Therapeutic exercise

Lec: 1

Body mechanics and movement

Learning Objectives:

By the end of this lecture, the student will be able to:

1. Group & Describe the purpose of the various bones used in skeletal articulations and Muscle attachment
2. Define and discuss the anatomical types of the Muscles and their function.
3. Identify the physiological structure of the skeletal muscles.
4. Describe the types of the skeletal muscles by fiber and associate each with a unique purpose.

5. Name & describe the types of joints in the body.

6. Identify &explain the anatomical planes and axes of the movement.

7. Identify the degrees of freedom of different joints.

I. Skeletal bones:

A. Divisions of the Skeleton (figure 1):

1. Axial Skeleton.

2. Appendicular Skeleton.

a) The skull.

b) The vertebral column (7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal).

c) Sternum.

d) Ribs (12 pairs).

2. Appendicular Skeleton

a. The bones of the upper extremity include the following:

 Arm region: upper arm- humerus.

 Forearm:

1. Radius: bone free to rotate located on the thumb.

2. Ulna: medial to the radius and longer.

 Hand bones: carpals (8 wrist bones), metacarpals (five bones in the palm of the hand), and phalanges (14 bones of the fingers).

b. The bones of the lower extremity include the following:

- Thigh: femur – patella.
- Leg: tibia- fibula.
- Foot: tarsal bones (7 ankle bones), metatarsals (5 bones of the forefoot), and phalanges (14 bones of the toes).

- B. Types of Bone Structures:
- 1. According to the bone Shape (table 1):
- □ Long bones
- □ Short bones
- □ Flat bones
- □ Irregular bones
- □ Pneumatic bones
- □ Sesamoid bones.

Table 1. Types of bones according to the shape:

Types of bone	Shape	Example
Long	Long longitudinal axes and expanded ends.	Arm and leg bones.
Short	Cube like with their lengths and widths are roughly equal.	Carpal bones, tarsal bone
Flat	Plate like with broad and smooth surfaces.	Cap of the skull, scapula, ribs and sternum.
Irregular	Have a verity of shapes.	Vertebrae, bones of the base of the skull and ear bones.
pneumatic	Contain air-filled spaces.	Skull bones.
Sesamoid	Typically, small bones embedded in tendons.	As the patella.

- 2. According to the dynamic structure:
- Compact bone: which forms the outer hard layer of bone.
- Spongy bone: which forms the inner delicate trabeculated layer of bone.

II. Muscles Types:

- ***Muscle***: is the contractile tissue of the body. Muscle cells contain contractile filaments that move past each other and change the size of the cell. Muscles are classified as skeletal, cardiac, or smooth muscles.

General function of the muscles:

- Their function is to produce force and cause motion.
- Muscles can cause either locomotion of the organism itself or movement of internal organs.

Types of the muscles:

There are three types of muscle (figure 2):

- **Smooth muscle** or "involuntary muscle" is found within the walls of the hollow internal organs and structures such as the esophagus, stomach, intestines, bronchi, uterus, urethra, bladder, blood vessels, and even the skin (in which it controls erection of body hair). Smooth muscle is under control of the autonomic nervous system and not under conscious control. It has non striated muscle cell that is spindle-shaped and has one central nucleus. Smooth muscle contracts slowly and rhythmically.

- **Cardiac muscle**: is also an "involuntary muscle" but is more akin in structure to skeletal muscle, and is found only in the heart. It is under control of the autonomic nervous system. The cardiac muscle cell has one central nucleus, like smooth muscle, but it is striated, like skeletal muscle. The cardiac muscle cell is rectangular in shape. It contracts strongly, and rhythmically.

Functions of the smooth and cardiac muscles:

Cardiac and smooth muscle contraction occurs without conscious thought and is necessary for survival. Examples are the contraction of the heart and peristalsis which pushes food through the digestive system.

- **Skeletal muscle or "voluntary muscle":** is anchored by tendons to bone and is used to effect skeletal movement such as locomotion and in maintaining posture. The peripheral nervous system controls the skeletal muscles. Thus these muscles are under conscious or voluntary control. The basic unit ifs the muscle fiber with many nuclei. These fibers are satiated (having transverse streaks) and each fiber acts independently of neighboring muscle fibers. An average adult male is made up of 40–50% of skeletal muscle and an average adult female is made up of 30–40% (as a percentage of body mass).

Figure 2. Three types of the muscle.

Function of the skeletal muscle:

1. They produce tension.
2. They are responsible for body motion.
3. They provide power either to mobilize bone ort to stabilize them. So it is considered as force generator system.
4. They maintain posture.

The physiological structure of the skeletal muscle (figure 3):

- The muscle as a whole is surrounded by connective tissue which is called epimysium, and another connective tissue sptae called perimysium is present between muscle bundles.
- Each muscle fiber in a bundle is surrounded by a connective tissue called endomysium.
- The skeletal muscle consists of striated muscle fibers. It contains longitudinal fibrils known as" myofibrils "which lie parallel to one another within the sarcoplasm (the cytoplasm of these muscle fibers).

- The myofibrils arrangement shows transverse striation due to presence of alternative dark (A-band) and light (I-band) on each myofibril. In the center of each A-band, there is H-band. While in the center of each I-band, there is Z- line.
- The area between two z lines is called sarcomere which is the functional contractile unit of the muscle fiber which contract and relax as one unit.

- Each myofibril contains two types of filaments which are responsible for the contraction of the skeletal muscle:
  a. Thin filaments; actin filaments.
  b. Thick filaments; myosin filaments. Cross bridges in between them to pull actin over myosin during muscle contractions.

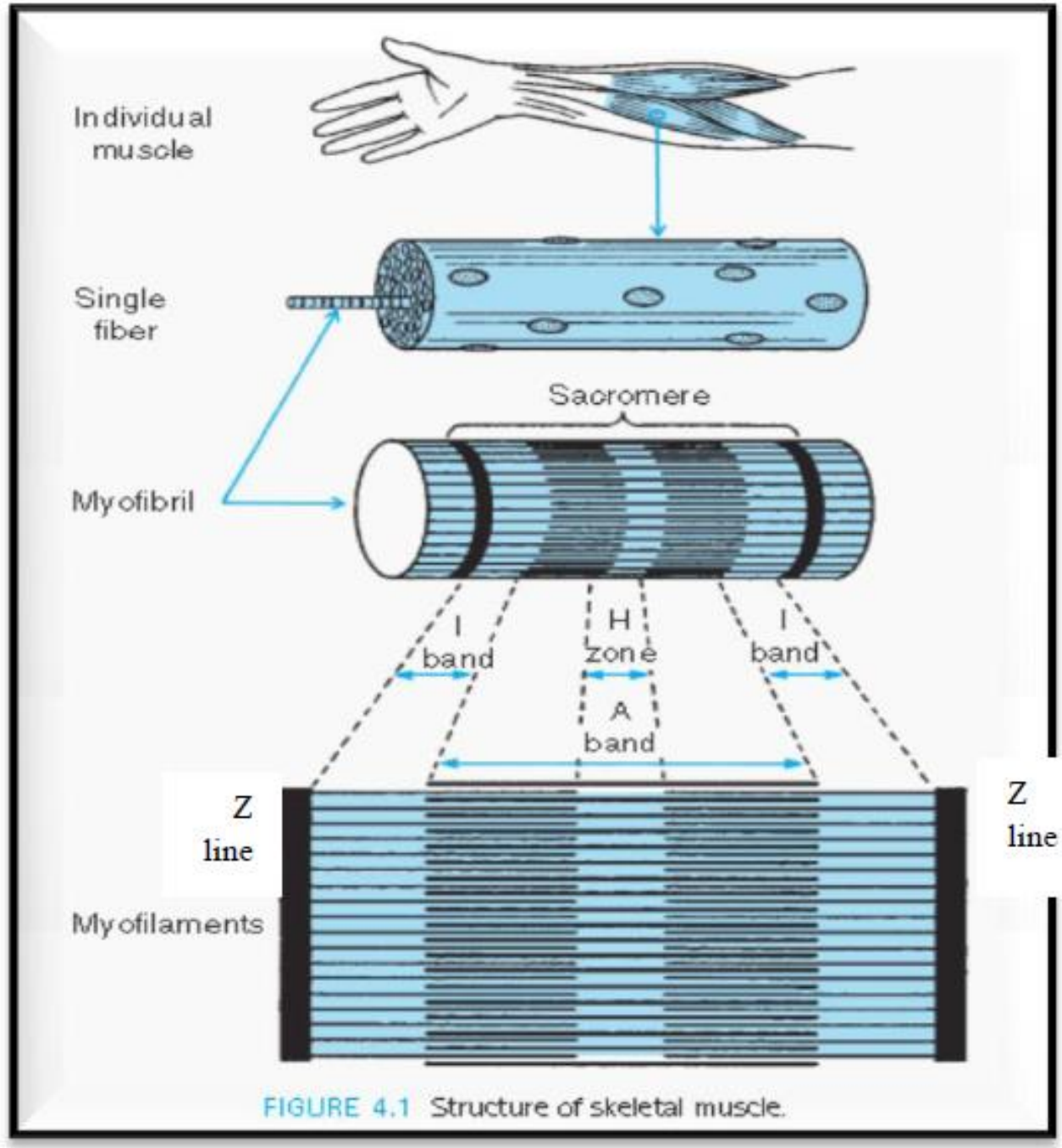


FIGURE 4.1 Structure of skeletal muscle.

Types of skeletal muscle fibers:

Skeletal muscle fibers are further divided into several subtypes:

- Type I, slow oxidative, slow twitch, or "red" muscle fiber is dense with capillaries and is rich in mitochondria and myoglobin, giving the muscle tissue its characteristic red color. It can carry more oxygen and sustain aerobic activity.
- Type II, fast twitch muscle, has three major kinds that are, in order of increasing contractile speed:
    - Type IIa, which, like slow muscle, is aerobic, rich in mitochondria and capillaries and appears red.

- Type IIx (also known as type IId), which is less dense in mitochondria and myoglobin. This is the fastest muscle type in humans. It can contract more quickly and with a greater amount of force than oxidative muscle, but can sustain only short, anaerobic bursts of activity before muscle contraction becomes painful (often incorrectly attributed to a build-up of lactic acid).
- Type IIb, which is anaerobic, glycolytic, "white" muscle that is even less dense in mitochondria and myoglobin.

III. Musculoskeletal Joints:

JOINTS:

- **Definition:** Is an articulation, the place of union or junction between two or more bones or parts of bones of the skeleton.

Types of joints: they may:

1. Immovable joints or synarthrosis. These allow no appreciable movement, and have no cavity. The bony surfaces are connected by cartilage or fibrous tissue.
2. Slightly movable joints or amphiarthroses. These permit limited movement and the bony surfaces are connected by fibrocartilage.
3. Freely movable joints or diarthroses. The freely movable joints permit varying types of movement.

Synarthroses joints:

Fibrous (or Immovable) Joints.

These joints are firmly held together by a thin layer of strong connective tissue. There is no movement between the bones such as the sutures of the skull and the teeth in their sockets (figure 4).

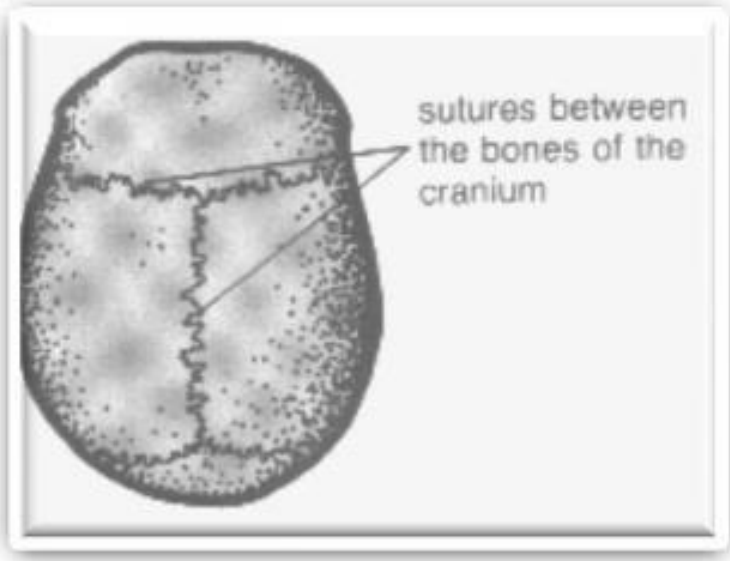


Figure 4. Fibrous joints (sutures in the skull).

Amphiarthroses:

Cartilagenous Joints.

Cartilagenous joints are joints where the articular surfaces of the bones forming the joints are attached to each other by means of white fibrocartilaginous discs and ligaments which allow only a limited degree of movement (figure 5). Examples are the cartilaginous disc between the vertebrae, the cartilage in the symphysis which binds the pubic bones together at the front of the pelvic girdle and the cartilage in the joint between the sacrum and the hip bone

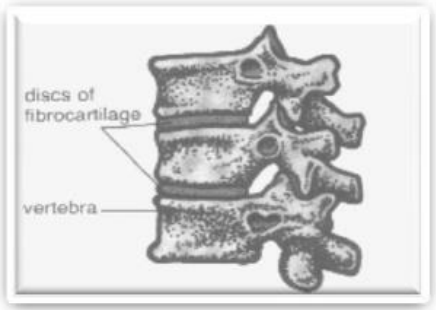


Figure 5. Cartilaginous joints between the thoracic vertebrae.

Diarthroses joints:

Synovial Joints.

These are freely movable joints. Most of the joints in the body are of the synovial type. The following are the main characteristics of a synovial joint (figure 6):

- The ends of the bones are covered with a layer of smooth hyaline cartilage, called articular cartilage in the joint regions. This reduces friction at the point.
- The joint is completely enclosed by a bag-like capsular ligament which holds the joint together and helps to contain the synovial fluid.

- The capsular ligament is lined with a synovial membrane. This membrane secretes synovial fluid into the synovial cavity; the synovial fluid lubricates the joint.
- The bones are also attached and held together by strong, tough ligaments made of dense connective tissue. These ligaments prevent dislocation during normal movement.
- The articulating surfaces of adjacent bones are reciprocally shaped.

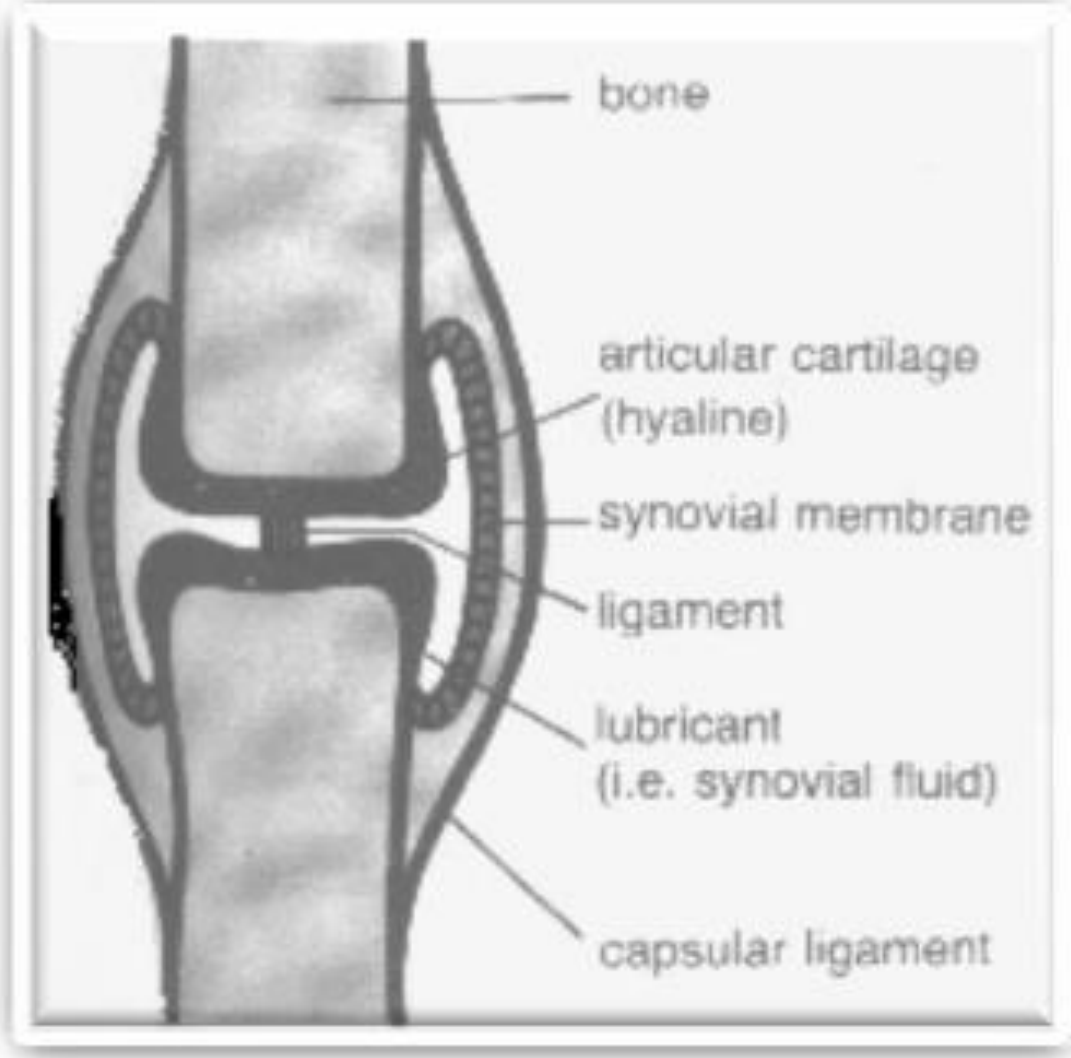


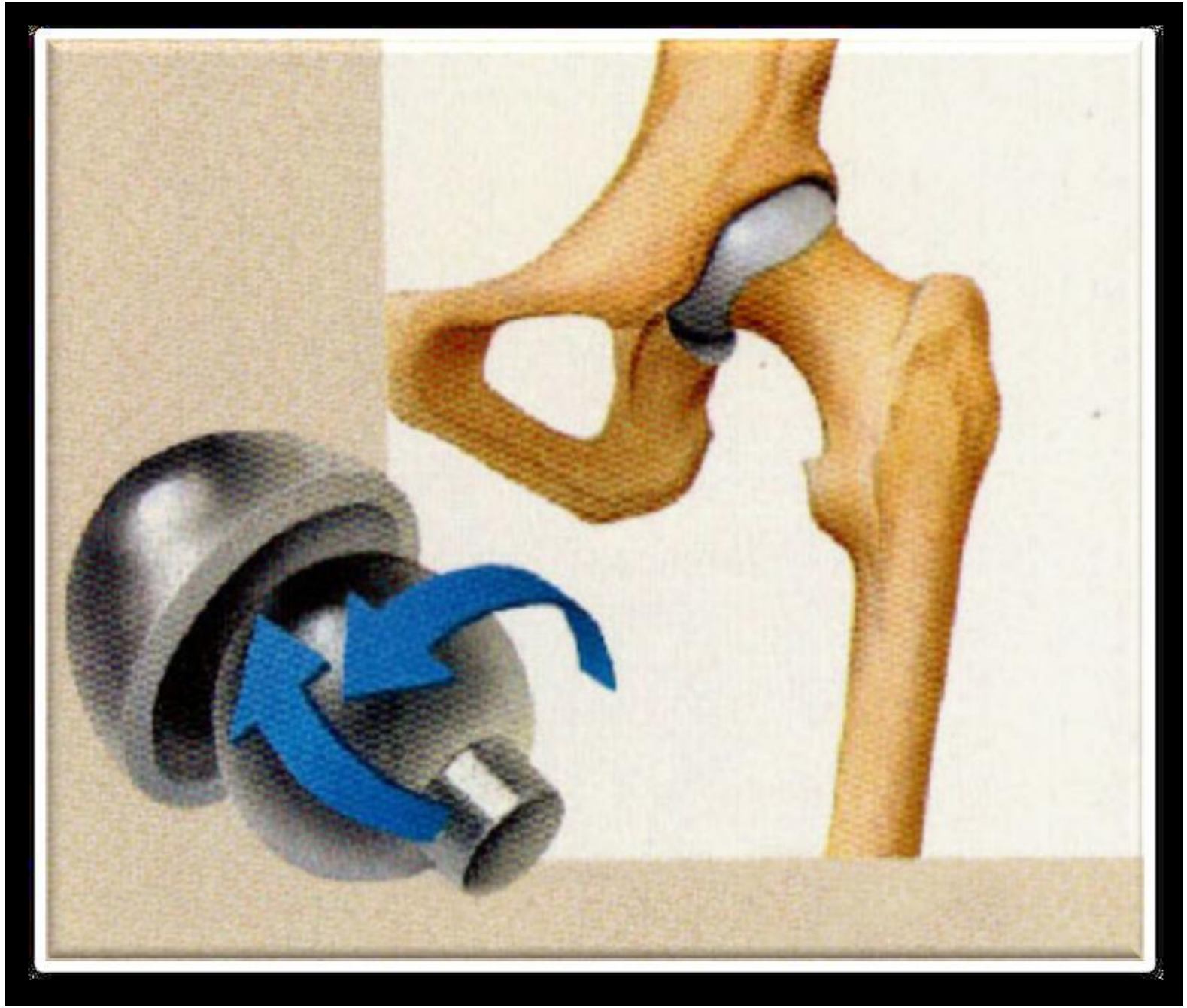
Figure 6. A generalized synovial joint.

Types of the synovial joints:

Synovial joints can be subdivided into the following groups according to the type of movement they carry out:

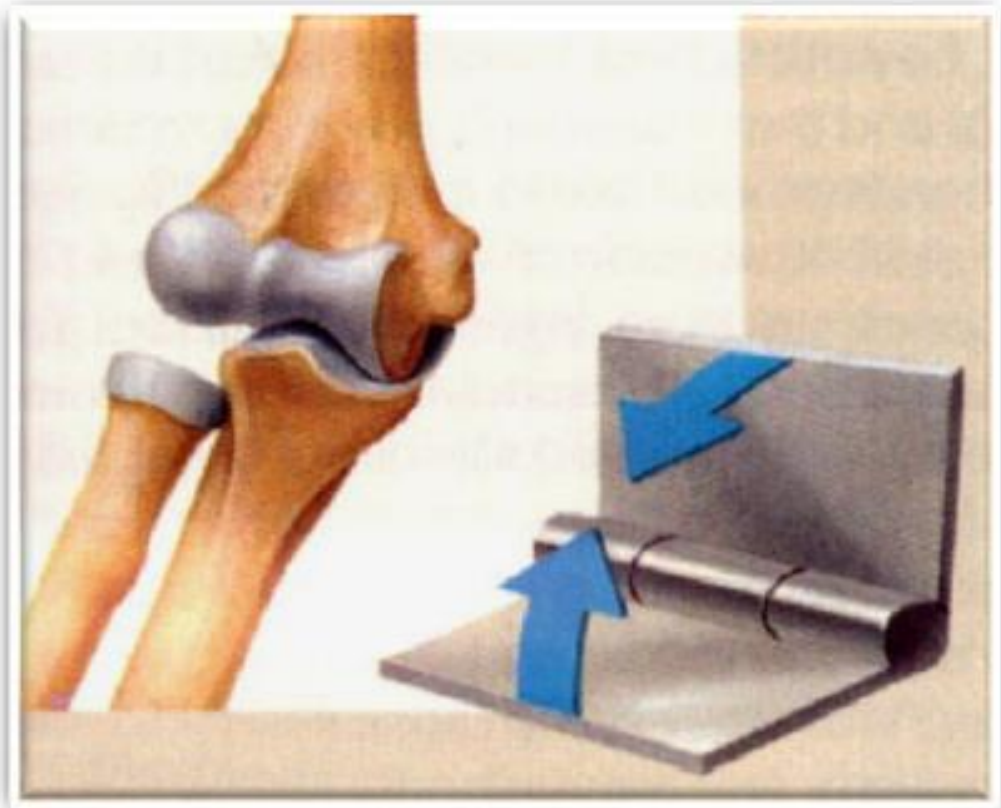
1. Ball-and-Socket Joints.

These joints are formed where the rounded head of one bone fits into the hollow, cup-shaped socket of another bone such as the shoulder joint and the hip joint (figure 7). Such joints allow freedom of movement in all directions.



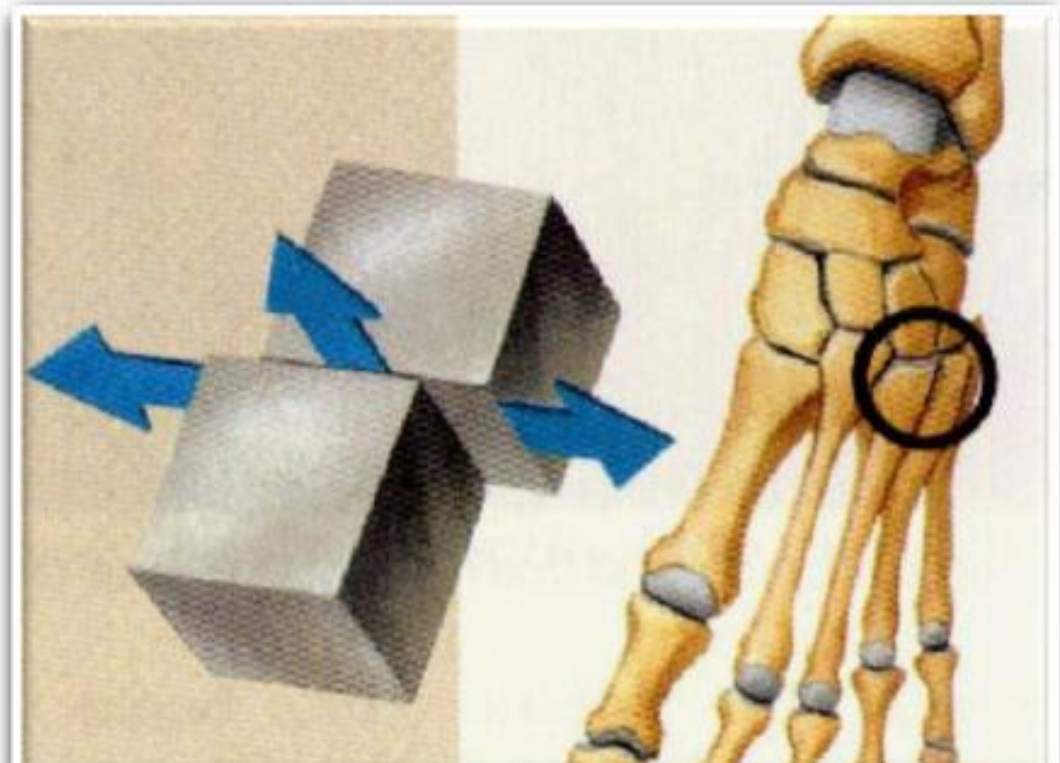
2. Hinge Joints.

These joints occur where the convex surface of one bone fits into the concave surface of another bone, so making movement possible in one plane only. Examples of these joints are the knee and the elbow joints. Hinge joints have ligaments mainly at the sides of the joints (figure 8).



3. Gliding Joints.

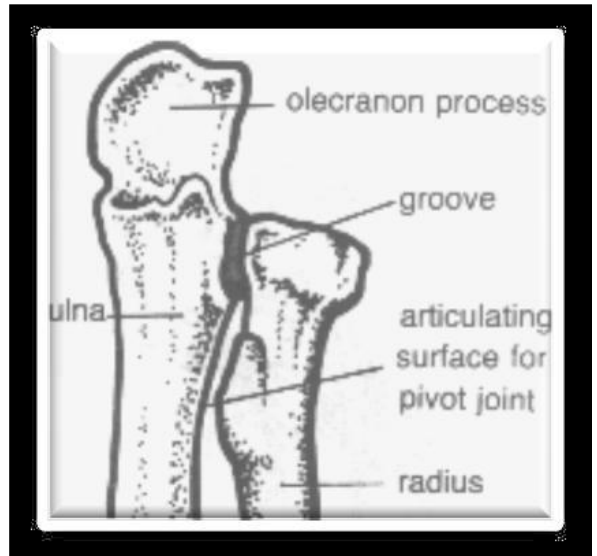
This type of joint allows for gliding movements between flat surfaces as the surfaces slide over one another. Only a limited amount of movement is allowed such as the joints between the carpal bones (figure 9), the joints between the tarsal bones and those between the articular processes of successive vertebrae.



4. Pivot Joints.

These joints occur where:

- A bony ring rotates round the pivot (axis) of another bone such as the ring-like atlas rotating around the odontoid process of the axis, allowing the head to turn from side to side.
- The end of one bone rotates round the axis of another bone such as the end of the radius rotating around the ulna as the palm of the hand is turned inwards or outwards (figure 10).

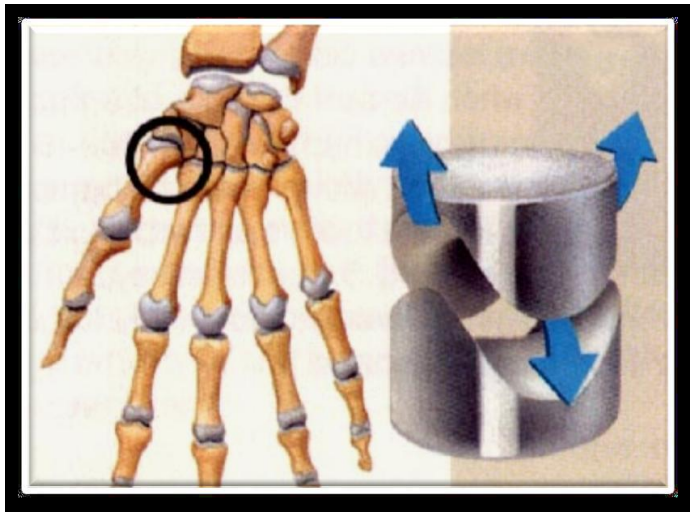


5. Condyloid joint.

- Biaxial
- In Condyloid joints the axes are at right angles to each other, Permitting flexion and extension, abduction and adduction and circumduction. E.g. metacarpophalangeal joint.

6. Saddle joints.

- Biaxial.
- Both articular surfaces have both concave and convex areas at right angles to each other. Saddle-shaped heads permit movement in two different planes (back/forth, up/down). E.g. Carpometacarpal joint of the thumb (figure 11).



7. Compound Joints.

These joints are made up of several joints between a number of different bones such as the set of joints which operate the movement of the skull on the vertebral column. The condyles at the base of the skull fit into the facets of the atlas, allowing for the nodding movement of the head. While one moves one's head, the atlas is able to rotate round the odontoid process of the axis, allowing the head to turn from side to side. There are also other articulating surfaces, where the atlas and axis meet. All these joints together make a compound joint with its many possible movements in the neck region (figure 12).

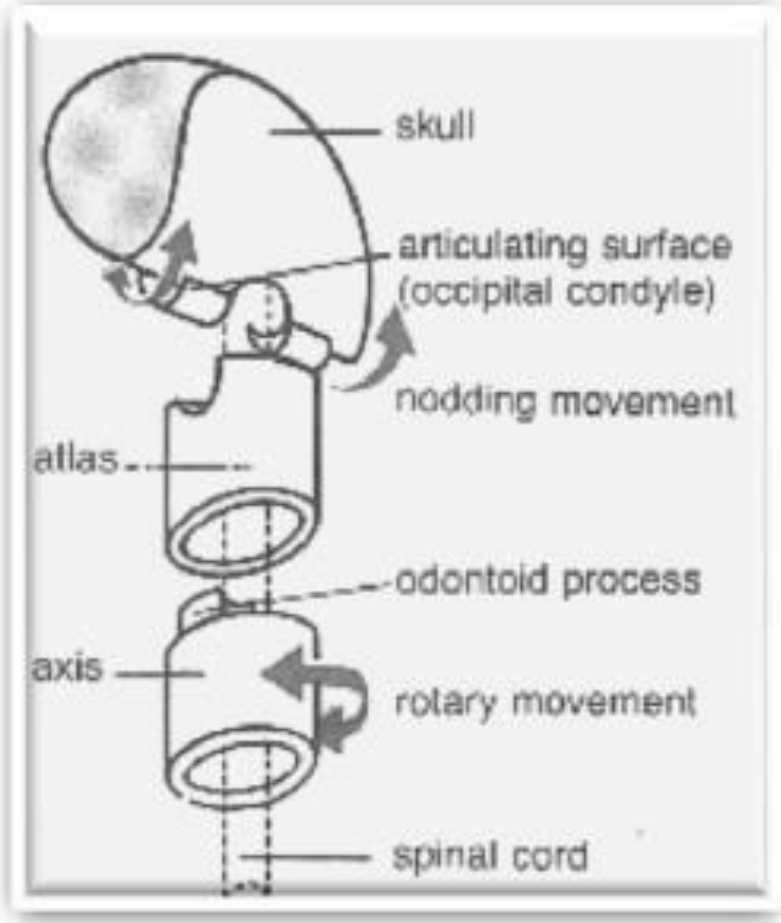


Figure 12. Model showing compound joints in the neck region.

8. Ellipsoid joints:

- Is an oval shape joint in which the joint surfaces are elongated or ellipsoidal.
- It is a biaxial joint. The two axes of motion at right angles to each other as the wrist joint.

VI. Anatomical planes and axes: figure 13.

Plane - is geometrical concept referring to an imagined flat surface. They are used to describe the sections of the body.

There are 3 main anatomical planes:

- **Sagittal plane** – it is an imaginary vertical plane (extending from front to back and top to bottom), dividing the body into left and right portions.
- **Frontal plane** – (also called the coronal plane) A vertical plane passing through the body (at right angles to sagittal plane) and divides the body into front (anterior) and back (posterior) portions

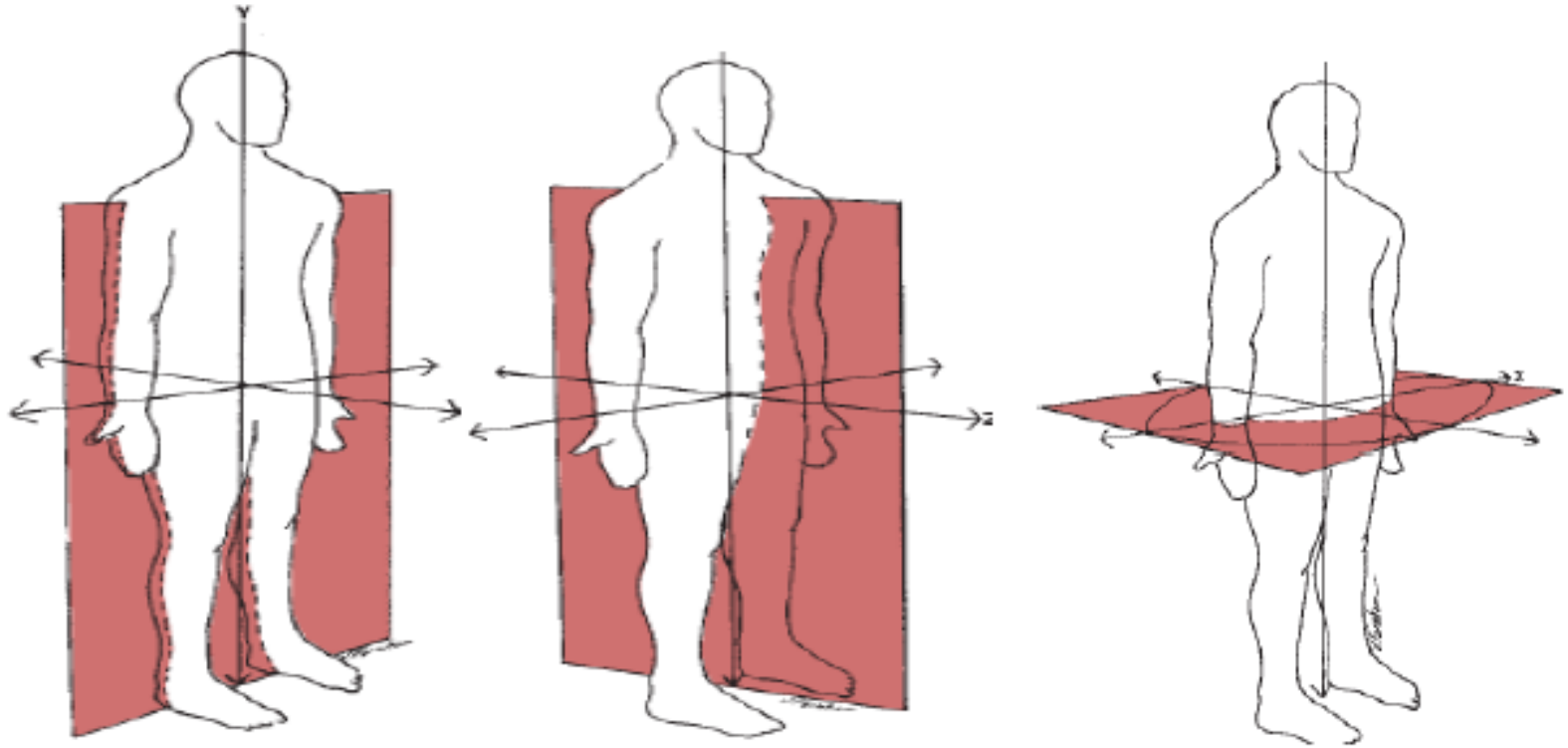
- **Horizontal plane** – (also called a transverse plane) It divided the body into top (superior) and bottom (inferior) portions.

Axes - are lines, real or imaginary, about which movement takes place. Related to the antomical planes, there are three basic types of axes at right angles to each other: (9)

1. A *sagittal axis* lies in the sagittal plane and extends horizontally from front to back (z axis). The movements of abduction and adduction take place about this axis in a coronal plane.

2. A *coronal axis* lies in the frontal plane and extends horizontally from side to side(x axis). The movements of flexion and extension take place about this axis in a sagittal plane.

3. **A *longitudinal axis*** extends vertically in a cranial-caudal direction through the length of long bones. The movements of medial and lateral rotation and horizontal abduction and adduction of the shoulder take place about this axis in a transverse plane.



A B C

Figure 13. A, Frontal plane. B, sagittal plane. C, Transverse plane.

V. Degrees of freedom- or how many directions can movement be produced.

A. UNIAXIAL- one degree of freedom - movements occur in only one plane - e.g. tibio-talar (ankle) joint permits only flexion and extension of the tarsus on the leg

B. BIAXIAL - two degrees of freedom independent movement possible in two planes. E.g. knee joint provides flexion and extension of leg on thigh as well as medial/lateral rotation of leg on thigh.

C. MULTIAXIAL - three degrees of freedom - independent movement around horizontal, transverse and sagittal planes. E.g. hip and shoulder joints.

INTRODUCTION

Exercise is one of the cornerstones of rehabilitation, widely used by many types of health professionals to manage an even wider range of medical conditions. It could be defined as ‘using voluntary muscle activity produced by the integration of higher centres, cardiovascular, pulmonary and neuro-musculoskeletal components to rehabilitate these systems.’ The aims and reported effects of exercise are also numerous.

Therapeutic Exercise

- **Definition**

- Systemic, planned performance of bodily movements, postures or physical activities intended to provide a patient/client with a means to prevent impairments; improve, restore, or increase physical function, prevent or decrease the health-related risk factors; optimize overall health status, fitness, or sense of well-being.

- **Patient** → Individual with impairments & functional limitations (diagnosed by a PT), who is receiving Physical therapy care to improve function & prevent disability.

- **Client** → Individual without diagnosed dysfunction, who engages in Physical therapy services to promote health & wellness, & to prevent dysfunction.

- Exercise can be delivered in a variety of ways: in the clinical setting or by teaching home exercises; as an individual or in a group setting; on land or in water. All approaches need to be considered to select the most appropriate for the individual requirements of each patient. The way in which the exercise is taught or delivered to an individual is also important in the ultimate success of this modality.

Aspects of Physical Function

- 1. Balance → Ability to align body segments against gravity, to maintain or move the body segments within the available BOS without falling.

OR

- Ability to move the body in equilibrium with gravity, via the interaction of sensory & motor systems.
- 2. Cardiopulmonary Fitness (Endurance) → Ability to perform the low-intensity, repetitive total body movements over an extended time period.

3. Flexibility → Ability to move freely, without restriction.

4. Postural control, stability & equilibrium → Synonym with static & dynamic balance.

5. Co-ordination → Correct timing & sequencing of muscle firing combined with appropriate intensity of muscular contraction leading to effective initiation, guiding & grading of movement.

6. Mobility → Ability of body structures or segments to move or be moved in order to allow the occurrence of ROM for functional activities.

- Active → depends on Neuromuscular activation
- Passive → depends on Soft tissue extensibility

7. Muscle performance → Capacity of muscle to produce tension & do physical work.

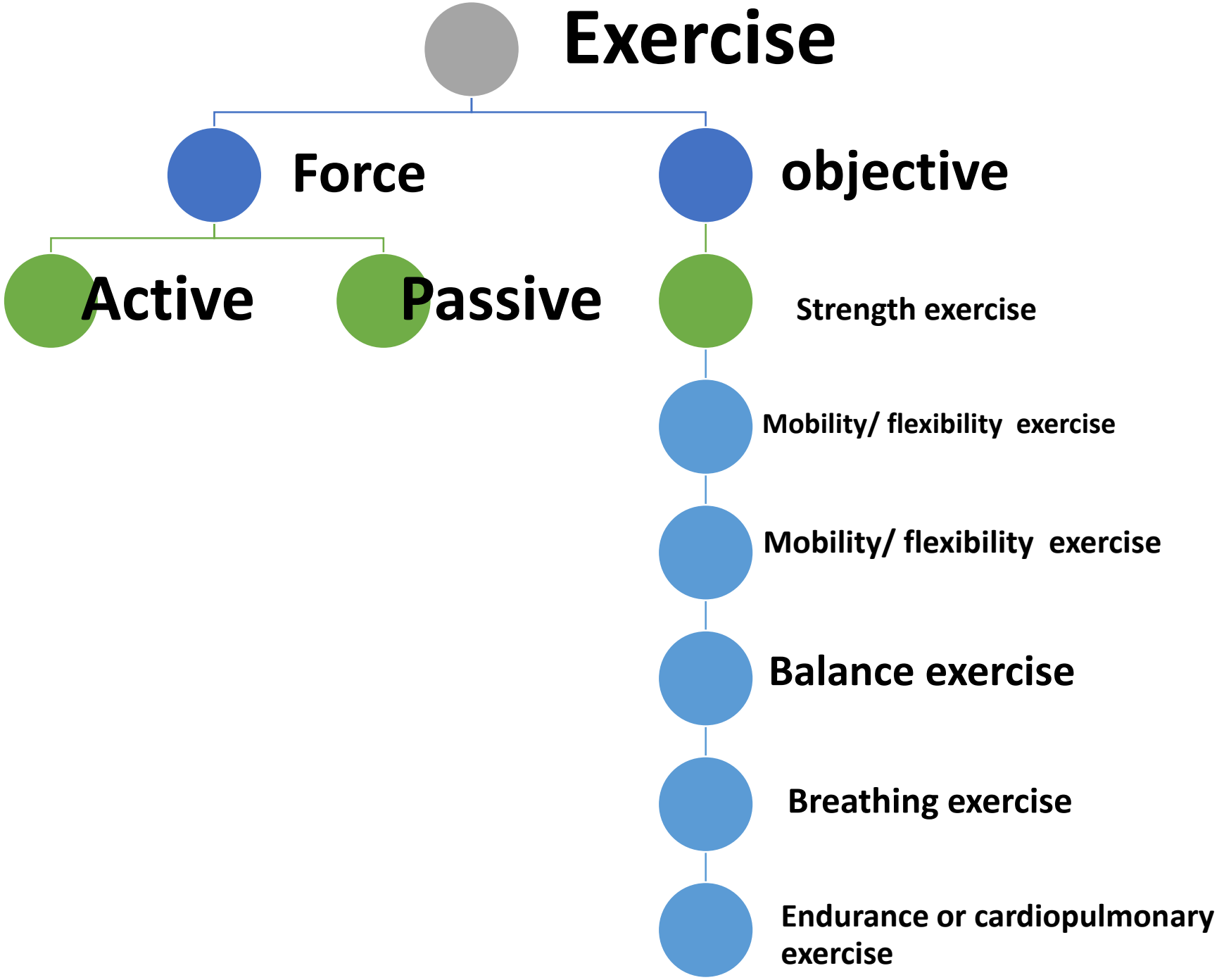
- 🡅 Encompasses → Strength, Power & Endurance.

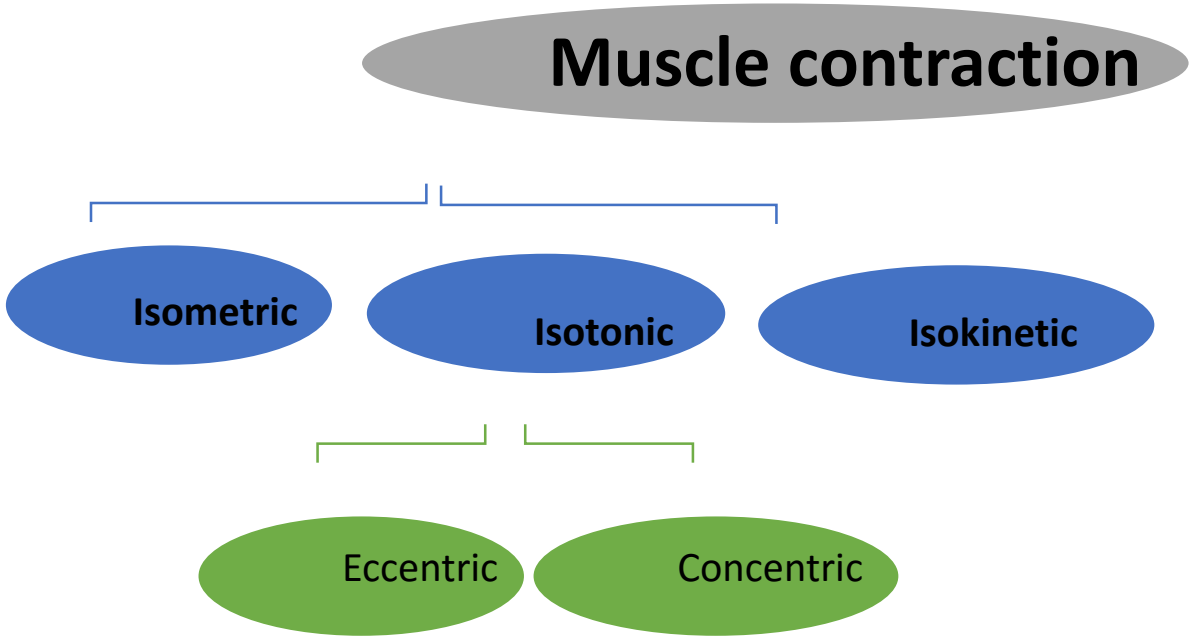
8. Neuromuscular control → Interaction of sensory & motor systems that enables the muscle to anticipate or respond to the proprioceptive & kinesthetic information & subsequently to work in correct sequence to create co-ordinated movements.

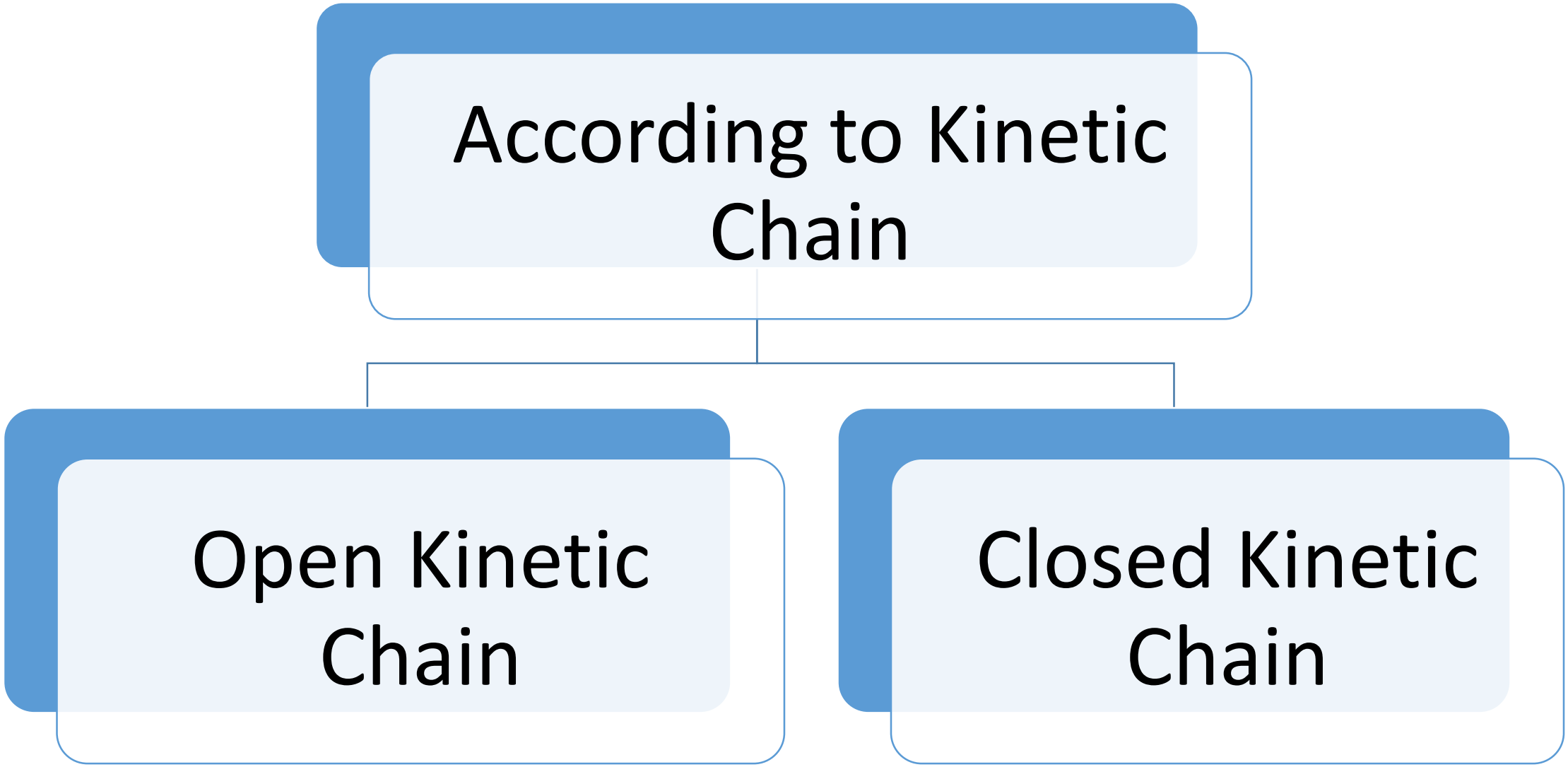
9. Stability → Ability of neuromuscular system through synergistic muscle action to hold a proximal part/distal body segment in a stationary position or to control a stable BOS during superimposed movement.

10. Joint stability → Maintenance of proper alignment of bony partners of a joint by means of passive or the dynamic components.

- Classifications of Therapeutic Exercise:
  - **Classification of therapeutic exercise on the basis of force required to produce movement:**
    - **Active**
    - **Passive**
  - **Classification of therapeutic exercise according to objective:**
    - **Strength exercise**
    - **Mobility/ flexibility exercise**
    - **Balance exercise**
    - **Breathing exercise**
    - **Endurance or cardiopulmonary exercise**
    - **….etc**
  - **Classification of therapeutic exercise according to muscle contraction:**
    - **Isometric**
    - **Isotonic**
    - **Isokinetic**


Exercise
Force
objective
Active
Passive
Strength exercise
Mobility/ flexibility exercise
Mobility/ flexibility exercise
Balance exercise
Breathing exercise
Endurance or cardiopulmonary exercise


Muscle contraction
Isometric
Isotonic
Isokinetic
Eccentric
Concentric


According to Kinetic Chain
Open Kinetic Chain
Closed Kinetic Chain

Therapeutic Exercise Interventions

- Aerobic conditioning & reconditioning.
- Muscle performance exercises → Endurance, Power, & Strength Training
- Stretching techniques → Muscle lengthening procedures, Joint mobilization
- Neuromuscular control, Inhibition, Facilitation, & Postural awareness training
- Postural control, Body mechanics, & Stabilization exercises
- Balance exercises & agility training
- Relaxation exercises
- Breathing exercises, Ventilatory muscle training
- Task-specific functional training