Prepared by:

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COURSE OUTLINE

- Introduction to Kinesiology
- Biomechanical principles of joint movement
- Biomechanical principles of human movement
- Principles of stability
- Principles of stability and mobility
- Mechanical principles application in human body

COURSE OUTLINE

- Muscle structure and function
- Joint structure and function
- Biomechanics and pathomechanics of bone, cartilage, ligament, tendon, muscles and joint.
- Posture
- Gait
- Movement analysis

Recommended Books

1. **Joint Structure and Function** by Cynthia Norkin & Levangie, latest edition.
2. **Mechanics and Pathomechanics** of Human Movement by Carol A. Oatis, latest edition.

I.INTRODUCTION TO KINESIOLOGY

1.1. **Definition**

- Kinesiology is ***the science of, or study of, human motion. It brings together the fields of anatomy,physiology, biomechanics, physics and geometry relating them to human movement.***

2.2. **Purposes of kinesiology**

- Move safely
- Move effectively
- Move efficiently

KINESIOLOGY

1. Kinesiology vs. Biomechanics

Kinesiology: the study of human movement from the point of view of physical sciences

- main areas: anatomical kinesiology & mechanical kinesiology

Biomechanics: ***application of the mechanical principles in the study of living organism***

- main interests: mechanical analysis of the biological systems such as the human

KINESIOLOGY

2. Biomechanics

Statics vs. Dynamics

- statics: "***branch of mechanics dealing with systems in the constant state of motion"***
- dynamics***: "branch of mechanics dealing with systems subject to acceleration"***

Kinematics vs. Kinetics

- kinematics: study of description of motion (description)
- kinetics: study of action of forces (explanation of motion)

TERMINOLOGY

- Mechanics
  - Statics: Study of factors relating to nonmoving systems or those characterized by steady motion.
  - Dynamics: Study of mechanical factors that relate to systems in motion
    - Kinematics
    - Kinetics

TERMINOLOGY

- Velocity
  - Speed and direction of the body
- Acceleration
  - **Change** in velocity involving the speed or direction
- Angular velocity
  - Angle that is rotated in a given unit of time
- Angular acceleration
  - Change of angular velocity for a unit of time

TERMINOLOGY

- Mass
  - Amount of matter possessed by an object
- Force
  - Any action that changes or tends to change the motion of an object(usually muscular contraction in the human body)
- Pressure
  - Ratio of force to the area over which force is applied

TERMINOLOGY

- Gravity
  - Natural force that pulls all objects toward the center of the earth
  - Center of gravity
- Friction
  - Force that occurs when surfaces come in contact and results from the sliding of one surface on the other

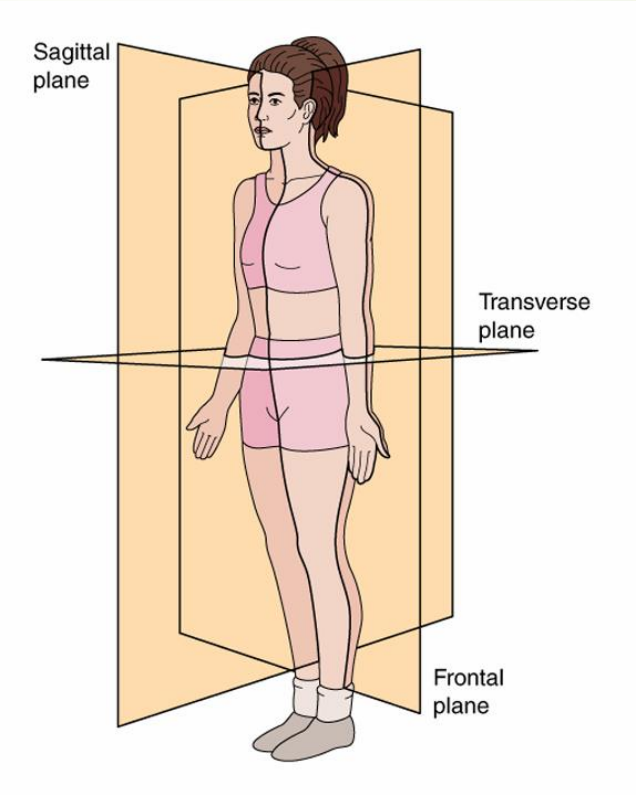
TERMINOLOGY

- Work
  - Force that is applied to a body through a distance and in direction of the force
- Power
  - Amount of work accomplished in one unit of time

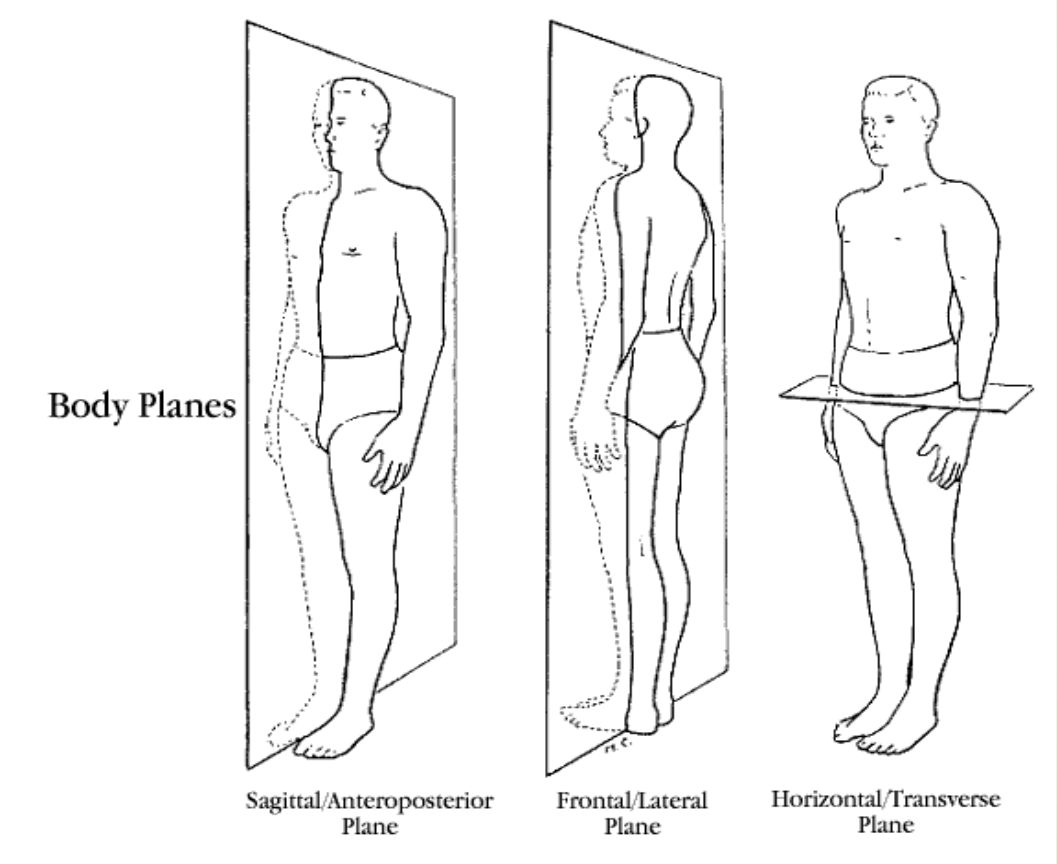
TERMINOLOGY

- **Lever** = Rigid bar that can rotate about a fixed point when a force is applied (bones)
- **Axis** = fixed point about which the lever rotates
- **Weight** = resistance that must be overcome
- **Weight arm** = (resistance) distance between the fulcrum and the weight
- **Force arm** = distance between the fulcrum and the force

BODY PLANES/CARDINAL PLANES



PLANES


Body Planes
Sagittal/Anteroposterior Plane
Frontal/Lateral Plane
Horizontal/Transverse Plane

PLANES

- FRONTAL PLANE: divides the body into anterior and posterior parts.
- SAGITTAL PLANE: divides the body into left and right parts.
- HORIZONTAL/TRANSVERSE PLANE: divides the body into upper and lower halves.(superior and inferior, proximal and distal).

AXES

- **Frontal axis/coronal**: lies horizontal and at right angles to the sagittal axis. Movement about the frontal axis is in sagittal plane.
- **Sagittal axis**: lies in an antero-posterior direction and movement about this axis is in a frontal plane.
- **Vertical axis**: lies parallel to the line of gravity and movement about this axis is in a horizontal plane.

MOVEMENT IN THE PLANES

- **FRONTAL PLANE:**
  - Abduction
  - Adduction
  - Side flexion
- **SAGITTAL PLANE:**
  - Flexion
  - Extension
- **HORIZONTAL:**
  - Rotation
  - Supination
  - Pronation

ANATOMICAL POSITION

A. Anatomical position

1. Standing erect
2. Eyes, head, and toes directed anteriorly
3. Upper extremities at side with palms facing anteriorly
4. Feet together with toes pointing anteriorly

POSITION AND MOTION

- **FUNDAMENTAL POSITIONS:**
  - Lying (Ly.):
  - Sitting (Sitt.)
  - Kneeling (Kn.)
  - Standing (St.)
  - Hanging (Hg.)

Derived positions

- **Lying:**
  - Side lying(S.LY.)
  - Supine lying(Sup.Ly.)
  - Prone lying (Pr.Ly.)
  - Across prone lying (Acr.Pr.Ly.)
  - Quarter Turn (1/4 Tn)
  - Half Lying (1/2 Ly.)
  - Crook Lying (Cr.Ly.)
  - Bridging

POSITION

- **Sitting(Sitt.)**
- Long sitting(Long Sitt.)
- Half sitting((1/2 Sitt.)
- Forward lean sitt.(Fwd.Ln.Sitt.)
- High sitting (High Sitt.)
- Crook sitting (Cr.Sitt.)
- Side Sitting(Side Sitt.)

POSITION

- **Kneeling(Kn.)**
- Kneel Sitting(Kn.Sitt.)
- Half kneeling((1/2 Kn.)
- Prone Kneeling(Pr.Kn.)

POSITION

- **Hanging(Hg)**
  - Arch Hanging(Arch Hang.)
  - Half hanging ((1/2 Hang.)

Kinematics:

Types of motion:

- **Linear(transilatory) Motion**
  - Movement in a straight line and from one point to another.
    - e.g. forward movement of the forearm/hand when reaching for an objet

Kinematics:

- **Rotary or angular motion**
  - Movement of a body around a center of rotation called an axis.
  - E.g.1) the elbow joint doing elbow flexion
  - Shoulder elevation

Direction of motion

- Movement may occur in the following planes: transverse, frontal and sagittal.

Kinematic Chains

A combination of several joints uniting successive segments

- **Open kinematic** chain – the distal segment terminates free in space
- **Closed kinematic** chain – the distal segment is fixed either by forming a closed ring (ribs attached to vertebrae and sternum) or by external force (the ground in weight bearing)

Kinematic Chains

- **Clinical Use**: If one joint is limited in the amount of motion available, then the other joints in the chain may compensate, but, this puts increased stress on the joint structures (especially the adjoining joints) which may result in hypermobility, decreased stability and pain

Kinematic Chains

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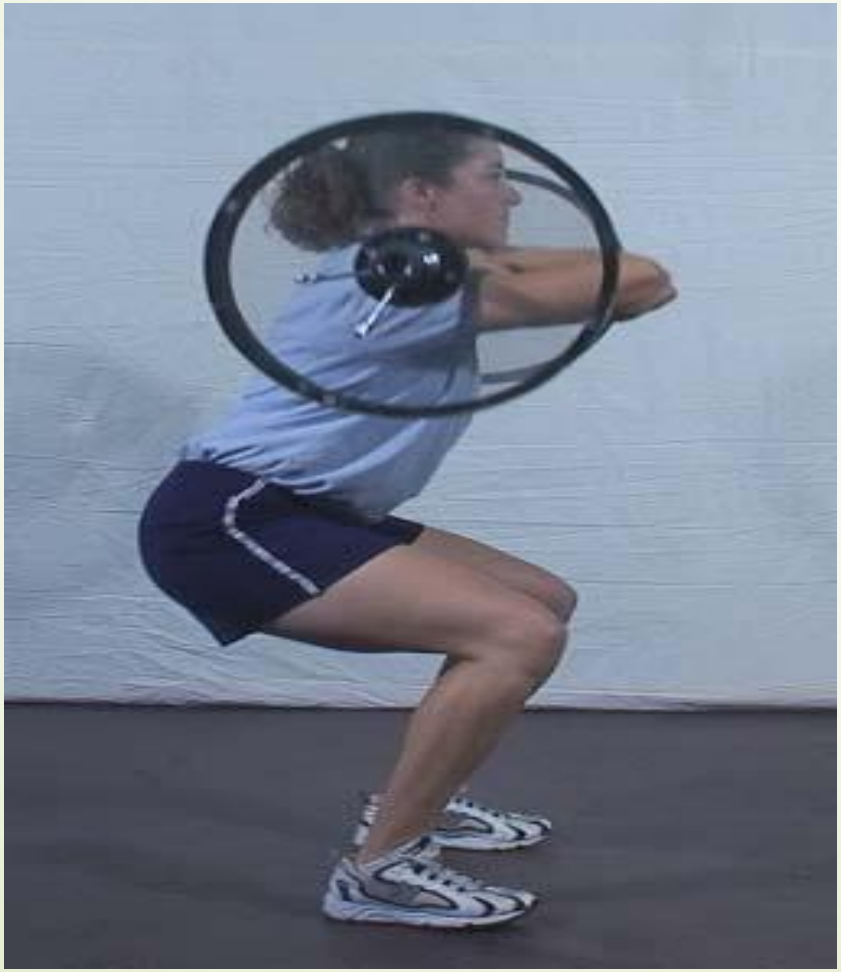
Closed kinematic chain



Open kinematic chain

Arthrokinematics:surface motion

- **Rolling** – each subsequent point meets a new point on other surface (wheels of a car moving)
- **Sliding** – anterior/posterior glide or lateral glide
- **Spinning** – rotation with no translatory motion

Arthrokinematics

- Combined rolling and sliding
- **Compression** – joint surfaces coming closer together
- **Traction** (distraction) – joint surfaces pulled apart

Arthrokinematics

- **Joint Play** = the minimal amount of passive motion allowed by gliding of joint surfaces.
- Not an angular motion
- May involve compression/distraction, lateral gliding, anterior/posterior gliding
- Joint play is important to ROM. Without joint play there is joint dysfunction, pain and decreased ROM

Joint Position

- **Loose packed**(resting) position = the position at which the joint is under the least amount of stress (capsule, ligaments, bone contact).
- **Close packed position**= the position in which the majority of joint structures are under maximum tension.

Arthrokinematics

- The greatest amount of joint play is in the **open-packed** position **or**, the position where there is the least stability from bony structures and ligaments
- **Closed pack** position is where the joint is the most stable
  - Maximum amount of contact between surfaces
  - A position that has the maximum stability from bony structures and ligaments; where the surfaces best match each other and little muscle action is needed to maintain the position

CONVEX-CONCAVE RULE

- If the bone with the convex surface moves on the bone with the concave surface, then the articular (arthrokinematic) surface will move in the **opposite** direction of the distal segment (osteokinematic)
- E.g. The shoulder joint: the head of the humerus (convex) moves downward during shoulder flexion and abduction as the arm (distal segment) moves up

CONVEX-CONCAVE RULE

- If the bone with the concave surface moves on the bone with the convex surface,the articular (arthrokinematic) surface will move in the **same** direction as the distal segment
- E.g. The elbow joint: the trochlear notch of the ulna (concave) moves upward during elbow flexion as the forearm moves upward

MUSCLE STRUCTURE AND FUNCTION

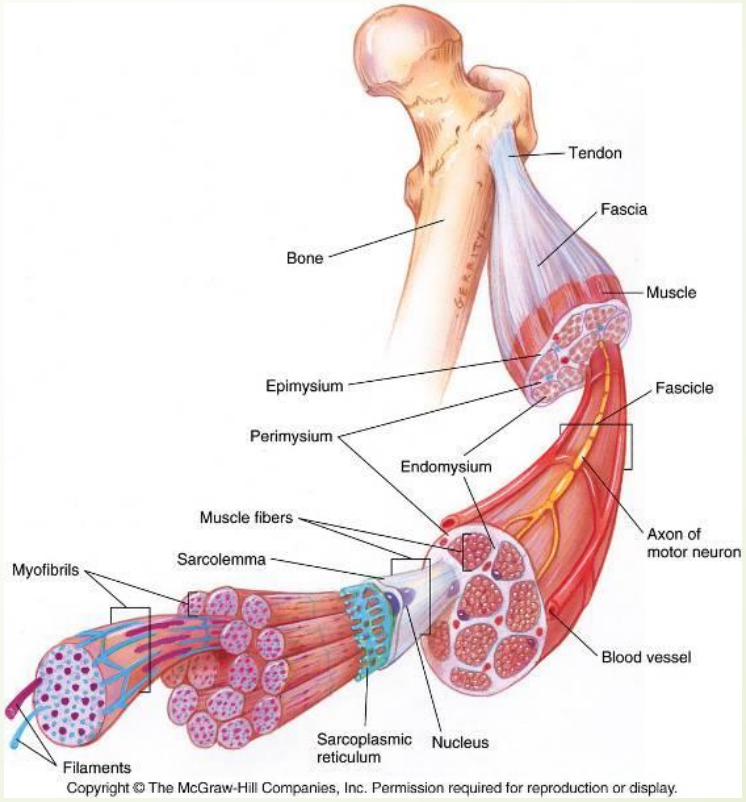
- Human body contains over 400 skeletal muscles
  - 40-50% of total body weight
- Functions of skeletal muscle
  - Force production for locomotion and breathing
  - Force production for postural support
  - Heat production during cold stress

MUSCLE STRUCTURE AND FUNCTION

Connective Tissue Covering Skeletal Muscle:

- Epimysium
  - Surrounds entire muscle
- Perimysium
  - Surrounds bundles of muscle fibers
    - Fascicles
- Endomysium
  - Surrounds individual muscle fibers

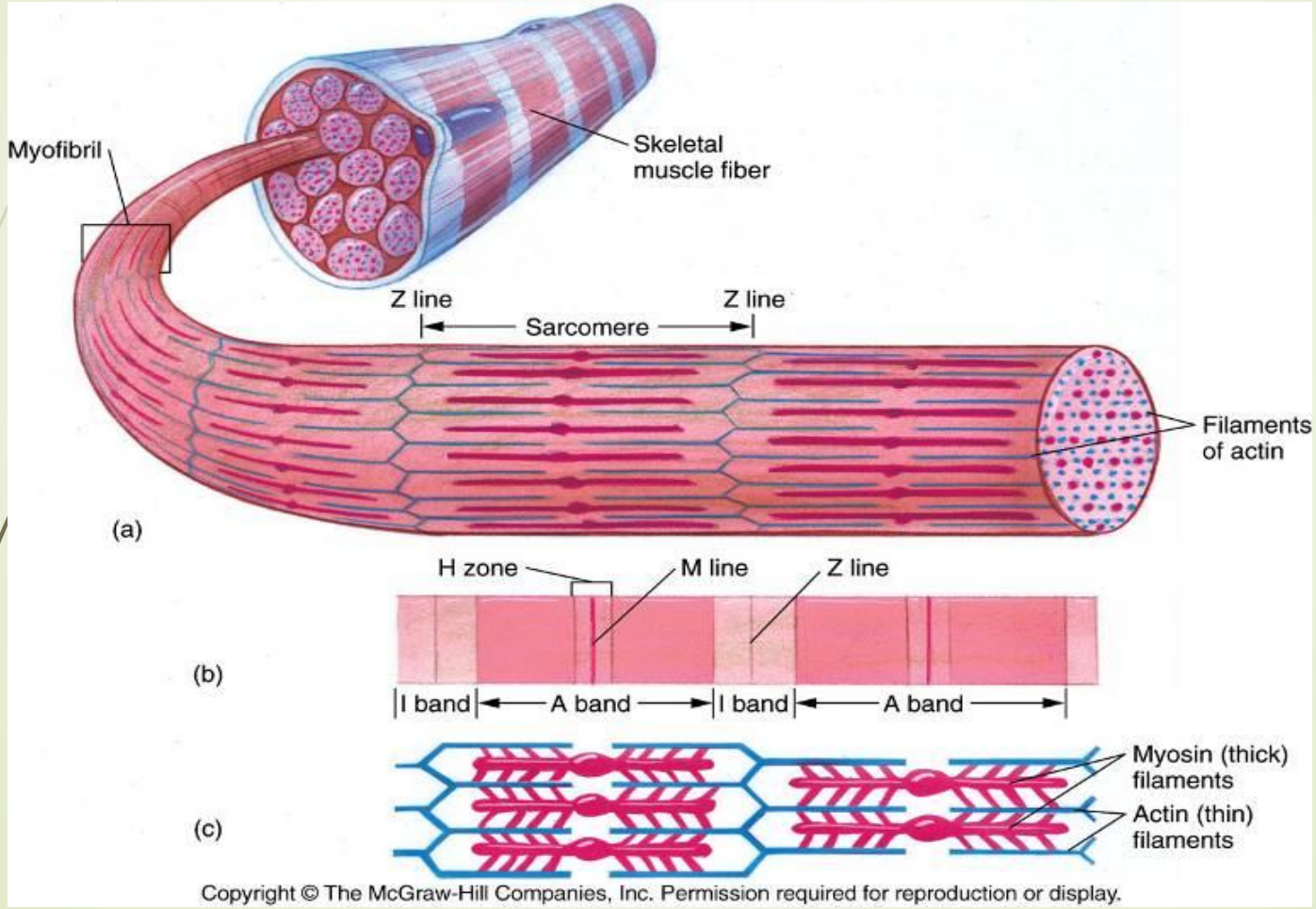
MUSCLE STRUCTURE



Microstructure of Skeletal Muscle

- Sarcolemma
  - Muscle cell membrane
- Myofibrils
  - Threadlike strands within muscle fibers
    - Actin (thin filament)
    - Myosin (thick filament)
- Sarcomere
  - Includes Z-line, M-line, H-zone, A-band, I-band
- Sarcoplasmic reticulum
  - Storage sites for calcium
- Transverse tubules

Microstructure of Skeletal Muscle



Muscular Contraction

- The sliding filament model
  - Muscle shortening occurs due to the movement of the actin filament over the myosin filament
  - Formation of cross-bridges between actin and myosin filaments
    - Power stroke
  - Reduction in the distance between Z-lines of the sarcomere

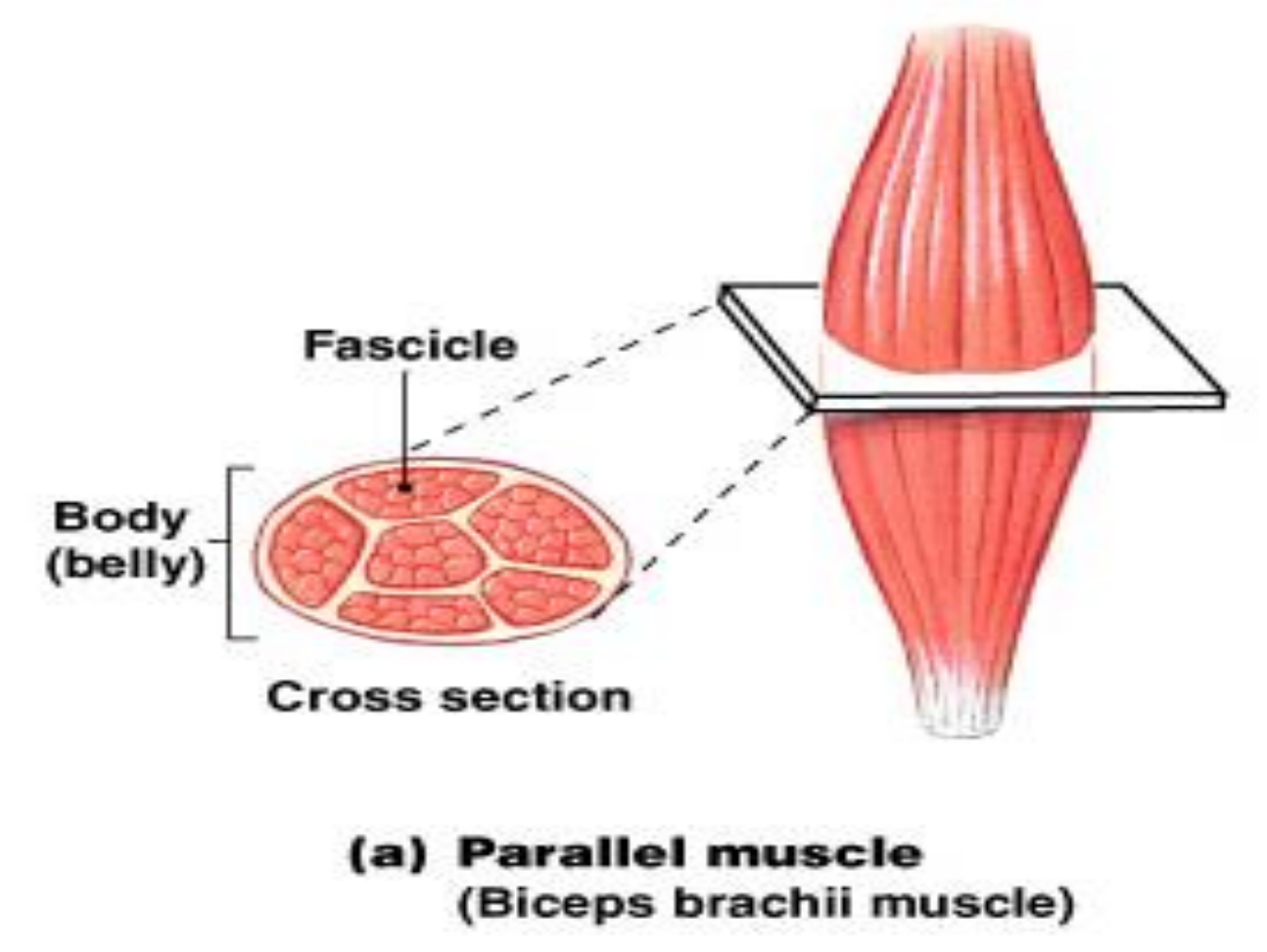
Classification of Skeletal Muscles

- By the way fascicles are organized
- By relationships of fascicles to tendons

Organization of Skeletal Muscle Fibers

- 4 patterns of fascicle organization:
  - parallel
  - convergent
  - pennate
  - circular

Parallel Muscles



Parallel Muscles

- Fibers parallel to the long axis of muscle

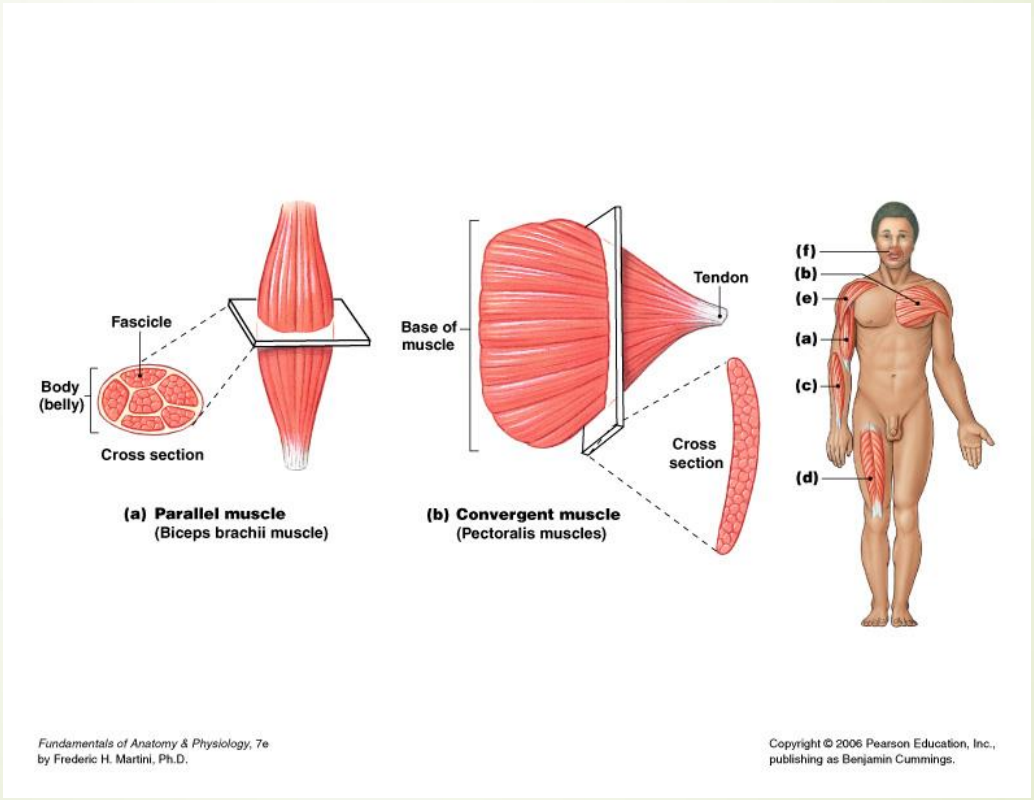
e.g., biceps brachii

- The center or body of the muscle thickens when parallel muscle contracts
- Parallel muscles contract about 30%

Convergent Muscles

- A broad area converges on attachment site (tendon, aponeurosis, or raphe)
- Muscle fibers pull in different directions, depending on stimulation
- *e.g.*, pectoralis muscles

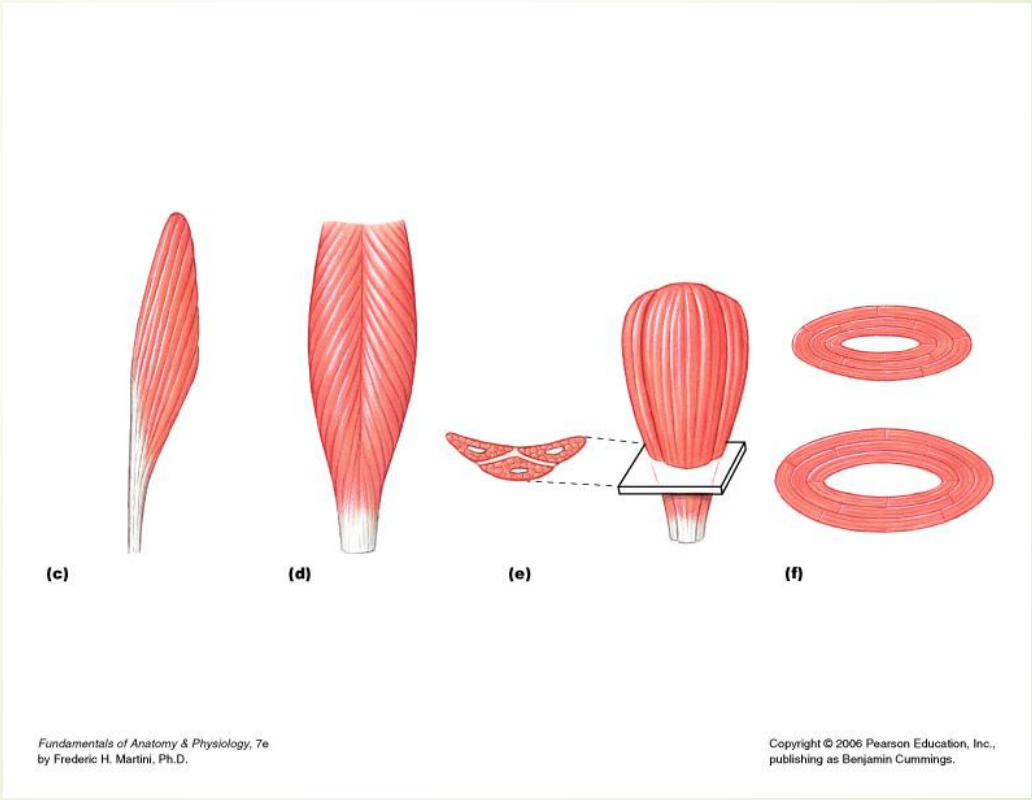
Convergent Muscles



Pennate Muscles

- Form an angle with the tendon
- Do not move as far as parallel muscles
- Contain more myofibrils than parallel muscles
- Develop more tension than parallel muscles

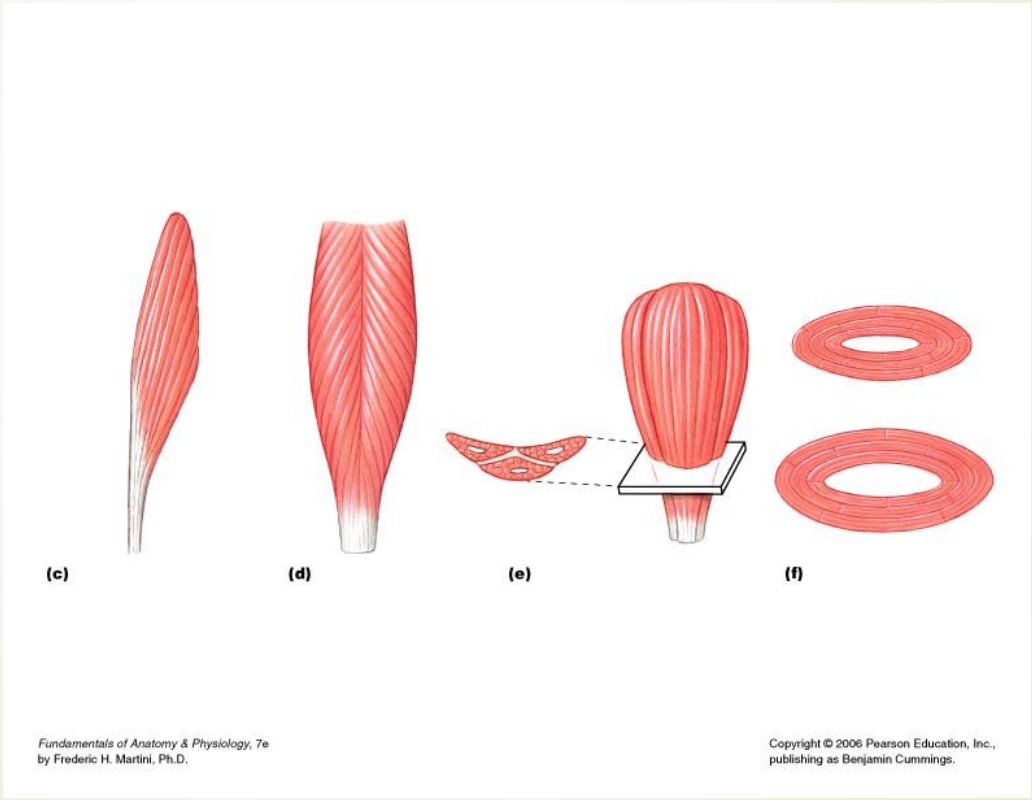
Pennate Muscles



Circular Muscles

- Also called sphincters
- Open and close to guard entrances of body
- *e.g.*, obicularis oris

Circular Muscles



Characteristics of Individual Fiber Types

- Type IIx fibers
  - Fast-twitch fibers
  - Fast-glycolytic fibers
- Type IIa fibers
  - Intermediate fibers
  - Fast-oxidative glycolytic fibers
- Type I fibers
  - Slow-twitch fibers
  - Slow-oxidative fibers

Fiber Types and Performance

- Nonathletes
  - Have about 50% slow and 50% fast fibers
- Power athletes
  - Sprinters
  - Higher percentage of fast fibers
- Endurance athletes
  - Distance runners
  - Higher percentage of slow fibers

Exercise-Induced Changes in Skeletal Muscles

- Strength training
  - Increase in muscle fiber size (hypertrophy)
  - Increase in muscle fiber number (hyperplasia)
- Endurance training
  - Increase in oxidative capacity
- Alteration in fiber type with training
  - Fast-to-slow shift
    - Type IIx → IIa
    - Type IIa → I with further training
  - Seen with endurance and resistance training

Age-Related Changes in Skeletal Muscle

- Aging is associated with a loss of muscle mass
  - 10% muscle mass lost between age 25–50 y
  - Additional 40% lost between age 50–80 y
  - Also a loss of fast fibers and gain in slow fibers
  - Also due to reduced physical activity
- Regular exercise training can improve strength and endurance
  - Cannot completely eliminate the age-related loss in muscle mass

FUNCTION OF MUSCLES

- **Agonist** (prime mover) – a muscle that causes a desired motion.
- **Antagonist** – muscles that have the potential to oppose the action of the agonist.

Ex., if shoulder flexion is the desired action (without gravity as a factor), the shoulder flexors are the agonists and the shoulder extensors are the antagonists

FUNCTION OF MUSCLES

- **Synergist** – muscles that assist the agonist in causing a desired action; may act as joint stabilizers (fixator)

- • **Co-contraction** – when the agonist and antagonists contract together and a joint must be stabilized.
- • **Stabilizer** – muscles that must co-contract to protect a joint and maintain alignment.

Types of Muscle Contraction

- • **Isometric** – no visible movement occurs and resistance matches the muscular tension.

Ex., bodybuilders use isometric action when they strike a pose to show their muscle development.

- Isotonic (dynamic):

• **Concentric** – the muscle shortens and overcomes a resistive force.

Ex., the biceps brachii act concentrically in the up-phase of a biceps curl with a dumbbell.

• **Eccentric** – the muscle lengthens and produces force; "putting on the brakes."

Ex., the biceps brachii act eccentrically in the return phase of a biceps curl performed with a dumbbell.

Types of Muscle Contraction

(a)

(b)

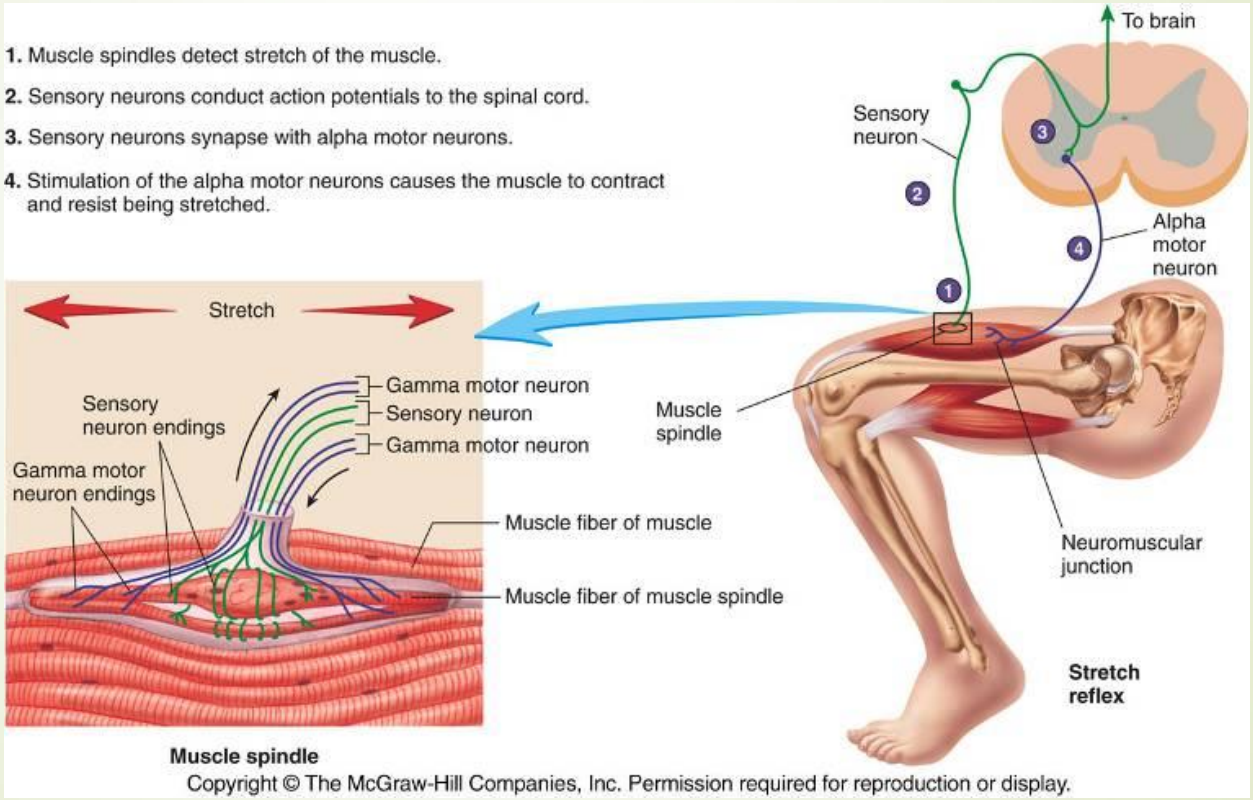
Receptors in Muscle

- Provide sensory feedback to nervous system
  - Tension development by muscle
  - Account of muscle length
- Muscle spindle
- Golgi tendon organ

Muscle Spindle

- Responds to changes in muscle length
- Consists of:
  - Intrafusal fibers
    - Run parallel to normal muscle fibers (extrafusal fibers)
  - Gamma motor neuron
    - Stimulate intrafusal fibers to contract with extrafusal fibers (by alpha motor neuron)
- Stretch reflex
  - Stretch on muscle causes reflex contraction
    - Knee-jerk reflex

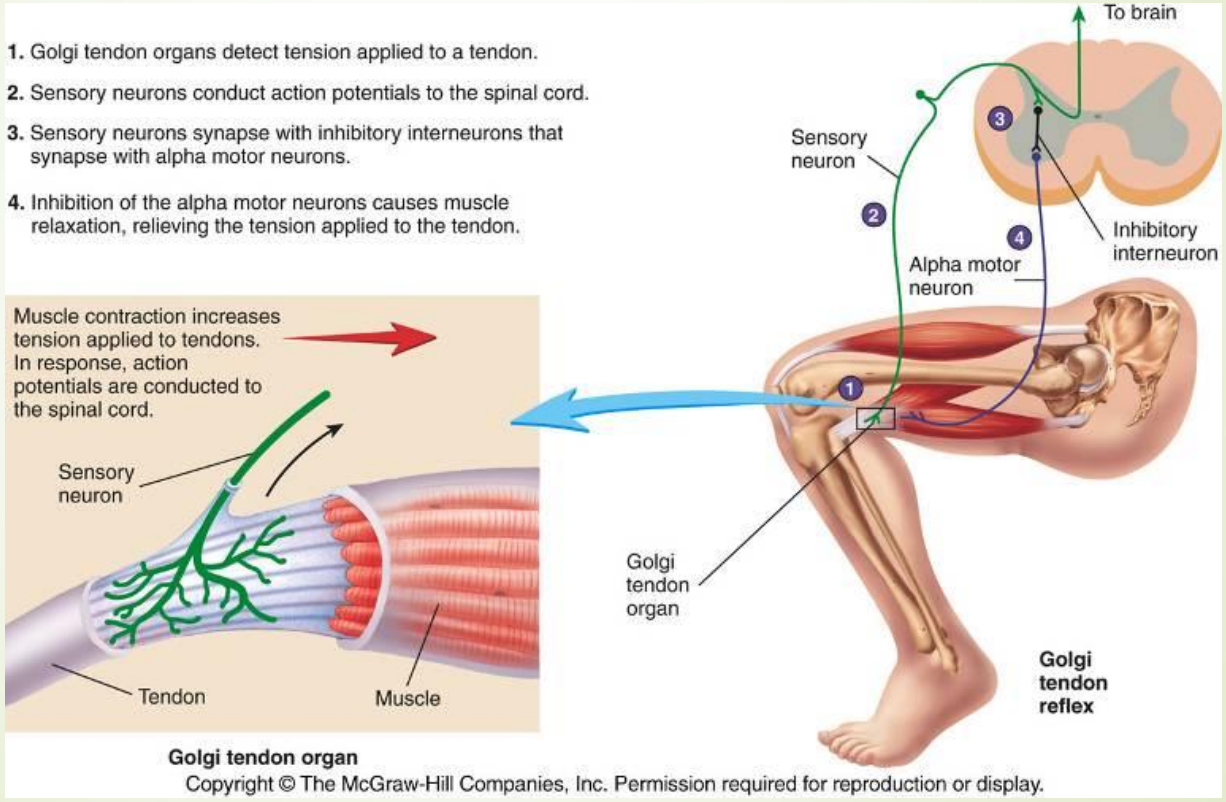
Muscle Spindle



Golgi Tendon Organ (GTO)

- Monitor tension developed in muscle
  - Prevents muscle damage during excessive force generation
- Stimulation results in reflex relaxation of muscle

Golgi Tendon Organ (GTO)



PRINCIPLES OF STABILITY

Objectives

- To define and explain :
  - Gravity
  - Centre of gravity
  - Line of gravity
  - Base of support
- To distinguish between the three states of equilibrium

Objectives cont'd

- To understand the factors affecting stability
- To acquire a knowledge of the principles of stability

KEY TERMS DESCRIPTIONS AND DEFINITIONS

- The centre of gravity of an object is the point at which all forces operate

(Hollis, 1984)

The COG of the human body lies approximately at S-2, anterior to the sacrum

- The line of gravity is a vertical line passing through the centre of gravity (Hollis, 1984)

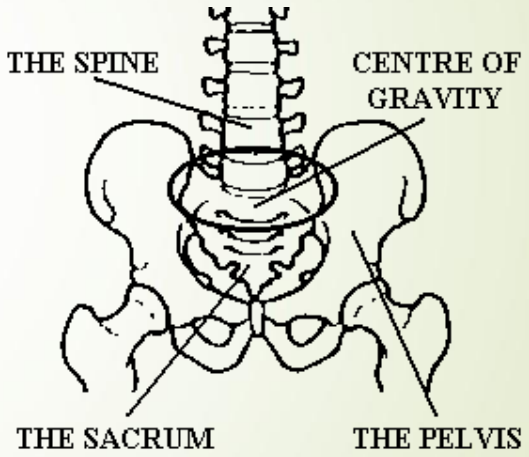
COG

The point where an object mass is considered to be concentrated

- Generally your centre of gravity may be found using the following calculation:

  MALES: 57% of height (height x 0.57)

  FEMALES: 55% of height (height x 0.55)



KEY TERMS DESCRIPTIONS AND DEFINITIONS

- The base of support is the area which supports a body or object
- Force of gravity:is the downward acting force which attracts bodies to the centre of the earth.

EQUILIBRIUM

- The forces acting upon a body are perfectly balanced and the body remains at rest.
- A body or object is said to be in equilibrium when a) the sum of the forces acting on it is equal to zero **and** b) the sum of the torques acting on it is equal to zero. In other words, there are no imbalancing forces or torques.

- Balance:

when a condition of equilibrium exists, all forces and all torques are equal to zero. In other words, they are in **balance.**

- Stability:

An object or body is either stable or unstable. There are not intermediate levels of stability. In other words, it is either in balance (sum of the forces and torques are equal to zero) or not (sum of the forces and torques are not equal to zero).

BALANCE

- **Factors impacting balance:**
  - Muscular weakness
  - Proprioceptive deficits
  - ROM deficits

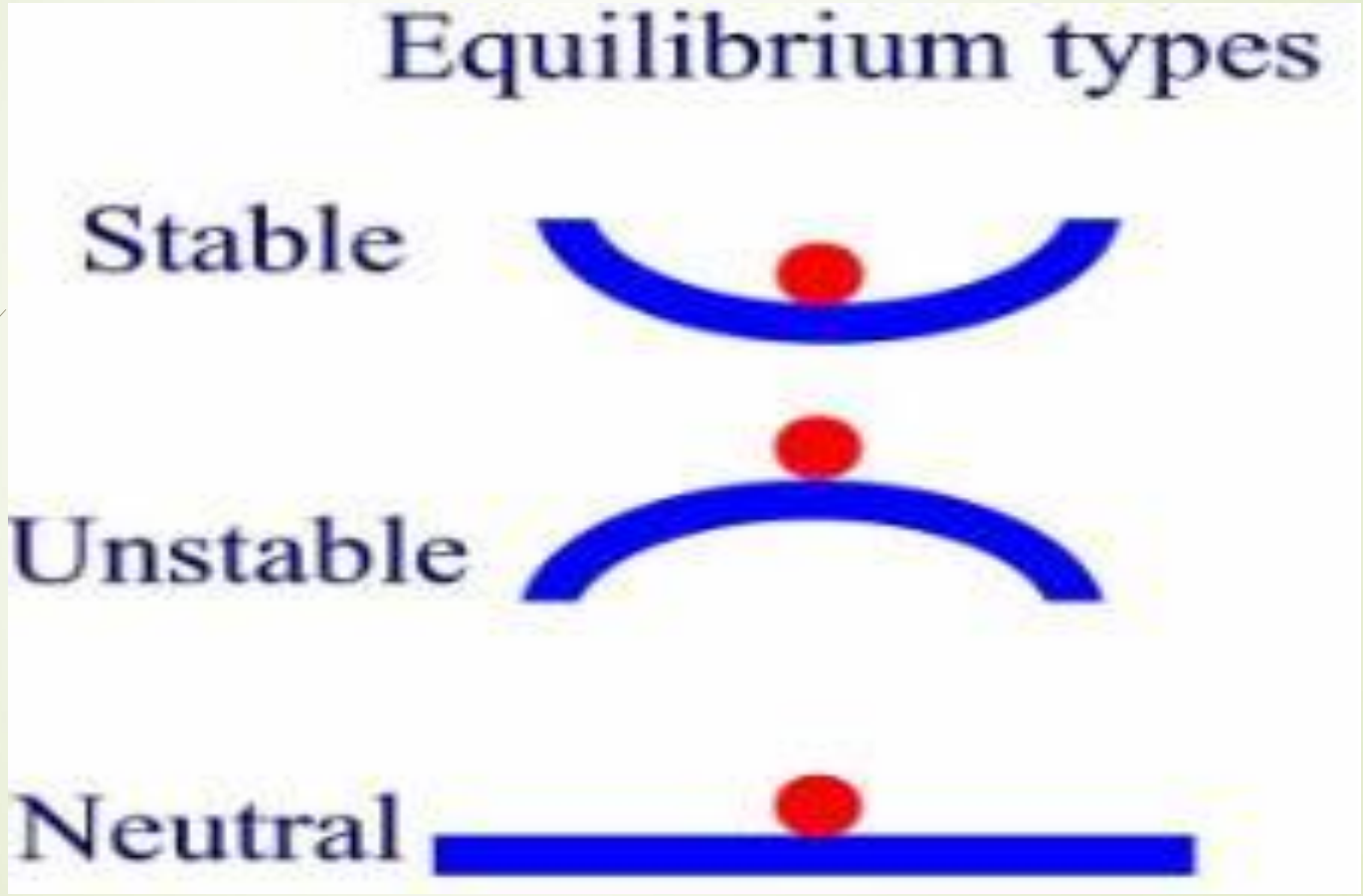
Types Of Equilibrium

- Three types of equilibrium exist :

(1) Stable

(2) Neutral: Neutral equilibrium exists when a body remains in its displaced position.

(3) **Unstable**: Unstable equilibrium exists when a body tends to continue movement after a slight displacement


Equilibrium types
Stable
Unstable
Neutral

Stable Equilibrium

- Centre of gravity as low as possible
- Large base of support
- Line of gravity falls near centre of base of support

Unstable Equilibrium

- Centre of gravity is very high
- Base of support is very small

Neutral Equilibrium

- Neutral equilibrium exists in spite of displacement of a body
- Height and position of the centre of gravity remain the same in relation to the base

FACTORS AFFECTING STABILITY

- Relation of L of G to base of support
- Height of the centre of gravity
- Size and shape of base of support
- Mass of body
- Friction
- Segmentation

FACTORS AFFECTING STABILITY

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Regaining Equilibrium

- Widen the base of support
- Lower the centre of gravity
- Centre the line of gravity over the base of support

PRINCIPLES OF BALANCE AND STABILITY

- For balance to exist, the line of gravity must intersect the base of support.
- If the area of the base of support of an object is increased, this tends to increase the stability of the object.

PRINCIPLES

- The lower the center of gravity is above the base of support the more stable the object tends to be. (This is true even though the size of the base of support is unchanged.)

PRINCIPLES CONT'D

- Objects that are more massive tend to be more stable.
- For an object, the farther the line of gravity's intersection is from the edge of its base of support the more stable the object tends to be in that direction.

PRINCIPLES CONT'D

- Visual focus on stable objects during locomotion ↑ stability
- Physical and emotional balance improves balance
- ↑ friction between supporting surfaces = ↑ stability
- Ability to start, stop, and change directions = manipulation of stability

- Changing of direction and stopping involves increasing the base of support (wide stance) and decreasing the height of the centre of gravity (crouching down).

1.2. Kinetics: analysis of force

- **A force** is a push or a pull exerted by one material object or substance on another (F=m.a).
- **External forces**: forces that push or pull the body from the outside e.g. gravity, air resistance, water resistance, inertia, friction.
- **Internal forces**: forces that act on the body and arise from sources within the human body.e.g.muscles,ligaments pulling on the bone.

1.2.1 Forces of gravity

- Gravity is the most consistent force encountered by the human body ($F=m.g$, where $g=9.8m/s^2$ on earth).

The center of gravity (COG) is hypothetical point at which all mass that object would appear to be concentrated.

1.2.2. Centre of gravity (COG) of human body

- The COG of the human body lies approximately at S-2, anterior to the sacrum. I f the body is considered as two segments then COG for the upper body and the lower body will be located.

1.3 Parallel force systems

- A parallel force system exist whenever two or more parallel forces act on the same object but at same distance from each other.
- The bones of body are levers that rotate around an axis. Forces that applied to these levers will produce either equilibrium (no motion) or movement such as rotation or translation.

FRICTION

Friction is a force that is generated when two objects move against each other.

Friction always...

A) runs parallel to the plane of contact of the two surfaces

B) has a magnitude that depends on...

- the materials involved
- the smoothness (texture) of the surfaces involved
- the force pressing the surfaces together

NEWTON'S LAWS OF MOTION

Newton's First Law of Motion:

The Law of Inertia

- **A body will remain in a state of rest or in uniform straight line motion, unless acted upon by a force to change that state of rest or motion**".

e.g.. John kicking a goal ball will remain at rest until He applies a force with his foot. The ball would travel in a straight line into the sky, but is acted upon by gravity and air resistance (wind) to change its motion

The Law of Inertia

- **Moving Inertia**

  An object in motion tends to remain in motion and to travel in a straight line with uniform velocity unless acted upon by some external force.

- **Stationary Inertia**

  An object at rest tends to remain at rest unless acted upon by some external force.

An object in motion tends to remain in motion and this tendency is called the body's **moving inertia**.

A force must overcome the body's moving inertia in order to alter the body's motion.

The motion of the basketball is altered, i.e. the ball is deflected when a force is applied by the hand

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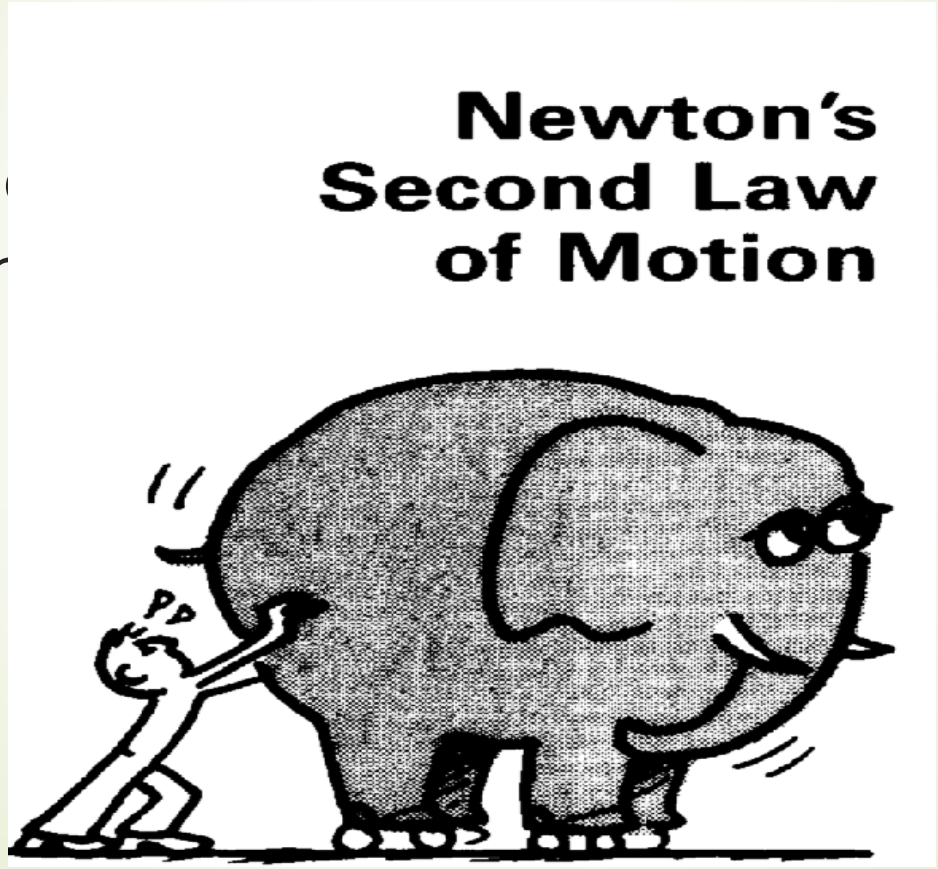


The 2nd Law of Motion

- **The acceleration (change in motion) of a body is proportional to the force causing it, and the change takes place in the direction that the force acts.**

- **Newton's Second Law of Motion, the law of acceleration can be expressed as:**

Acceleration = force / mass

When a body is acted upon by a force.....

- The greater the force, the greater the acceleration.
- The smaller the mass, the greater the acceleration.
- The change in motion takes place in the direction in which the force is applied.

The Law of Action-Reaction
"The third Law of Motion"

- Newton's Third Law of Motion states that :

"For every action, there is an equal and opposite reaction."

The third Law of Motion

For every action there is an equal and opposite reaction;

- A force acting anywhere always has a force equal to that acting in the opposite direction
- Forces work in pairs opposing one another
- The initial force (action force) is opposed by a second force (reaction force)

FORCE SUMMATION

- Force generation by the body is explained in terms of **force summation** the sequential acceleration of body segments, timing of body parts, Range of Motion (impulse) and Stretching Out.
- The acceleration of body parts can be greatly improved through the process of **FORCE SUMMATION.**

Force = mass x acceleration

FORCE SUMMATION

- The body parts that are large muscle groups can generate large forces. The large force causes a large acceleration in that body part. When that body part reaches peak force then the body part has reached peak acceleration, after which the body part would start decelerating (slow down).

FORCE SUMMATION

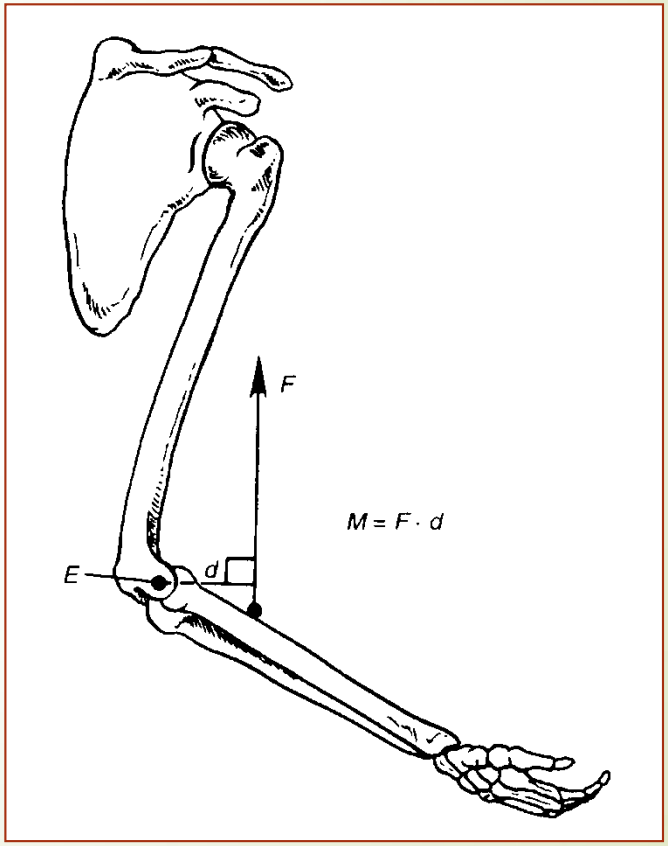
- In many sporting actions such as kicking a rugby ball, the desired movement is a combination of a number of body parts and the forces each body part generates.
- These forces are added together through a sequence of body movements to generate a far greater force.
- The correct sequence and timing of body parts permits the athlete to produce a greater force and therefore attain optimal velocity at release or contact.

ASSIGNMENT 1

- Identify the planes and axis(es) of motion for different synovial joints.
- Identify anatomical and directional terminology
- Identify examples of different levers in the human body.

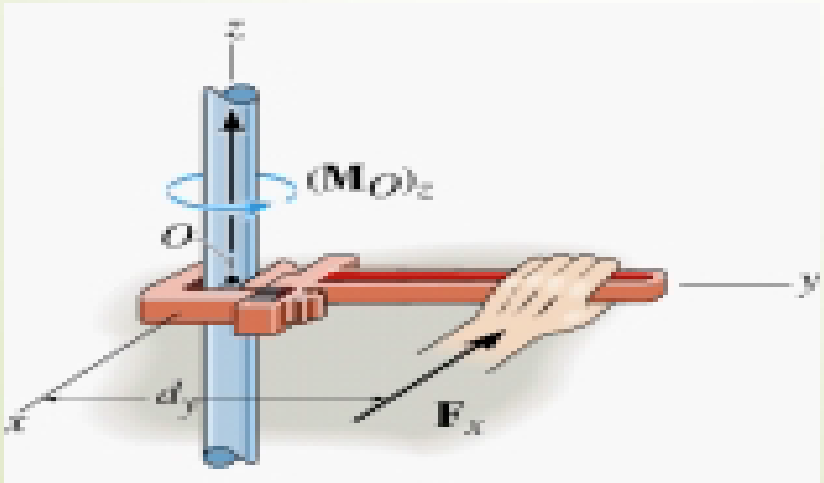
Moments of Force (Torque)

- Effect of a force that tends to cause rotation about an axis
- M = F ·d (Nm)
  - If F and d are ⊥
- Force through axis



TORQUE

- Mathematically, torque is defined as the cross product of the lever-arm distance vector and the force vector, which tends to produce rotation.
- Loosely speaking, torque is a measure of the turning force on an object such as a bolt. For example, pushing or pulling the handle of a wrench connected to a nut or bolt produces a torque (turning force) that loosens or tightens the nut or bolt.



Pressure

- $P = F/A$
- Units ($Pa = N/ m^2$)
- In the human body also called stress
- Important predisposing factor for injuries

Work, Energy and Power

- Kinetic energy is mechanical energy possessed by any moving object. An equation for Kinetic Energy can be derived from the work definition:
- Work = force x distance moved in the direction of the force

Kinetic Energy = ½ x mass x velocity^2 (result is in joules)

- Power is defined as the rate at which energy is used or created from other forms

Power = energy used ÷ time taken

Power = (force x distance) ÷ time taken

Power = force x velocity

Distance and displacement

Distance and displacement are quantities used to describe the extent of a body's motion.

Distance is the length of the path a body follows and displacement is the length of a straight line joining the start and finish points e.g. in a 400m race on a track the length of the path the athlete follows (distance) is 400m but their displacement will be zero metres (they finish where they start).

Speed and velocity

- Speed and velocity describe the rate at which a body moves from one location to another. These two terms are often thought, incorrectly, to be the same.
- Average speed of a body is obtained by dividing the distance by the time taken where as the average Velocity is obtained by dividing the displacement by the time taken e.g. consider a swimmer in a 50m race in a 25m length pool who completes the race in 60 seconds - distance is 50m and displacement is 0m (swimmer is back where they started) so speed is 50/60= 0.83m/s and velocity is 0/60=0 m/s
- Speed and Velocity = distance traveled ÷ time taken

Mechanical Principle: Leverage

- **Lever** - mechanical device used to produce a turning motion around a fixed point called an *axis*.
- **Lever components**
  - **Fulcrum** - center or axis of rotation
  - **Force arm** - distance from the fulcrum to the point of application of the force
  - **Resistance arm** - distance from the fulcrum to the weight on which the force is acting

LEVER

- In the body a lever is represented by a bone, which is capable of movement about a fulcrum formed at the articulating surfaces of a joint; the effort which works the lever is supplied by the force of muscle contraction, applied at the point of insertion to the bone, while the weight may be either at the centre of gravity of the part moved, or of the object to be lifted.

Lever

- Levers are used to help move loads
- In the body lever = bone
- Fulcrum is usually a joint
- Load is the part of the body being moved plus any implement
- Effort is supplied by the muscle contracting and pulling on the tendon
- The longer the lever the faster its speed at the end

Levers systems

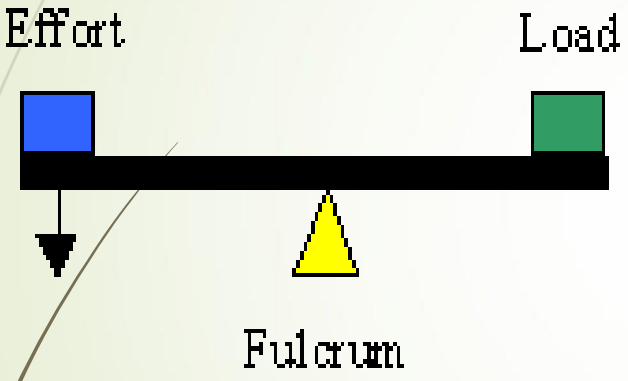
- **First class lever**
- The axis is located between the force and the weight (resistance)
- Designed best for **balance**
- Example: atlanto-occipital joint
- As the fulcrum moves toward the load the mechanical advantage increases and the load becomes easier to move but its range of motion and distal end speed decreases.
- As the fulcrum moves towards the force the range of motion and the distal end speed increases but the mechanical advantage decreases.

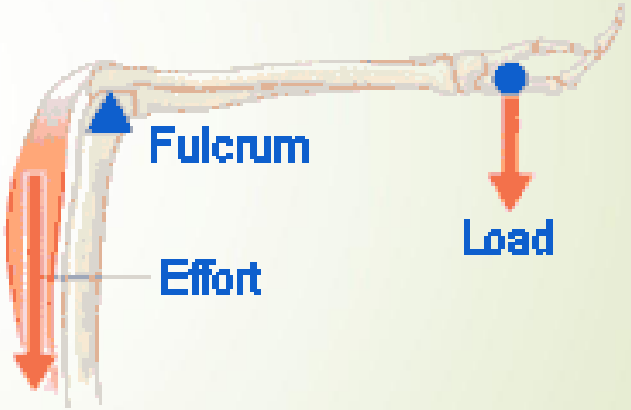
First class lever

Eg:- 1) During nodding movements of the head,
Lever – Skull
Fulcrum – Atlanto-occipital joint
Weight – Anteriorly in face
Effort – Contraction of posterior neck muscles

2) During tilting movements of pelvis,
Lever – Pelvis
Fulcrum – Hip joint
Weight – Body weight
Effort – Contraction of hip extensor muscles

First class lever





Second class lever

- **Second class lever**
- Axis is located at one end, resistance is in the middle and the force at the opposite end
- Designed best for **power**
- Example: wheelbarrow; rising up on toes

Second class lever

- As the load moves toward the fulcrum the mechanical advantages

increases and it becomes easier to move but its range of motion and speed decrease.

- As the load moves towards the force the range of motion and speed

increases but the mechanical advantage decreases.

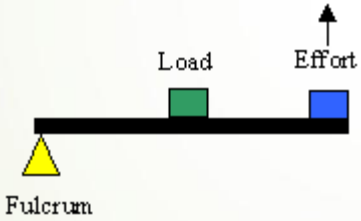
Second class lever

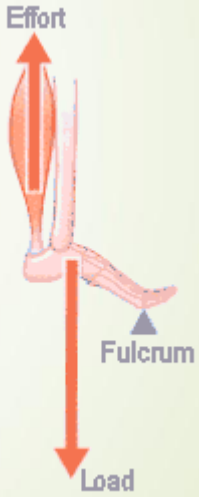
Eg:- 1) When heels are raised to stand on toes,

- **Lever** – Tarsals and metatarsals
- **Fulcrum** – Metatarophalangeal joint
- **Weight** – Body weight is transmitted through ankle joint to talus

Effort – At insertion of tendo-calcaneum by contraction of calf muscles

Second class lever





Third class lever

- **Third class lever**
- Axis is at one end, force is in the middle and the resistance at the opposite end
- Designed for ROM (mobility); most common lever system in humans
- Example: hinged door; normal muscle contraction

Third class lever

- As the force moves toward the fulcrum the mechanical advantage decreases and the load becomes more difficult to move but its range of motion and distal end speed increases.
- As the force moves towards the load the range of motion and the distal end speed decreases but the mechanical advantage increases

Third class lever

Eg:- 1) When **Lever** – Forearm

Fulcrum – Elbow joint

Weight – Some object held in hand

Effort – Contraction of brachialis muscle applied at its insertion it can be seen that small amount of muscular contraction will be translated into much more extensive and rapid movement at hand.

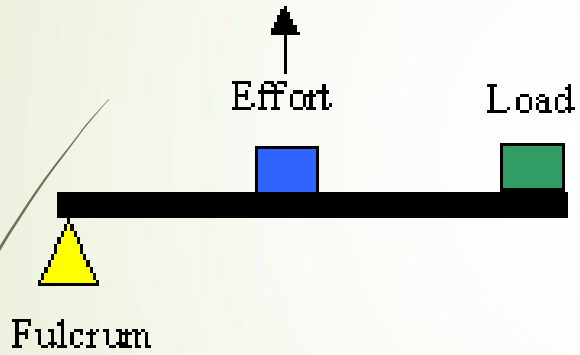
2) When Lever – Leg

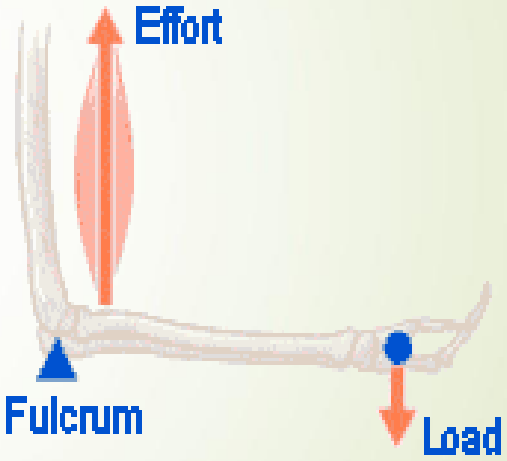
Fulcrum – Knee joint

Weight – Some weight applied at the foot

Effort – Contraction of hamstring muscles applied at its insertion it can be seen that small amount of muscular contraction will be translated into much more extensive and rapid movement of the foot.

Third class lever





3rd class lever

2) During action of biceps brachii muscle in flexing the elbow joint,

Lever – Humerus

Fulcrum – Elbow joint

Weight – Situated in forearm bones

Effort – At insertion of tendon of biceps brachii by its contraction

Mechanical advantage

- Mechanical advantage (MA) = the ratio of effort arm to resistance arm

1. MA greater than one: effort force is greater than the resistive force
2. MA less than one: effort force is less than the resistive force

Mechanical advantage CONT'D

- IDEAL MECHANICAL ADVANTAGE: Predicted mechanical advantage.

IMA=dE/dR (Effort distance divide by resistance distance)

- ACTUAL MECHANICAL ADVANTAGE: The real mechanical advantage that results when the machine is in use.

AMA=FR/FE (Resistance Force divide by Effort Force)

The **resistance arm** is the distance between the axis and the point of resistance application.

The distance between the axis and the point of force application is known as the **force arm**.

There is an inverse relationship between force and the force arm just as there is between

resistance and the resistance arm. The longer the force arm, the less force required to move the

lever if the resistance and resistance arm remain constant. In addition, if the force and force arm

remain constant, a greater resistance may be moved by shortening the resistance arm.

JOINT STRUCTURE AND FUNCTION

ASSIGNMENT 2

1. Discuss fluid mechanics
2. Discuss In Step Soccer Kick
3. Explain classifications
4. Joint motion and function
5. General effects of disease, injury and immobilisation on joints
6. Identify the abnormal gait patterns

BIOMECHANICS AND PATHOMECHANICS OF CONNECTIVE TISSUES.

- **LIGAMENTS AND TENDONS**

The role of ligaments and joints capsules:

- Connect bone with bone
- Increase the mechanical stability of the joints
- Guide joint motion
- Prevent excessive motion

The role of tendons:

- Attach muscle to bone
- Transmit tensile loads from muscle to bone, thereby producing motion

COMPOSITION AND STRUCTURE OF TENDONS AND LIGAMENTS.

- They are dense connective tissues known as parallel-fibered collagenous tissues.
- Composed largery of Collagen (a fibrous protein constituting approximately one third of the total protein in the body).
- The great mechanical stability of collagen gives the tendons and ligaments their characteristic strength and flexibility.
- Like other connective tissues, tendons and ligaments consist of relatively few cells (fibroblasts) and an abundant extracellular matrix.
- Cellular material occupies about 20% of the total tissue while the extracellular matrix accounts for the remaining 80%.
- 70% of the matrix consists of water and approximately 30% is solids.
- These solids are collagen, ground substance and small amount of elastin

- The collagen content is generally over 75% and is somewhat greater in tendons than ligaments.

COLLAGEN

- Collagen molecule is synthesized by the fibroblast
- Within the cell as a larger precursor (Procollagen) which is then secreted and cleaved extracellularly to become collagen.
- Tendons and ligaments, like bone, are composed of the most common"type I collagen"
- Type I collagen consists of three polypeptide chains(two identical alpha-1 chains and one alpha-2 chain)
- Almost two thirds of the collagen molecule consists of three amino-acids: glycine (33%), proline (15%), and hydroxyproline (15%).

- The arrangement of the collagen fibers differs somewhat in tendons ad ligaments and is suited to the function of each structure.
- In tendons, fibers have an orderly, parallel arrangement (to handle unidirectional tensile loads)
- In ligaments, fibers are closely interlaced with one another.

ELASTIN

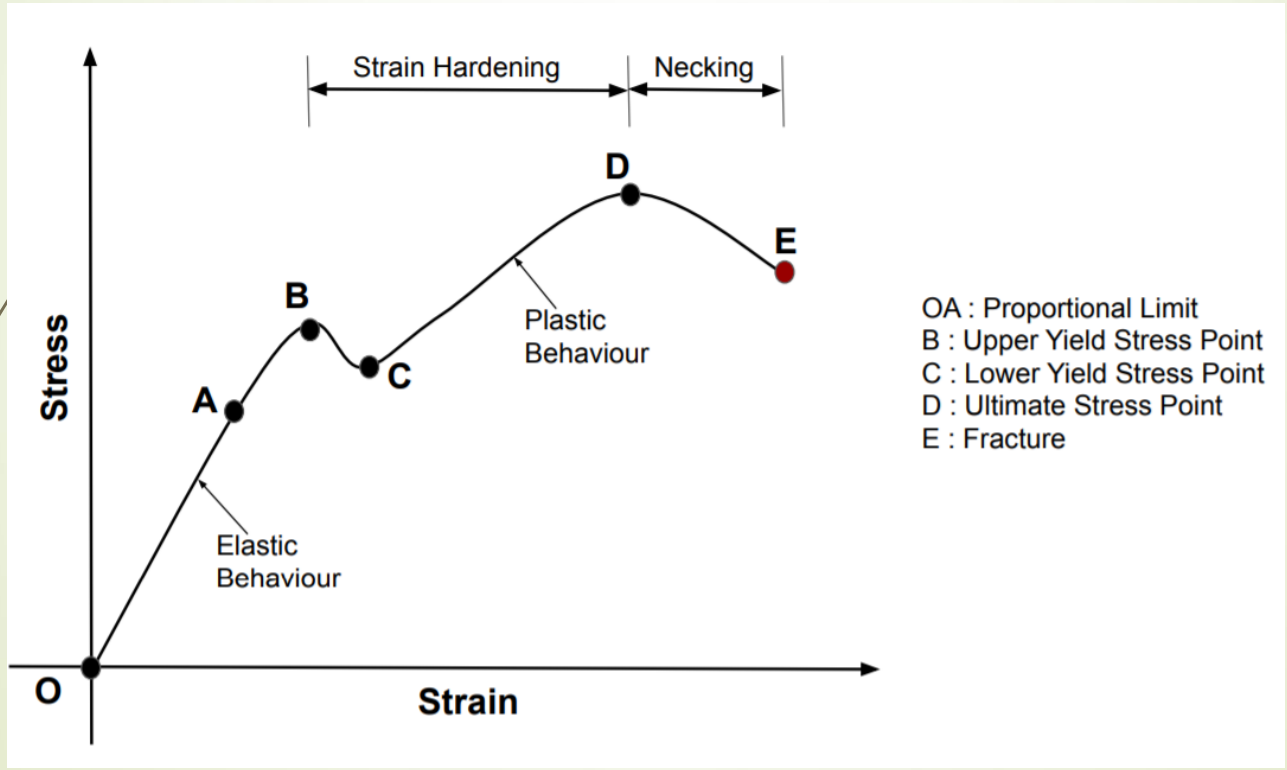
The protein elastin is scarcely present in tendons and extremity ligaments, but in elastic ligament such as the ligamentum flavum the proportion of elastic fibers is substantial.

GROUND SUBSTANCE

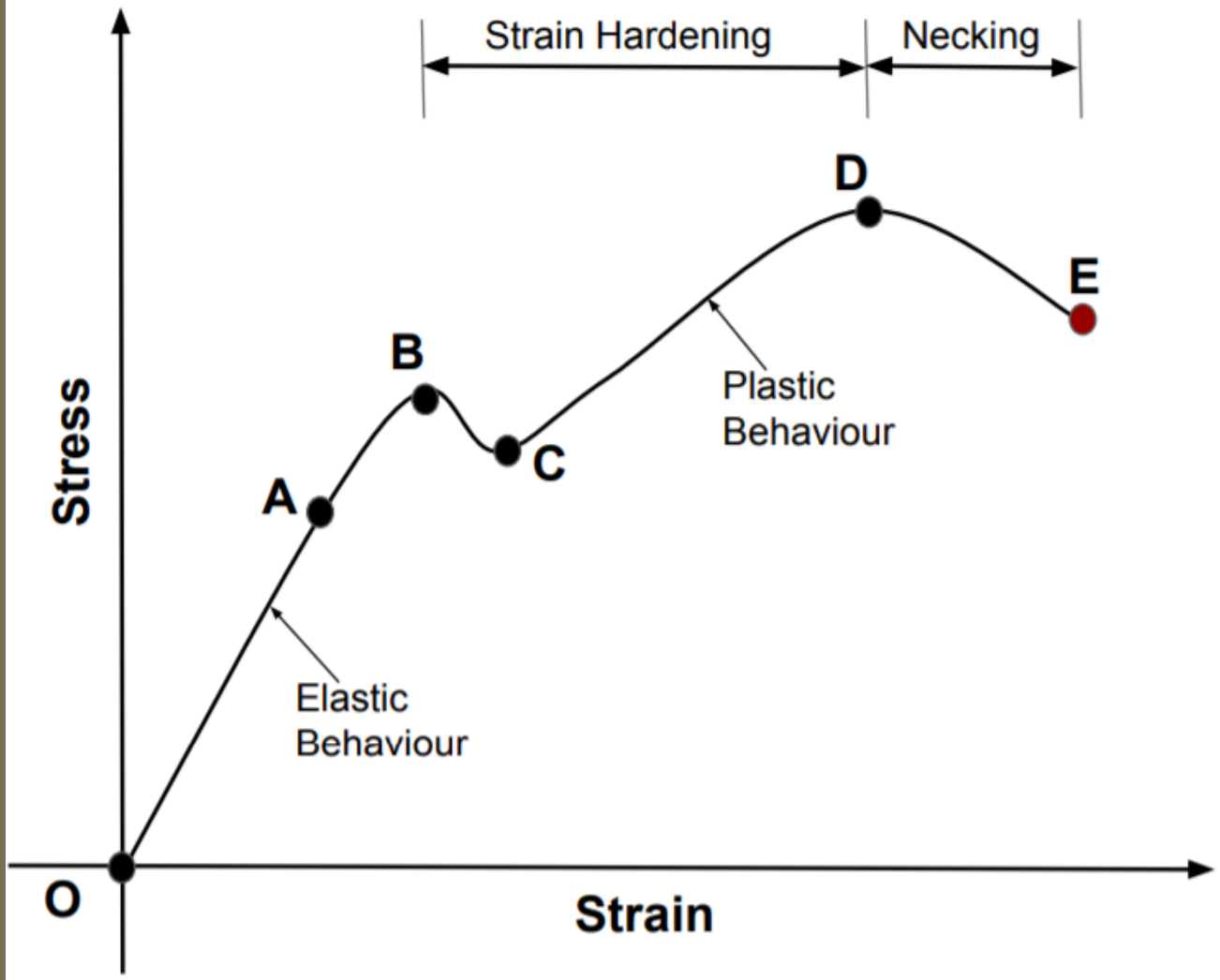
- Consists of proteoglycans(PGs) up to about 20% of the solids along with structural glycoproteins, plasma proteins and a variety of small molecules
- The PG units, are macromolecules composed of various sulfated polysaccharide chains (glycosaminoglycans) bind to a long hyaluronic acid (HA) chain to form an extremely high-molecular weight aggregate like that found in ground substance of articular cartilage.
- The PG aggregates bind most of extracellular water of the ligament and tendon, making the matrix a highly structured gel-like material.

BIOMECHANICAL PROPERTIES

- Load-elongation curve or stress-strain curve



STRESS-STRAIN CURVE



OA : Proportional Limit
B : Upper Yield Stress Point
C : Lower Yield Stress Point
D : Ultimate Stress Point
E : Fracture

FACTORS THAT AFFECT THE BIOMECHANICAL PROPERTIES OF TENDONS AND LIGAMENTS

- **Aging**: The collagen content of tendons and ligaments decreases during aging, contributing to the gradual decline in their mechanical properties (strength, stiffness, and the ability to withstand deformation)
- **Pregnancy and postpartum period**: Increased laxity of the tendon and ligaments in the pubic area during later stages of pregnancy and postpartum period.
- Immobilization: decreases the tensile strength and stiffness of the ligaments
- Injury
- NSAID's
- Disease: R.A (collagen disease)

BONE

- Bone is primary structural component of the body
- Important for taking loads, locomotion and organ protection
- Body's reservoir for minerals (calcium) and site of haematopoiesis.
- It can repair, remodel and reshape in response to injury and loads.
- Attachment for muscles and ligaments

TYPES

- Compact bone (cortical and solid)
- Cancellous bone (trabeculae, spongy)

BONE

- Bone is a composite of inorganic mineral salts deposited on a framework of organic supporting material
- **Basic structural unit consists of OSTEOID**, with inorganic salts such as Calcium phosphate, hydroxyapatite, citrate, sodium, magnesium, phosphate, fluoride
- Mineral homeostasis is important or long term calcium deficiency can lead to osteoporosis because there is mobilisation of bone mineral in an attempt to maintain normal plasma calcium concentrations
- Parathyroid hormone can increase plasma levels by increasing calcium mobilisation from bone and increasing renal absorption
-

BONE

ORGANIC MATRIX:

- 95% collagen TYPE I with a slightly different chemical property for increased strength
- 5% on non-collagen substance, is the Ground substance of proteoglycans of high molecular weight (carbohydrates and proteins)

BONE CELLS: Three primary cell types are involved in the formation and resorption of mature bone.

- OSTEOBLASTS (Synthesis of the osteoid. They are flattened cells when inactive covering surfaces of trabeculae and endosteal(inner) surface of cortical bone, separating cortical bone and marrow and the action of the osteoclasts)
- OSTEOCYTES (Osteocytes are the osteoblasts which are trapped in the bone matrix and surrounded by the cavities or lacunae. They communicate with each other and the surface osteoblasts via the canalicular system
- OSTEOCLASTS (involved in the process of bone resorption)

BONE

- CORTICAL BONE
- Skeletal mass=approximately 80% cortical bone
- Found mainly in shafts of long bones
- The collagen laid down in a lamellae, with parallel fibre direction around a central canal
- The density and strength of bone give the skeletal system its integrity.

BONE MECHANICAL PROPERTIES

- ANISOTROPY: Cortical bone will demonstrate that the results will reflect the site of central canal or the direction of test/loads
- Cortical bone under tension, you may observe 2 things:
  - It will deform in a linear fashion and will yield at a low stress
  - It will tend to crack
- Trabeculae bone: It linearly deforms but it is elastic
- Vertical forces are compressive and close cracks
- Horizontal forces will shear and microdamage
- Osteon is the element and it is able to withstand the axial loading but is susceptible to shear
- The structure goes about the cement line joins of the osteons.
- Fractures will tend to occur in places of lower concentrations of osteons and where they are further apart.

CARTILAGE

- Can exist for a long period of time
- Withstand extremely high loads
- Can be destroyed by high impulse loads or shearing forces
- Has a long half-life and a poor capacity for repair
- Is essentially aneural and avascular.

Cartilage can be classified into:

- Hyaline: costal cartilages, nasal, tracheo-bronchial and all temporary cartilage
- White fibro-cartilage:IVD, articular discs, lining of bony grooves where tendons run
- Yellow elastic fibrocartilage: External ears, larynx, epiglottis

CARTILAGE

Articular cartilage is a layered structure:

- Outermost layer=parallel lying and is primarily a Type II fibres
- Mid-zone=a network of mesh (but mainly vertical) fibres
- Inner layer= a network of perpendicular fibres and cells adjacent to the adjacent subcondral layer

The cartilage matrix consists of:

- A few chondrocytes, water, and proteoglycans, fibrous collagen attached to the subchondral bone.

The framework consists of:

- Collagen fibers trapping large protein molecules, causing an increased osmotic gradient which influences the intake of water.
- Proteoglycans have a central protein core and the two glycosaminoglycans (GAGs)

- Chondroitin sulphate (along the length) attached like a bottlebrush
- Keratin sulphate (attached more at the end)

- Oligosaccharides are attached along the length of the molecule
- Decrease in motion or weight bearing has experimentally been seen to lead to a decrease in GAG's
- Cartilage ultrastructure varies with age, pathology and site

MECHANICAL PROPERTIES OF CARTILAGE

- Cartilage is time-dependent and is biphasic viscoelastic acting in two modes: **Solid and Fluid**
- **Solid structure** =mesh network of cells and ground substance
- Fluid structure=water and other elements in the space.
- Structure causes the response to loading with the interaction of the collagen network, the stiffness of collagen and proteoglycans, maintaining the extracellular matrix (ECM), water/fluid equilibrium.
- An increase in water in the ECM, will decrease the modulus of compressibility
- A well maintained high level of GAGs will reduce the loss of fluid and deformation under loading

CARTILAGE

IN A SOLID MATERIAL:

- Fast loading reduces quick response and deformation
- Slow loading allows adaptation of matrix to take large loads and deformations

IN A FLUID STRUCTURE

- Fluid diffuses equally in normal and tangential directions; demonstrating the isotropic nature of proteoglycan-water gel structure through which fluid flows.
- Fast/high loading cause great fluid loss because of the loss of fluid through the porous matrix, the chondrocytes in the matrix srtucture take the axial load
- Slow/low loads have time to raise a high hydrostatic pressure in the extracellular matrix, causing less deformation. With slow loads the risk of shear loading is greater.

PATHOMECHANICS OF SOFT TISSUES

I. Common pathomechanical changes in muscles

1-Muscle fatigue.

2- Disuse atrophy in patients.

3- Acute muscular strain.

4-Muscle Contusion.

5-Delayed-onset muscle soreness “DOMS” exercise induced muscle injury.

6-Considerations regarding tendon transfers.

7- joint position influence on muscle strength

1-Muscle fatigue

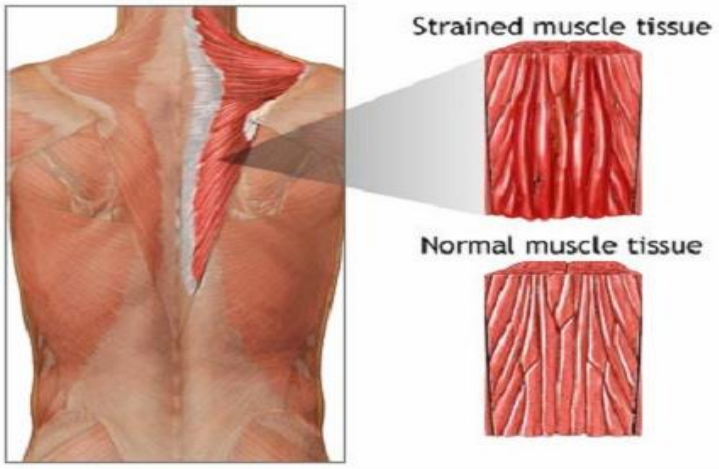
Much is known about the physiological impairments that can cause muscle fatigue. It is known that fatigue can be caused by many different mechanisms, ranging from the accumulation of metabolites within muscle fibres to the generation of an inadequate motor command in the motor cortex, and that there is no global mechanism responsible for muscle fatigue. The development of muscle fatigue is typically quantified as a decline in the maximal force or power capacity of muscle, which means that submaximal contractions can be sustained after the onset of muscle fatigue.

2-Disuse atrophy in patients:

Patients who have spent prolonged periods in bed are likely to demonstrate significant loss of strength and endurance resulting directly from the inactivity and causing muscle atrophy due to decreased number and size of muscle fibers.

3- Acute muscular strain:

Typically result from over stretching a passive muscle or from a dynamically overloading an active muscle, either concentrically or eccentrically resulting from unaccustomed activity. The severity of tissue damage depends on magnitude of the force, the rate of the force application and the strength of the musculotendinous structure.



- strain should be applied only to injury involving the muscle-tendon unit.
- Accepted categorization:
- 1- mild (first-degree)
- 2- moderate (second-degree)
- 3-severe (third-degree).

In any case, it is the attendant inflammatory changes that produce pain, discomfort, and concomitant lameness.

4- Muscle Contusion:

Result from blunt force trauma, some are called bruises. Soft tissue contusions cause skin discoloration, as blood vessels may bleed directly under the skin. This can create a virtual rainbow of colors and a bruise might look brown, red, blue, purple, or yellow.

there may be a perceptible lump at the site of the injury. This can cause cramping, stiffness, and considerable pain in the affected area.

Patient should follow the RICE method of treatment (rest, ice, compression, elevation).

5- Delayed-onset muscle soreness "DOMS" exercise induced muscle injury:

Results from connective and contractile tissue disruption. That occur 24 to 72 hours after participation in vigorous exercise.

Typically is associated with exercise using resisted eccentric exercise due to the fact that muscle exerts maximum mechanical loading in maximum eccentric contraction more than maximum concentric contraction. As the eccentric contraction involves both passive and active tension.

6-Considerations regarding tendon transfers:

Must ensure that the replacement muscle has an excursion-generating capacity similar to that of the original muscle.

This may be accomplished by:

a) choosing a structurally similar muscle

b) surgically manipulating the anatomical moment arm of the transferred muscle to increase or decrease its excursion capability.

Clinical example: radial nerve palsy with paralysis of the extensor digitorum muscle.

Surgeons uses the flexor carpiradialis muscle at the wrist as a substitute for because it has long muscle fibers and there fore, the capacity to extend the fingers through their full range of motion.

In contrast, the flexor carpi ulnaris, another muscle of the wrist, has very short fibers.

7- joint position influence on muscle strength

- In case of severe weakness; positioning the patients limb so that the contracting muscles are functioning in the stretched position leads to enhancement of the muscle's abilities to generate tension.

For example, hyperextension of the shoulder increases elbow flexion strength by stretching the biceps brachii. Or

i.e. the stretching before contraction works on the concept of starling's law which present the fact that the produced tension is known combination between active tension and passive tension produced by stretch

Conversely, placing muscles in a very shortened position decreases their ability to generate force.

Ex: Muscles of the wrist and fingers.

It is difficult to make a forceful fist when the wrist is flexed because the finger flexor muscles are so short they produce insufficient force. This phenomenon is known as ACTIVE INSUFFICIENCY.

II. Pathomechanics of articular cartilage:

Once the cartilage microstructure is disrupted any mechanical damage mechanism becomes possible including impairment of the articular cartilage's load transmission ability.

Wear of the articular cartilage:

Wear is the removal of material from the solid surfaces by a mechanical action. Wear can be divided into two components:

1- Interfacial Wear:

Occurs due to interaction of the bearing surfaces. if the bearing surfaces came in contact. This defect causes the surface layer of the cartilage to become softer and more permeable. The resistance of the fluid to move decreases which enables it to leak away. The loss of fluids increases the probability of solid contact of the surfaces.

2- Fatigue Wear:

Occur due to accumulation of microscopic damage in a material when it is repetitevily stressed leading to fatigue failure. Although the magnitude of the applied stress may be much less than the material's ultimate strength, failure will occur. Rotation and sliding causes the articular surfaces to move in and out of contact area, this in addition to the physiological activities will cause a repititive stressing on cartilage, which causes tensile failure of collagen frame work.

III. Pathomechanics of ligaments:

Sprain: is injury of ligaments with torn collagen fibers

Ligament injury has three categories:

1st category:

Some pain is felt, tenderness localized to the area of sprain in ligament. no joint instability can be detected clinically. Micro-fracture of collagen fibers may occur.

Second category:

Severe pain, tenderness well localized to the area where the ligament has been sprained, and some joint instability. The strength and the stiffness of the ligament may decreaseby 50% or more.

– Partially torn ligaments slowly repair themselves

Third category:

Severe pain during the course of trauma, with less pain after injury.

The joint is completely unstable. Most collagen fibers have ruptured but a few may still be intact, giving the ligament the appearance of continuity although it is unable to support any loads.

– Completely torn ligaments require surgical repair.

All of ligaments injuries are characterized as having a strong tendency to recurrence and aggravation, often leading to persistent instability of the joint and frequently cause development of secondary osteoarthritis.

IV. Pathomechanic of Tendons

Tendon injury is treated only by suturing

After repair:

Period of about 3 weeks of immobilization is necessary to prevent rupturing of a surgically repaired tendon.

From the six day the tendons gradually regain their strength reaching nearly normal strength by the twentieth day.

A human tendon probably does not regain its normal strength until 40-50 weeks after surgical repair

III. Pathomechanic of joints

1-Dislocation (luxation):

– articulating surfaces forced out of position

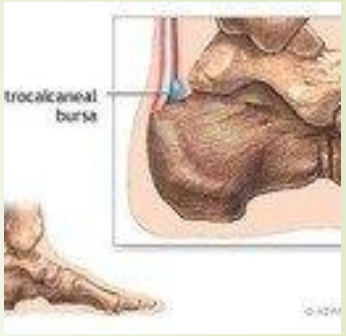
– damages articular cartilage, ligaments (sprains), joint capsule

2-Subluxation:

– a partial dislocation

3-Inflammatory and Degenerative Conditions

a) **Bursitis:** – An inflammation of a bursa, usually caused by a blow or friction.



a) **Tendonitis: -** Inflammation of tendon sheaths (which are enlarged bursa) typically caused by overuse.
b) **Arthritis**: All forms of rheumatism that damage articular cartilages of synovial joints

4-Osteoarthritis

Caused by wear and tear of joint surfaces, or genetic factors affecting collagen formation.

- The exposed bone ends thicken, enlarge, form bone spurs, and restrict movement.

- Joints most affected are the cervical and lumbar spine, fingers, knuckles, knees, and hips.

POSTURE

- Posture can be either static or dynamic. In static postures the body and its segments are aligned and maintained in certain positions e.g.standing, lying or sitting
- Dynamic posture refers to postures in which the body and/or segments are moving e.g. walking, running, jumping, throwing and lifting.

Postural control

- Postural control refers to a person's ability to maintain stability of the body and body segments in response to forces that threaten to disturb the body's structural equilibrium
- Postural control may be either static or dynamic

- Static postural control involves maintenance of stability during movements of the body or body segments and or changes in supporting surfaces
- Maintenance of control of posture is dependent on the integrity of
  - The CNS
  - The visual system
  - The vestibular system
  - The musculoskeletal system
  - Input from receptors in and around , tendons and ligaments

OPTIMAL POSTURE

- In normal posture, the LOG fails close to , but not through most joint axes therefore in normal optimal standing posture the gravitational forces may be balanced by countertorques generated by passive ligamentous tension and minimal muscle activity

- In normal optimal standing posture
- The body segments are near vertical alignment
- The compression forces are distributed optimally , over the weightbearing surfaces of the joints
- No excessive tension is exerted on the ligaments and muscles

- **Types of Posture**
  - Good Posture
  - Kyphotic-lordotic Posture
  - Flat-back Posture
  - Sway-back Posture

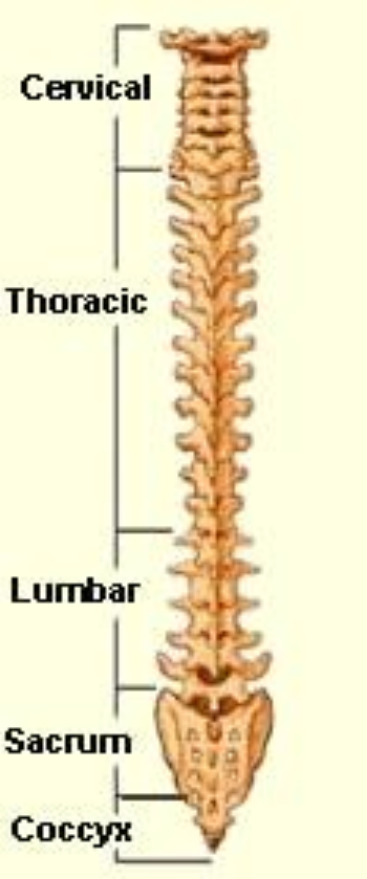
Correct Posture

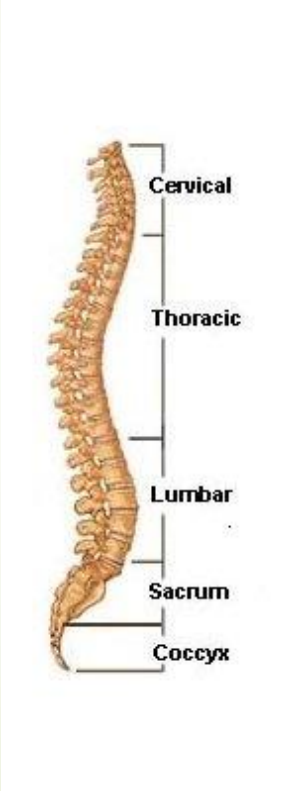
"…that state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity irrespective of the attitude (erect, lying, squatting) in which these structures are working or resting. Under such conditions the muscles will function most efficiently and the optimum positions are afforded for the thoracic and abdominal organs."

- **Maximal biomechanical efficiency**
- **Minimal stress on ligaments and strain on muscles**

Normal Spine Curvature

Posterior (Back)
Spinal Column

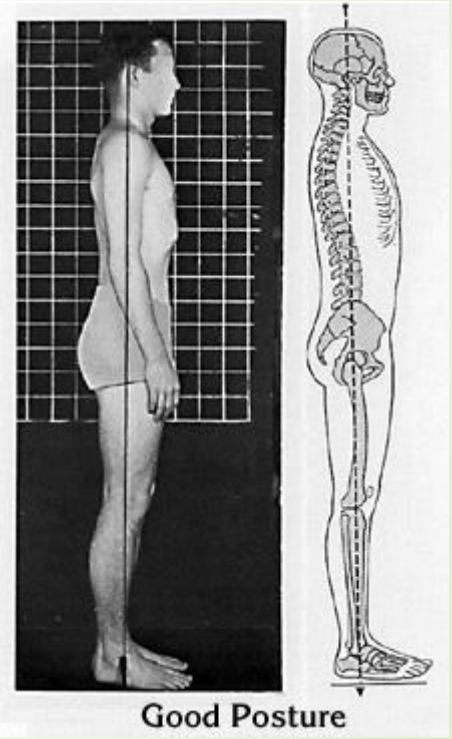




Correct Posture (Lateral)

Line is…

- Through external auditory meatus (Ear)
- Midway through shoulder
- Through lumbar bodies
- Slightly anterior to midline of knee
- Slightly anterior to lateral malleolus

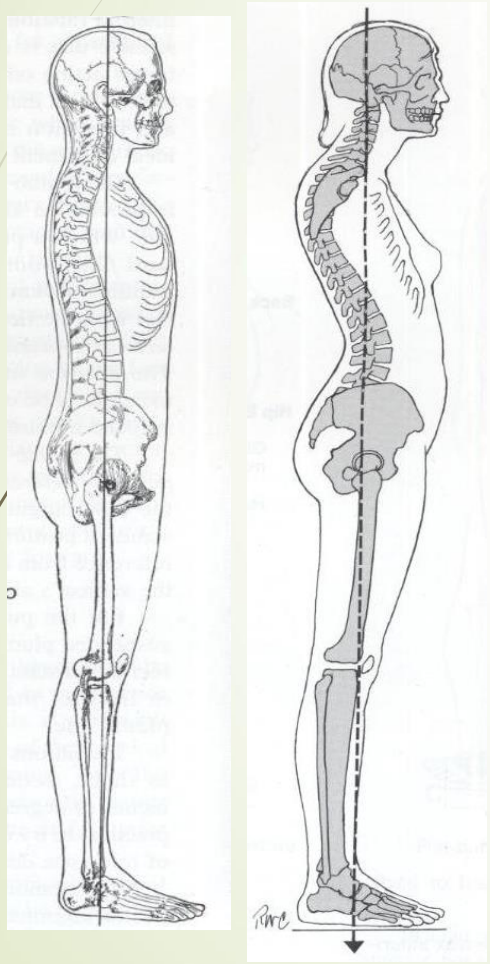


Poor Posture

"*…faulty relationship of the various parts of the body which produces increased strain on the supporting structures and in which there is less efficient balance of the body over its base of support.*"

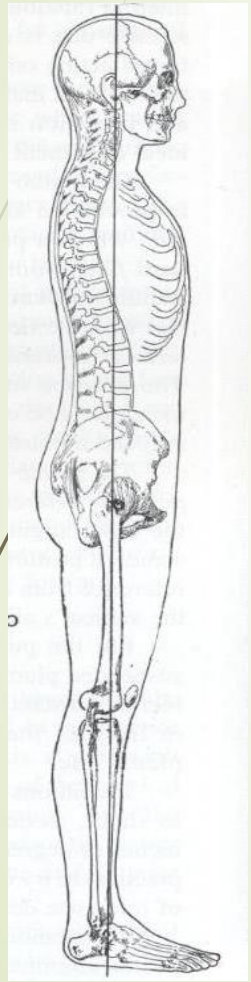
- Increased strain on body and less efficient
- Cause of various physiological and anatomical impairments

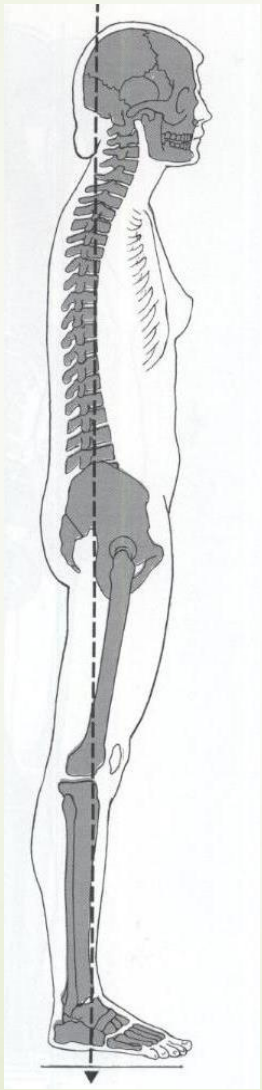
Kyphotic-Lordotic Posture



IDEAL

Head- Forward
Cervical Spine- Hyperextended
Thoracic Spine- increased flexion
Lumbar Spine- lordosis; hyperextended
Pelvis- Anterior tilt (forward and down)
Knees- hyperextended
Ankle joints- plantar flexed, legs are behind midline





IDEAL

Evaluation

Lateral Evaluation

- Plumb Alignment: aligned anterior to lateral malleolus

Things to Examine

- Position of knees
  - Check for hyperextension or flexion
- Pelvic position and spine curvature
- Head, chest and abdominal position

Anterior Evaluation

- Position of feet
  - Check for pronation or supination
  - Check arch of the foot
- Position of legs
  - Check for bowlegs
- Position of knees
  - Check for knock-knees
- Appearance of ribs
- Position of head

Posture of Children

- Child development and flexibility allows for momentary deviations that would be considered faulty in adults.
  - Foot generally flat until 6-7 years of age
  - Hyperextension of knees common
  - Knock-knee common until 6-7 years of age

Factors that influence Posture

- Aging- your body gradually loses its capacity to absorb and transfer forces however its not aging that influences posture as does:
- Inactivity/sedentary living/reluctance to exercise -leads to loss of natural movement flow,
- Poor postural habits -eventually becomes your structure,
- Biomechanical compensation → muscle imbalance, adaptive shortening, muscle weakness & instability,

- Body composition – increases load, stresses on spinal structure, leads to spinal deviation,
- Workspace –ergonomics,
- Poor movement technique/execution/training ,
- Injury -leads to reduced loading capacity or elasticity,
- Others:

Posture is the single most common cause of painful soft tissue syndromes affecting the body!

Posterior Evaluation

- Plumb Alignment- align midway between heels

Things to Examine

- Note alignment of Achilles Tendon
- Hip adduction/abduction
- Check for level posterior iliac spine
- Check for lateral pelvic tilt
- Check for spine and shoulder problems

GAIT

- INTRODUCTION
- Gait is the medical term to describe human locomotion, or the way that we walk. Interestingly, every individual has a unique gait pattern. A person's gait can be greatly affected by injury or disease process.

THE GAIT CYCLE

- The gait cycle is used to describe the complex activity of walking, or our gait pattern. This cycle describes the motions from initial placement of the supporting heel on the ground to when the same heel contacts the ground for a second time

I. FUNCTIONS OF THE LOWER EXTREMITY

- Bipedalism is the process by which we are able to stand upright and to move about on 2 limbs.
- Bipedalism imparts three unique functions on the lower limbs.
- The limbs must
  - bear weight
  - provide a means for locomotion
  - maintain equilibrium.

A. Weight Bearing Properties

1. Support weight of head and torso with minimal expenditure of energy
2. Bony Features
    a. Relatively large areas of articulation
    b. Close pack fit of articular surfaces of bones involved in the formation of joints

Hip joint

C.Wide surface areas

- Knee joint

d. Weight supporting arches

- Arches of the foot

3. Ligaments

- Strong
- Maintain stable configuration

B. **Center of gravity**

1. Center of mass of body generally falls halfway between iliac crests and in front of second sacral vertebra

2. Position

- Posterior to hip joint
- Anterior to knee joint
- Anterior to ankle joint

- **C. Stability**

1. Position of joints during normal upright standing
   - Due to center of mass of body
2. Can be maintained while bearing weight with minimal expenditure of energy (muscle contraction)
3. Stable position maintained through use of : ligaments

   a. close packing of joints

- Position
  - Hip joint = extension
  - Knee joint = extension
  - Ankle joint = dorsiflexion
  - no ligamentous support
  - Foot = supinated position

II. Locomotion

A. Position of the Lower Extremity

1. Weight bearing / Fixed
    a. Motion occurs with foot fixed to ground
    b. Limb is in good position to support weight
2. Non weight bearing / Free
    - Foot is not in contact with the ground
    - Limb is not in a position to support weight
3. Same relative motion occurs in both position
    - Different bones will move

- B. Movements of the Lower Extremity
  - 1. Hip Joint

    a. Weight bearing - pelvis moves on femur

    b. Non weight bearing - femur moves on pelvis
    - Types
      - Flexion - Extension
      - Abduction - Adduction
      - Medial rotation - Lateral rotation

2. Knee Joint
   - Weight bearing - femur moves on tibia

   a. Non weight bearing - tibia moves on femur

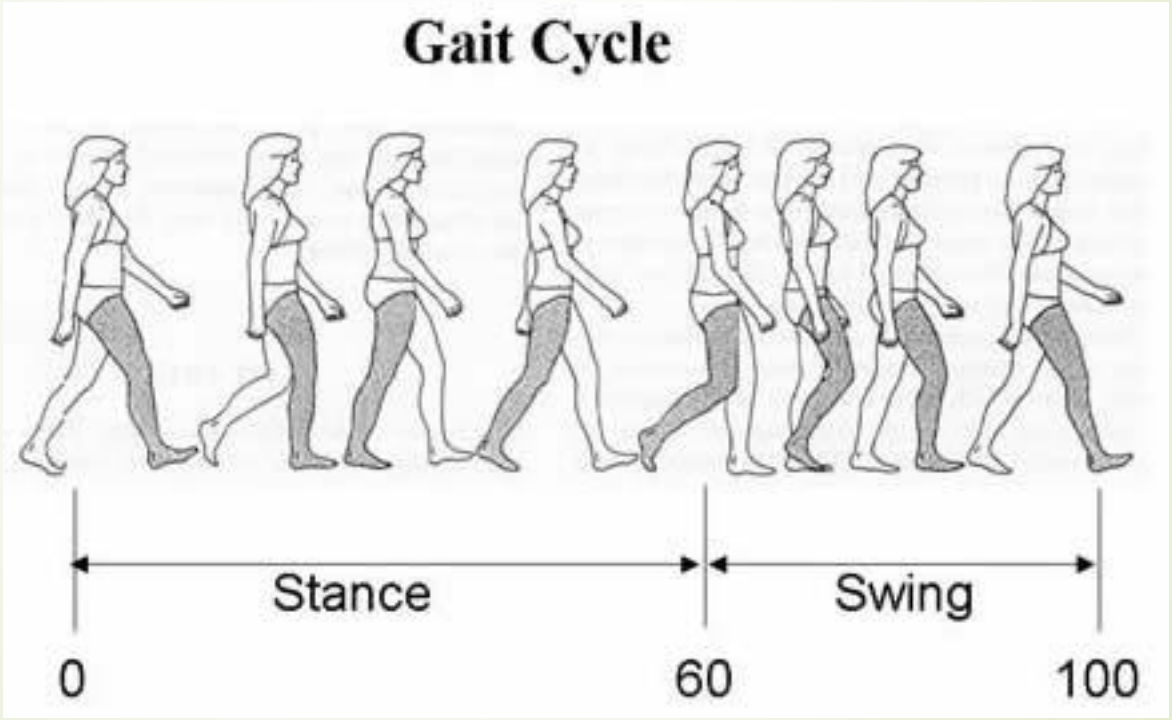
   b. Types
      - Flexion - Extension
      - Medial rotation - Lateral rotation

3. Ankle Joint
   - Weight bearing - tibia and fibula moves on foot
   - Non weight bearing - foot moves on tibia and fibula
   - Types
   - Dorsiflexion - Plantar flexion

4.Foot (Tarsal Joints)
   - Pronation - Supination

GAIT CYCLE

- The rhythmic alternating movements of the 2 lower extremities which result in the forward movement of the body. Simply stated, it is the manner in which we walk.
- The gait cycle is divided into two phases:
- 1) **Stance** -- defined as the interval in which the foot is on the ground (60% of the gait cycle)
  2) **Swing** -- defined as the interval in which the foot is not in contact with the ground (40% of the gait cycle)


Gait Cycle
Stance
Swing
0
60
100

- Stance is divided into four phases:
  1) Heel strike to foot flat
  2) Foot flat through midstance
  3) Midstance through Heel off
  4) Heel off to Toe off
- Swing is divided into two phases:
  1) Acceleration to midswing
  2) Midswing to deceleration

- Phases

1. **STANCE (support) PHASE** - Begins when the heel of the forward limb makes contact with the ground and ends when the toe of the same limb leaves the ground.

   a. Heel Strike - heel of forward / reference foot touches the ground

   b. Mid Stance - foot is flat on the ground and the weight of the body is directly over the supporting limb.

   c. Toe Off - Only the big toe of the forward / reference limb in contact with the ground.

2. **SWING (unsupported) PHASE** - Begins when the foot is no longer in contact with the ground. The limb is free to move.

- Acceleration - the swinging limb catches up to and passes the torso
- Deceleration - forward movement of the limb is slowed down to position the foot for heel strike.

3. **DOUBLE SUPPORT** - both limbs are in contact with the ground simultaneously .

4. **GAIT CYCLE** - the activity that occurs between heel strike of one limb (reference limb) and the subsequent heel strike of that same limb

Analysis of the Gait Cycle - Joint Position

1.Heel Strike

- Ankle joint = is in a neutral position. It is neither dorsiflexed nor plantar flexed
- Knee joint = flexed
  - Weight of body behind knee
  - Slight flexion helps absorb the impact of the foot contacting the ground from impact between
- Hip joint flexed
  - lengthens limb in preparation for contact between heel and ground. Helps provide for proper placement of foot so that the heel make contract with the ground.
- Foot = supinated

2. Midstance

- Ankle joint = dorsiflexed
- Knee joint = extended
  - lengthens limb to help support weight of torso which is now directly over limb
- Hip joint = Neutral
- Foot = Slight pronation

3.Toe Off

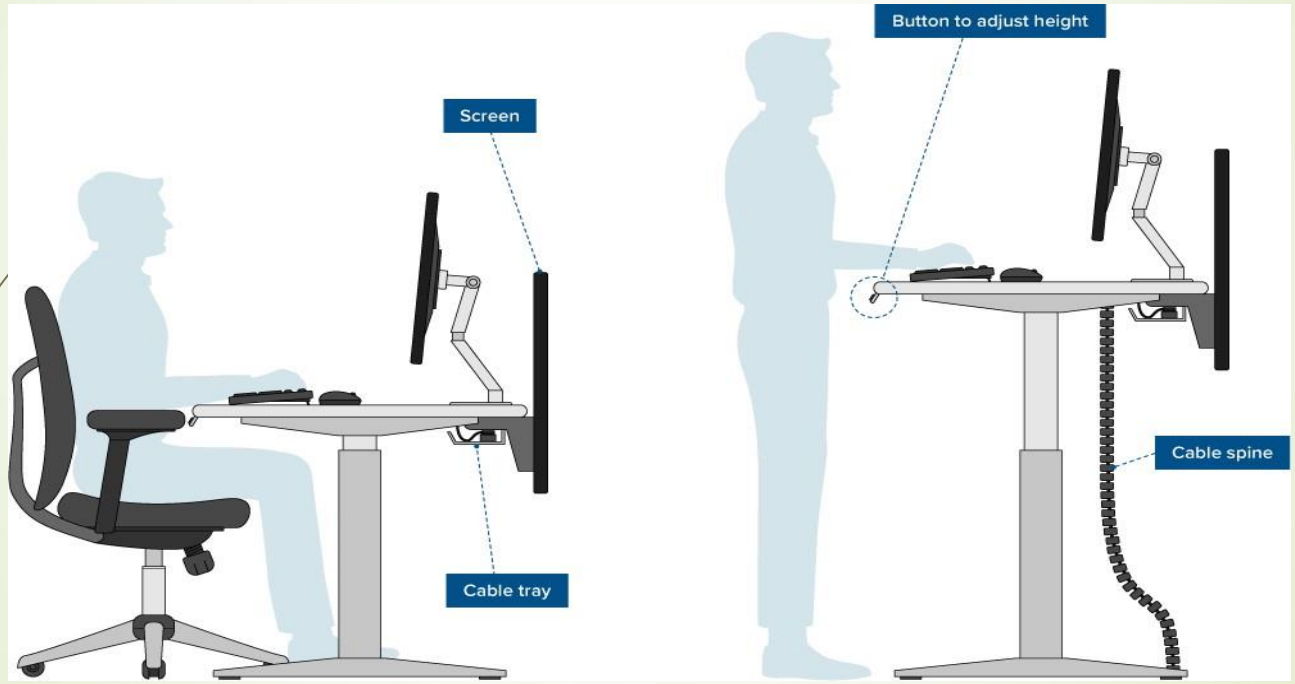
- Ankle joint = plantar flexed
  - triceps surae (superficial muscles in posterior compartment of leg) begin to contract strongly bringing the ankle joint into a plantar flexed position
- Knee joint = flexed
  - contraction of the gastrocnemius muscle , one of the triceps surae muscles, causes active flexion of the knee joint
  - shorten limb to allow clearance from ground
- Hip joint = Extended
  - Torso on the opposite side has moved forward of reference limb
- Foot = supinated

4. Acceleration

- Ankle joint = neutral
- Knee joint = flexed
  - shorten limb to maintain foot off of the ground
- Hip joint = flexed
  - Limb catches up to and then passes the torso
- Foot = slight pronation

- D. Determinants of Position
  - Active factors
    - Muscle activity is responsible for determining the position of the joint
  - Passive factors
    - Position of the joint is determined by forces such as gravity

      or movement of the opposite side of the body


Screen
Cable tray
Button to adjust height
Cable spine