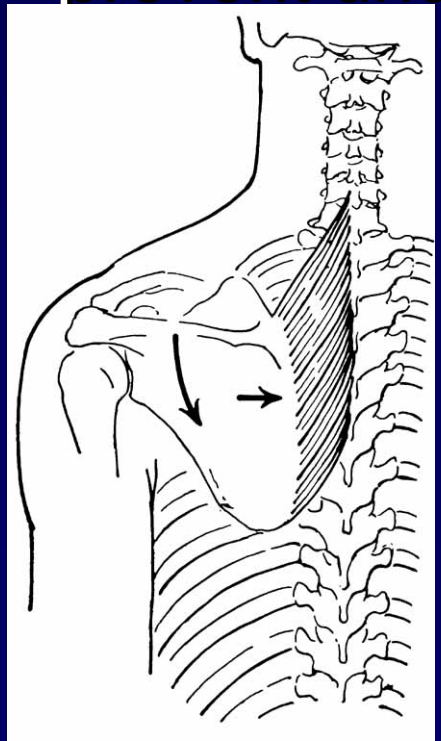
- Stabilizers: cooperative muscle function
  - Stabilizing, Fixator, & Support Muscles





Roles of Muscles

- Synergists (Concontractors): cooperative muscle function
  - Neutralizers – prevent undesired action



Cocontraction

- The simultaneous contraction of movers and antagonists
- Neutralizers and Stabilizers may need to cocontract to counteract as additional function of a mover

Types of Bodily Movements

- Passive: no effort on the part of the person involved, assisted help.
- Active: movement is produced by the subject's own muscular activity

Reference Body Positions

Understand 4 reference points or beginning positions.

1. Musculoskeletal system
2. Planes of motion
3. Joint classification
4. Joint movement terminology

Reference Body Positions

- Center of Gravity- S2-changes with movement
- Line of Gravity-is an imaginary vertical line going through center of gravity
- Anatomical position-palms face forward
- Fundamental position-palms facing sides, ex. Army

Anatomical Directional Terminology

- 1. proximal/distal
- 2. superficial/deep
- 3. midline
- 4. medial/lateral
- 5. anterior/posterior
- 6. supine/prone
- 7. ventral/dorsal
- 8. ipsilateral/contralateral

Reference Body Positions

- Center of Gravity: imaginary point representing the weight center of an object (Second Sacral Segment, S2)
- Line of Gravity: imaginary vertical line that passes through the center of gravity

Planes of motion

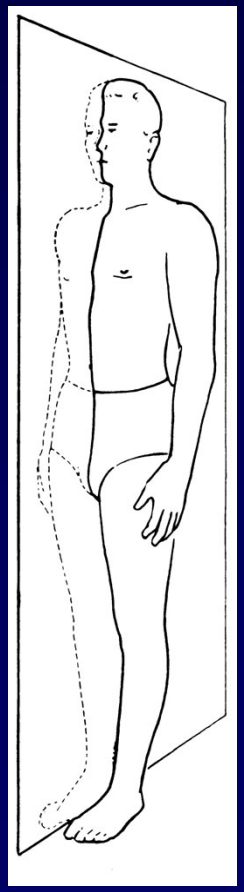
- 3 planes of motion in which various joints can be classified
- define movement in one of 3 planes
- movements not specifically in one plane, usually a combination
- maybe diagonal or horizontal

3 Planes

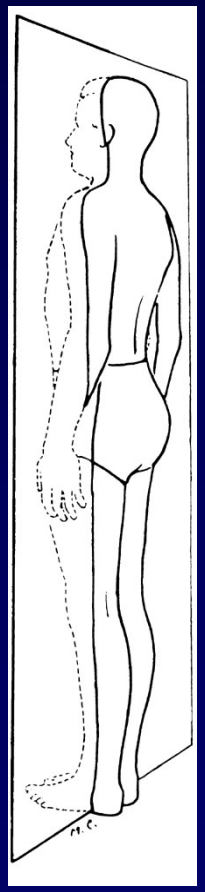
- Sagittal plane- divides body in right and left sides
- Frontal plane- divides body from anterior (front) to posterior (back)
- Transverse or horizontal plane- divides body from superior (upper) to inferior (lower)

ORIENTATION OF THE BODY

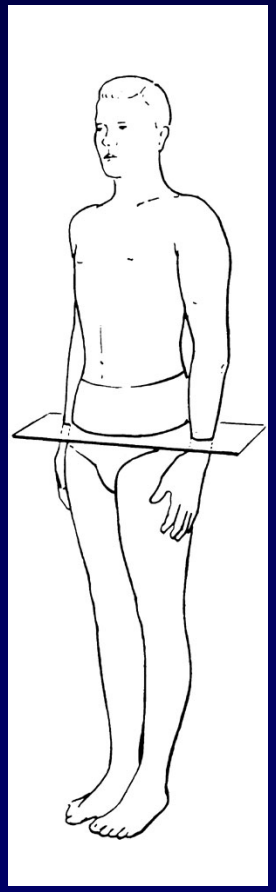
Planes of the Body



Sagittal



Frontal



Transverse

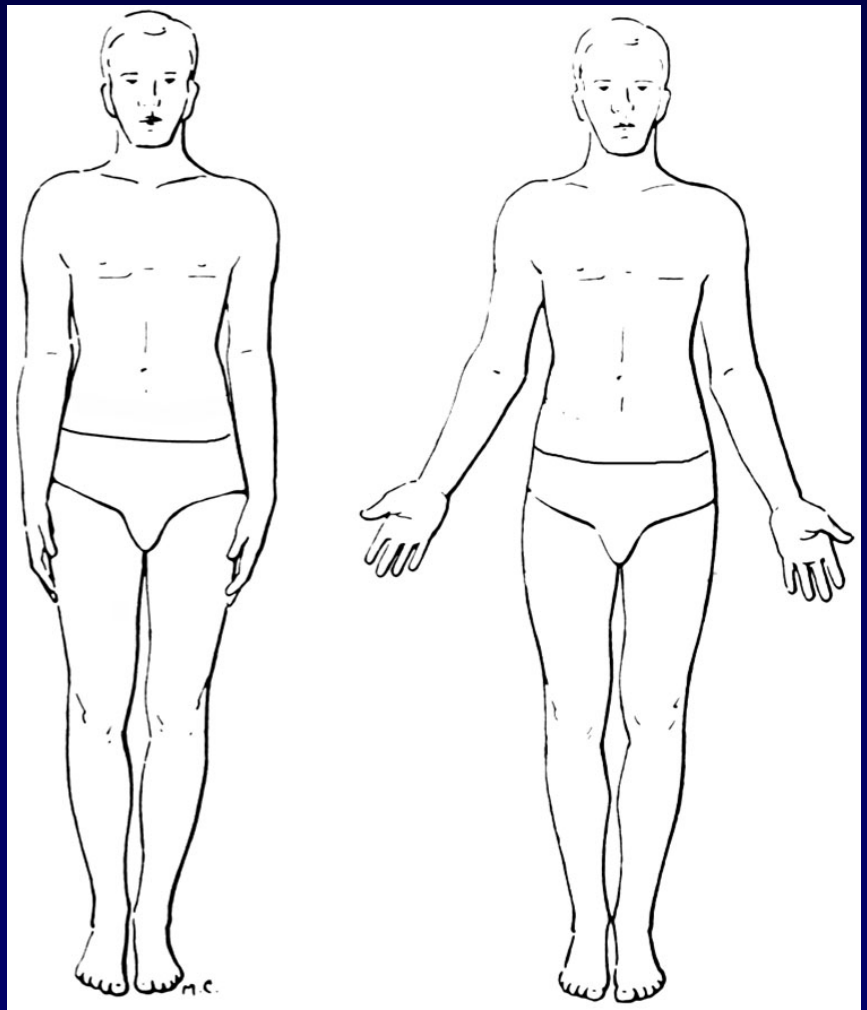
ORIENTATION OF THE BODY
Axes of Motion

- Frontal : axis passes horizontally form side to side
- Sagittal : axis passes horizontally form front to back
- Long/Ver.: axis is perpendicular to the ground
- Rotary movement occurs in a plane and around an axis
- Axis of movement is always at right angles to the plane in which it occurs

ORIENTATION OF THE BODY

Standard Starting Positions

Fundamental Standing Position



Anatomical Standing Position

Movements in Joints

- Abduction
- Adduction
- Flexion
- Extension
- circumduction
- Internal/external rotation
- Supination/pronation
- Radial/Ulnar deviation
- opposition of thumb

Movements in Joints

- elevation
- depression
- retraction
- protraction
- upward rotation
- downward rotation
- Lateral flexion
- rotation

Movements in Joints

- eversion
- Inversion
- Dorsiflexion
- plantarflexion