Skeletal & Muscular Considerations for Movement

Kinesiology
RHS 341
Lecture **3**
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The kinetic chain concept

- Extremities consist of several bony segments linked by a series of joints

Chain

1) **Open**-kinetic chain

- When the distal end of the extremity is not fixed to any surface.
- Allows any joint in the extremity to move without causing movement in the other joints.
- Example: shoulder shrug

2) **Closed**-kinetic chain

- When the distal end of the extremity is fixed to a surface.
- Movement of one joint can not occur without causing predictable movements of the other joint in the extremity.
- Example: push-up

Why learn kinetic chain?

- For determining appropriate ***conditioning exercises*** to improve function.

- Open-chain usually isolate one segment, while closed-chain exercises work all segments in the chain, resulting in conditioning of the muscles crossing each joint.

Kinetic chain

- Most sports involve closed-kinetic chain activities in the lower limb, and open-kinetic chain in the upper limb.

Kinematic chain

- Derived from combining degrees of freedom at various joints to produce movement.

- = the summation of the degrees of freedom in adjacent joints that identifies the total degrees of freedom available or necessary for the performance of a movement.

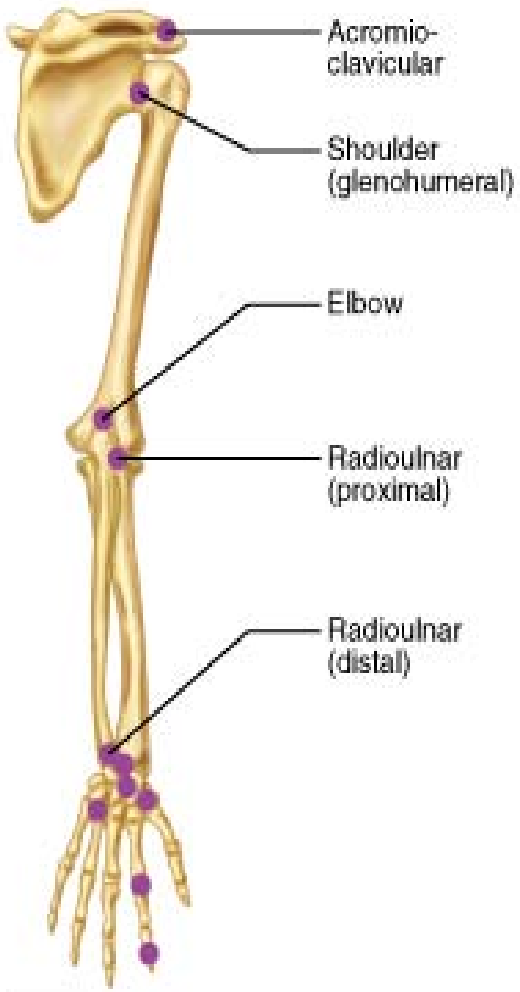

Illustration	Joint	Articulating bones	Structural type*	Functional type; movements allowed
	Acromio-clavicular	Acromion process of scapula and clavicle	Synovial; plane	Diarthrotic; gliding and rotation of scapula on clavicle
✦	Shoulder (glenohumeral)	Scapula and humerus	Synovial; ball and socket	Diarthrotic; multiaxial; flexion; extension, abduction, adduction, circumduction, rotation of humerus/arm
✦	Elbow	Ulna (and radius) with humerus	Synovial; hinge	Diarthrotic; uniaxial; flexion; extension of forearm
✦	Radioulnar (proximal)	Radius and ulna	Synovial; pivot	Diarthrotic; uniaxial; rotation of radius around long axis of forearm to allow pronation and supination
	Radioulnar (distal)	Radius and ulna	Synovial; pivot (contains articular disc)	Diarthrotic; uniaxial; rotation (convex head of ulna rotates in ulnar notch of radius)

*Fibrous joints indicated by orange circles, **cartilaginous joints** by blue circles, and **synovial joints** by purple circles.

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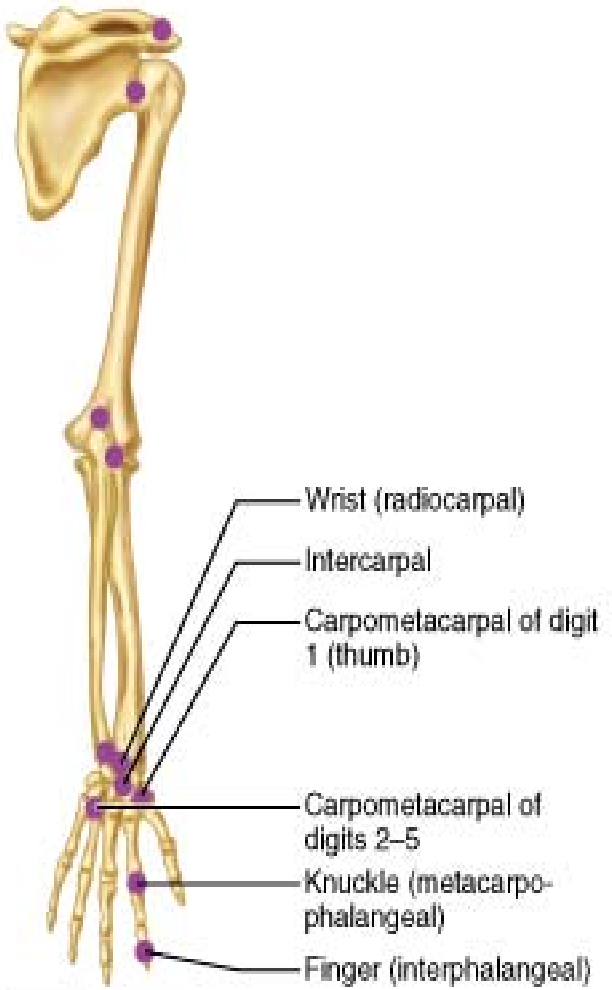	Wrist (radiocarpal)	Radius and proximal carpals	Synovial; condyloid	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction of hand
	Intercarpal	Adjacent carpals	Synovial; plane	Diarthrotic; gliding
	Carpometacarpal of digit 1 (thumb)	Carpal (trapezium) and metacarpal 1	Synovial; saddle	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction, opposition of metacarpal 1
	Carpometacarpal of digits 2–5	Carpal(s) and metacarpal(s)	Synovial; plane	Diarthrotic; gliding of metacarpals
	Knuckle (metacarpophalangeal)	Metacarpal and proximal phalanx	Synovial; condyloid	Diathrotic; biaxial; flexion, extension, abduction, adduction, circumduction of fingers
	Finger (interphalangeal)	Adjacent phalanges	Synovial; hinge	Diarthrotic; uniaxial; flexion, extension of fingers

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	Sacroiliac	Sacrum and coxal bone	Synovial; plane	Diarthrotic; little movement, slight gliding possible (more during pregnancy)
	Pubic symphysis	Pubic bones	Cartilaginous; symphysis	Amphiarthrotic; slight movement (enhanced during pregnancy)
	Hip (coxal)	Coxal bone and femur	Synovial; ball and socket	Diarthrotic; multiaxial; flexion, extension, abduction, adduction, rotation, circumduction of femur/thigh
	Knee (tibiofemoral)	Femur and tibia	Synovial; modified hinge	Diarthrotic; biaxial; flexion, extension of leg, some rotation allowed
	Knee (femoropatellar)	Femur and patella	Synovial; plane	Diarthrotic; gliding of patella

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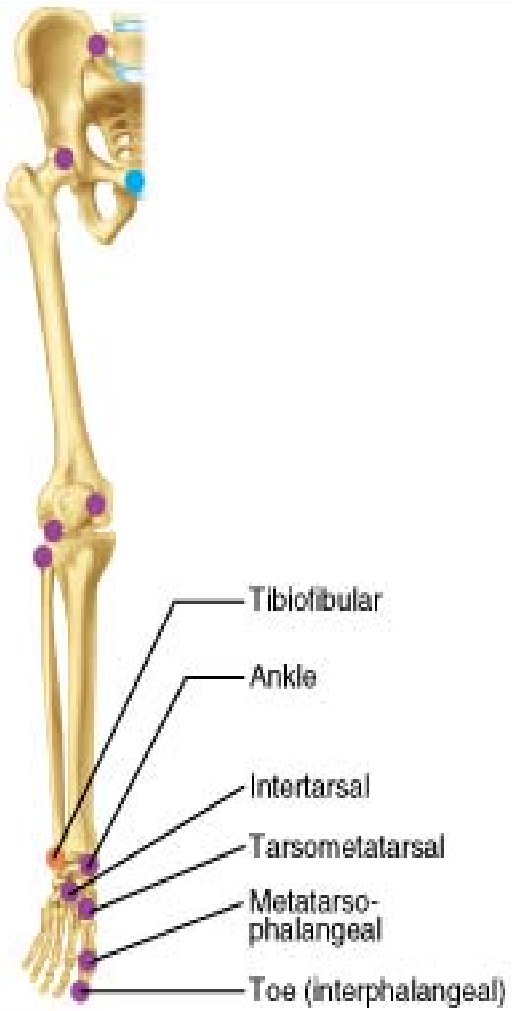	Tibiofibular	Tibia and fibula (proximally)	Synovial; plane	Diarthrotic; gliding of fibula
	Ankle	Tibia and fibula (distally); both anterior and posterior ligaments exist	Fibrous; syndesmosis	Synarthrotic; slight "give" during dorsiflexion of foot
		Tibia and fibula with talus	Synovial; hinge	Diarthrotic; uniaxial; dorsiflexion and plantar flexion of foot
	Intertarsal	Adjacent tarsals	Synovial; plane	Diarthrotic; gliding; inversion and eversion of foot
	Tarsometatarsal	Tarsal(s) and metatarsal(s)	Synovial; plane	Diarthrotic; gliding of metatarsals
	Metatarso-phalangeal	Metatarsal and proximal phalanx	Synovial; condyloid	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction of great toe
	Toe (interphalangeal)	Adjacent phalanges	Synovial; hinge	Diarthrotic; unaxial; flexion, extension of toes

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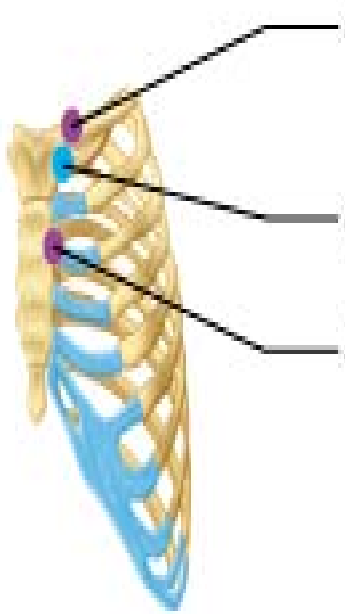
Table 9.2 Structural and Functional Characteristics of Body Joints

Illustration	Joint	Articulating bones	Structural type*	Functional type; movements allowed
	Sternoclavicular	Sternum and clavicle	Synovial; shallow saddle (contains articular disc)	Diarthrotic; multiaxial (allows clavicle to move in all axes)
	Sternocostal	Sternum and rib 1	Cartilaginous; synchondrosis	Synarthrotic; no movement
	Sternocostal	Sternum and ribs 2–7	Synovial; double plane	Diarthrotic; gliding

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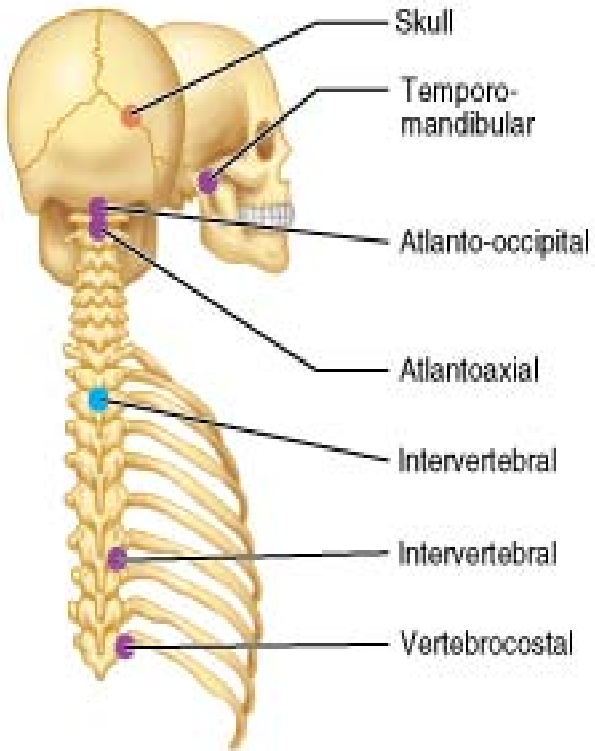	Skull	Cranial and facial bones	Fibrous; suture	Synarthrotic; no movement
	Temporomandibular	Temporal bone of skull and mandible	Synovial; modified hinge (contains articular disc)	Diarthrotic; gliding and uniaxial rotation; slight lateral movement, elevation, depression, protraction and retraction of mandible
	Atlanto-occipital	Occipital bone of skull and atlas	Synovial; condyloid	Diarthrotic; biaxial; flexion, extension, abduction, adduction, circumduction of head on neck
	Atlantoaxial	Atlas (C_1), and axis (C_2)	Synovial; pivot	Diarthrotic; uniaxial; rotation of the head
	Intervertebral	Between adjacent vertebral bodies	Cartilaginous; symphysis	Amphiarthrotic; slight movement
	Intervertebral	Between articular processes	Synovial; plane	Diarthrotic; gliding
	Vertebrocostal	Vertebrae (transverse processes or bodies) and ribs	Synovial; plane	Diarthrotic; gliding of ribs

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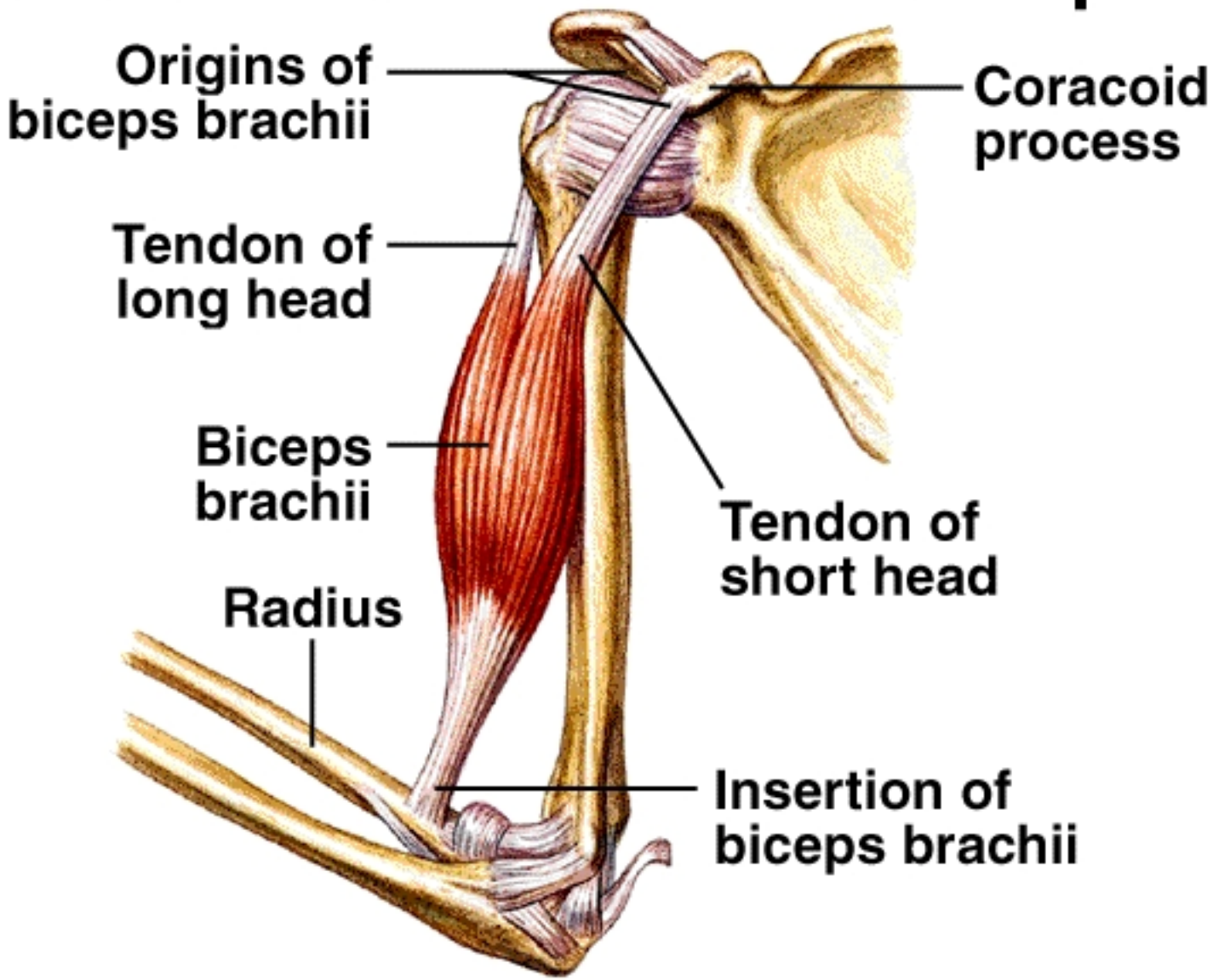
Muscle attachment

- A muscle typically attaches to a bone at both ends.

- **Origin**= proximal attachment
- **Insertion** = distal attachment

- Muscles pull equally on both ends (both attachment sites receive equal force).

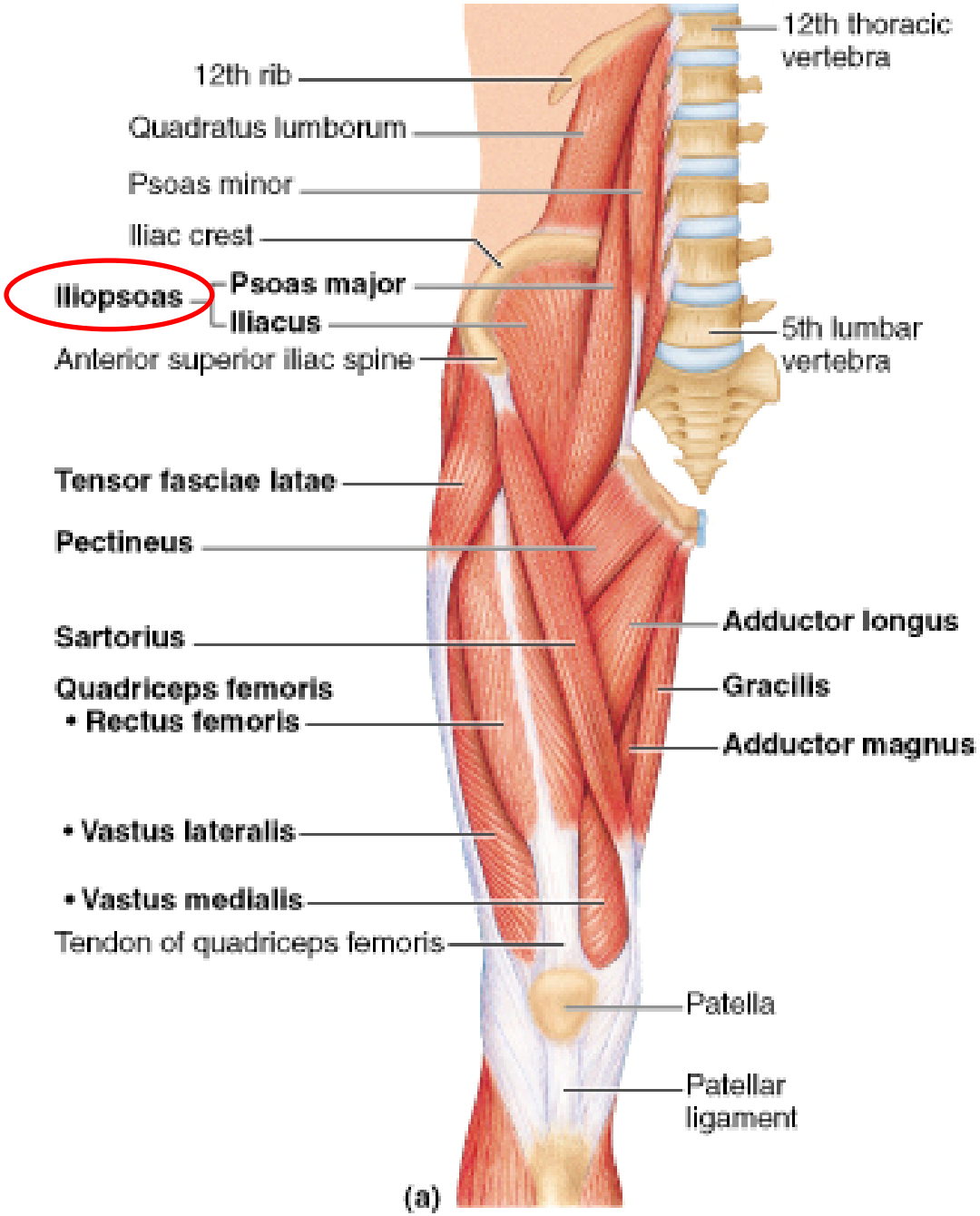
Skeletomuscular Relationship



Muscle attachment

- Both muscle ends can move depending on the activity….

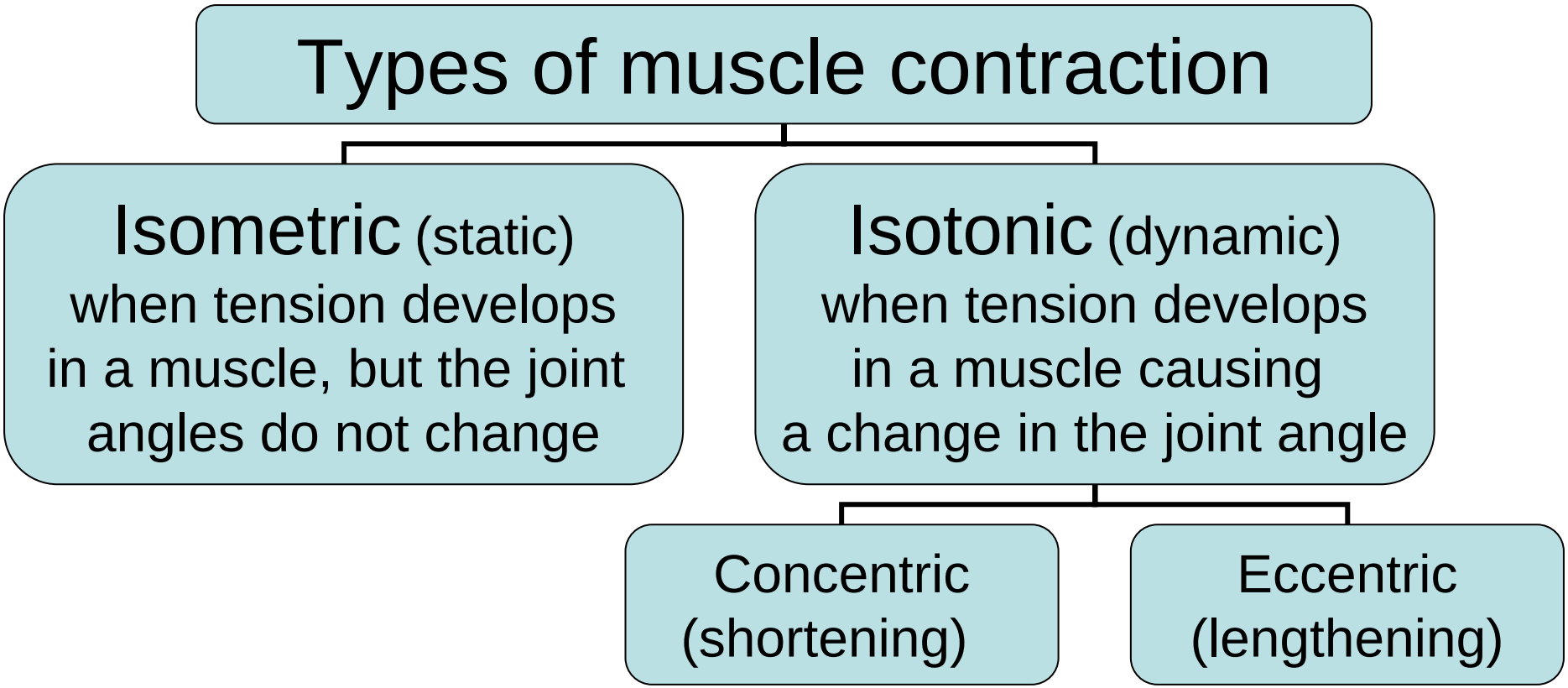
- Example: Psoas major
  - leg raise (hip flexion)
  - sit-up (trunk flexion)



Muscular contraction

- = active shortening of a muscle with the distance between the two muscle attachments decreasing

- But, muscles also produce force while lengthening….


Types of muscle contraction
Isometric (static)
when tension develops
in a muscle, but the joint
angles do not change
Isotonic (dynamic)
when tension develops
in a muscle causing
a change in the joint angle
Concentric
(shortening)
Eccentric
(lengthening)

Isometric contraction

- Static
- Muscle force = resistance force
- Muscle tension with NO change in:
  - Joint angle
  - Muscle length

Isotonic contraction

- Dynamic
- Muscle force greater OR less than resistance force
- Muscle tension with a change in:
  - Joint angle
  - Muscle length (shortening or lengthening)

Isotonic contraction
1) Concentric contraction

- Causes the body part to move against gravity or resistance.

- Muscle force greater than resistance force

- Muscle tension with a change in:
  - Joint angle
  - Muscle length (shortening)

Isotonic contraction
2) Eccentric contraction

- Control the movement with gravity or resistance.

- Muscle force less than resistance force

- Muscle tension with a change in:
  - Joint angle
  - Muscle length (lengthening)

Internal vs. external force

- **Concentric** contraction: internal forces produced by the muscles are greater than the external forces applied

- **Eccentric** contraction : external forces are greater than the internal force

Contraction & movement

- **Concentric** contraction:
  - movement occurs against gravity
  - joint moves towards the inner range
- **Eccentric** contraction:
  - movement occurs slowly in the direction of gravity
  - joint moves towards its outer range

Muscle force

- **Concentric** contraction: produce the **lowest** magnitude of muscle force……**why**???

- **Eccentric** contraction: produce the **highest** magnitude of the muscular force

Note

- If a movement occurs in certain direction, **slowly towards gravity**, the group of muscles that is opposite to this direction is acting in an eccentric contraction.

Example

- Elbow extension in the direction of gravity:
- What is the acting muscle group?

Isometric contraction

- The overall **muscle length** does not change
- The **internal force** produced by the muscle equals the effects of the external forces
- No **joint movement** is produced
- No **mechanical work** is done, but fatigue develops…why??
- Produce intermediate magnitude of **muscle force**

Isokinetic exercises

- Specific technique of exercise that may use any of the muscle contractions.

- = ***dynamic exercise*** using concentric and/or eccentric muscle contraction in which (throughout the movement):
  - the speed (or velocity) is constant
  - muscle contraction ideally maximum

Isokinetic exercises

- **Procedure:** The subject is positioned so that the body movement to be measured is isolated. The equipment is then set at different speeds and the force applied can be measured throughout the range of movement.

Isokinetic exercises

- **Results**: The results are often reported at different speeds so that a **speed/strength/power relationship** can be seen. Comparison of the relative strengths of the different sides of the body, or agonists/antagonists (quads/hamstrings) can show specific limitations.

Isokinetic exercises

- **Equipment required:** Isokinetic testing equipment (e.g. Biodex, Cybex)
- **Advantages**: nearly any joint action can be tested by the adjustment of the equipment.
- **Disadvantages:** the equipment required is bulky and expensive.

Passive movement

- Occurs without any muscle contraction.
- = movement produced by external forces such as those applied by a therapist, resistance, or the force of gravity.