Muscle Activity and Strength

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Learning Objectives

By the end of this chapter, the student should be able to:

- Explain the differences in various muscle activation methods;
- Discuss the differences between the types of muscle functions;
- Explain the Passive Excursion of Muscles (Passive Insufficiency and Tendon Action of Muscle)

Chapter outline

- Introduction
- Muscle Activity
  - Recording of Contraction
  - Terminology of Muscle Contraction
  - Anatomic action of muscles
  - Functional Terminology of Muscle Activity
- Passive Excursion of Muscles
  - Passive Insufficiency
  - Tendon Action of Muscle

Introduction

- The largest and most frequent source of force generated within the body is by contraction of muscles.
- Additional passive force from tension on fascia, ligaments, non-contractile structures of muscle.
- Normally, muscle never contract alone because this would produce ***a stereotyped nonfunctional motion.***

Introduction

- Eg. The isolated contraction of biceps brachii would produce elbow flexion, supination and shoulder flexion.
- Several muscles in an exquisite combination of forces contribute to produce the desire force and resulting motion or segment position.
- Soft tissues may transmit active forces of muscles through attachments to fascia, ligaments, cartilages, joint capsules, and tendons of other muscles as well as to bones.

Muscle activity

Recording of contraction

- The role of individual muscle or group of muscles may be **examined by palpating** the muscle to judge when it is active or relaxed.

- Only one or two superficial muscles can be examined at one time

- There is **no record for analyzing the timing or magnitude of muscle contraction.**

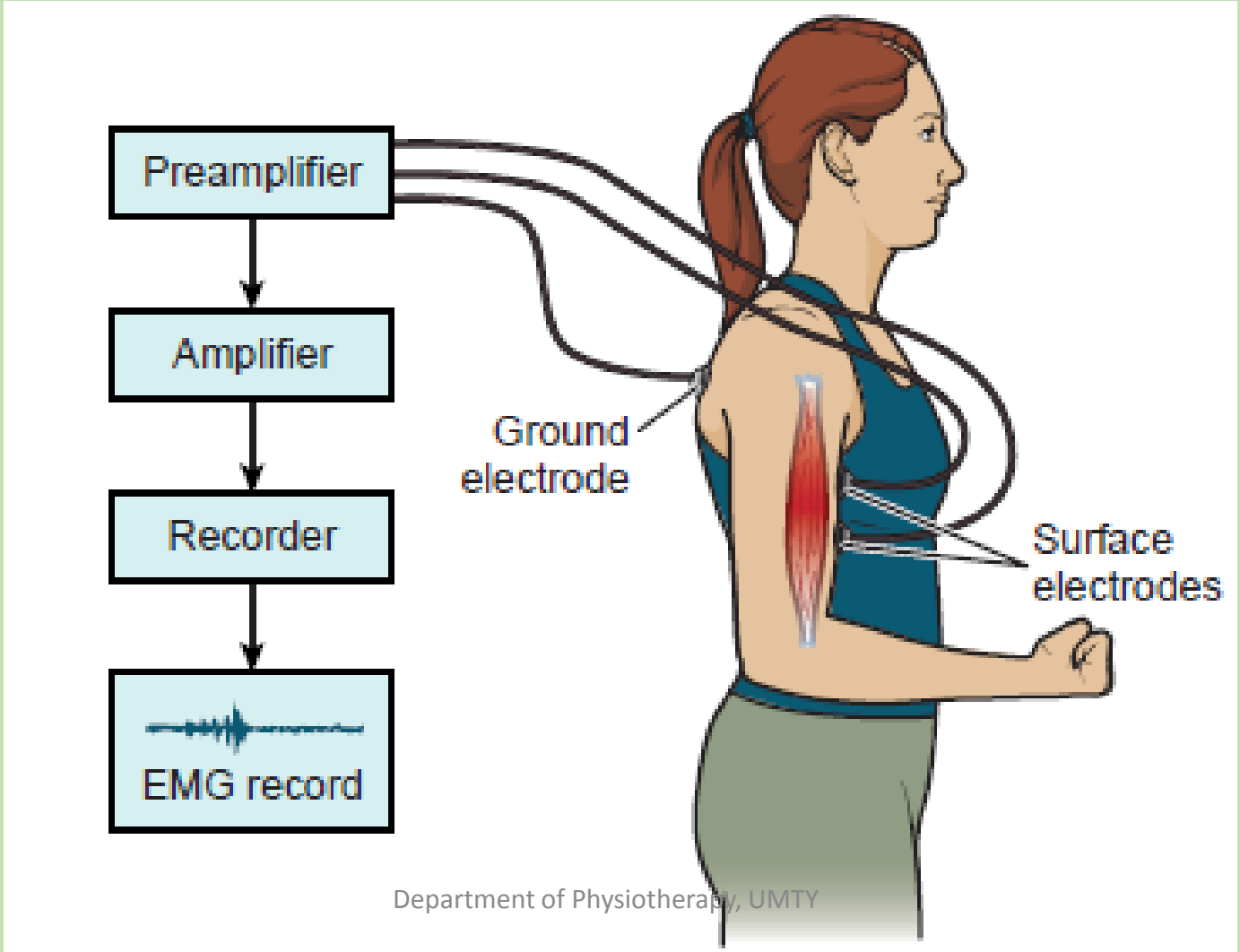
Muscle activity

- Since activation of muscle fiber is associated with transient depolarization and repolarization of muscle fiber membrane

- Recording electrodes placed on the skin overlying a muscle can be used to monitor the small changes in electric field produced by the conduction of muscle action potentials over groups of muscle fibers.

EMG

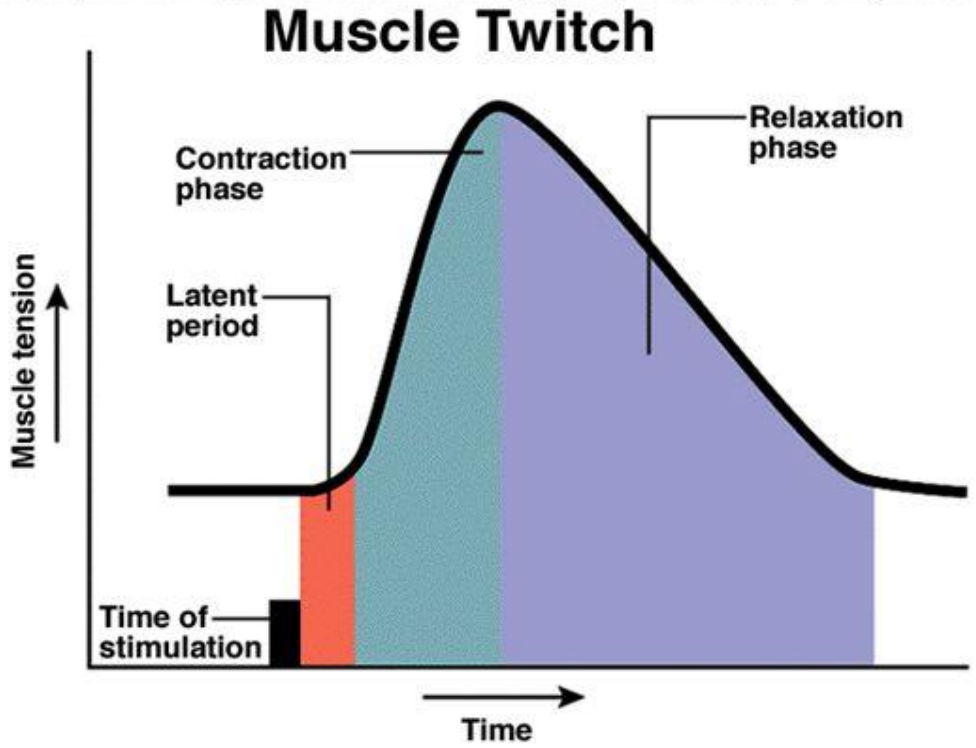
Recording muscle output and activity using surface, needle, or indwelling wire electrodes is called electromyography (EMG)



Muscular Responses

- Recording a Muscle Contraction

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Muscle activity

- The development of amplifying and recording equipment during World War II made it possible to use improved methods for study of muscle activity.

- Recording muscle output and activity using surface, needle, or indwelling wire electrodes is called electromyography (EMG)

- Each pairs of electrodes is connected to a channel of recording apparatus.

Muscle activity

- The use of multichannel instruments allows the contraction and relaxation pattern of several muscles to be recorded simultaneously during some particular movement or postural state of a joint.

Muscle Activation or Terminology of Muscle Contractions

- A muscle is able to produce different types of muscle tension, either with or without movement.
- There are different types of motions that muscle activation produces.
- This section briefly describes each of them.

Muscle Activation or Terminology of Muscle Contractions

1. Isometric

- A muscle contracts and produces force **with no gross change in the joint angle**, the contraction is said to be isometric.
- iso=equal, metron=measure
- Often called static or holding contractions.
- Functionally these contractions stabilize joints.

Eg. To reach forward with the hand, the scapula must be stabilized against the thorax.

Muscle Activation or Terminology of Muscle Contractions

2. Concentric

- **A shortening of muscle** during contraction is called a concentric contraction or shortening contraction.

eg. The quadriceps muscle when an individual is rising from a chair. OR

The elbow flexor when an individual is lifting a glass of water to mouth.

- Concentric contractions produce acceleration of body segments.

Muscle Activation or Terminology of Muscle Contractions

3. Eccentric

- When **the muscle lengthens** during contraction, it is called eccentric or lengthening contraction.

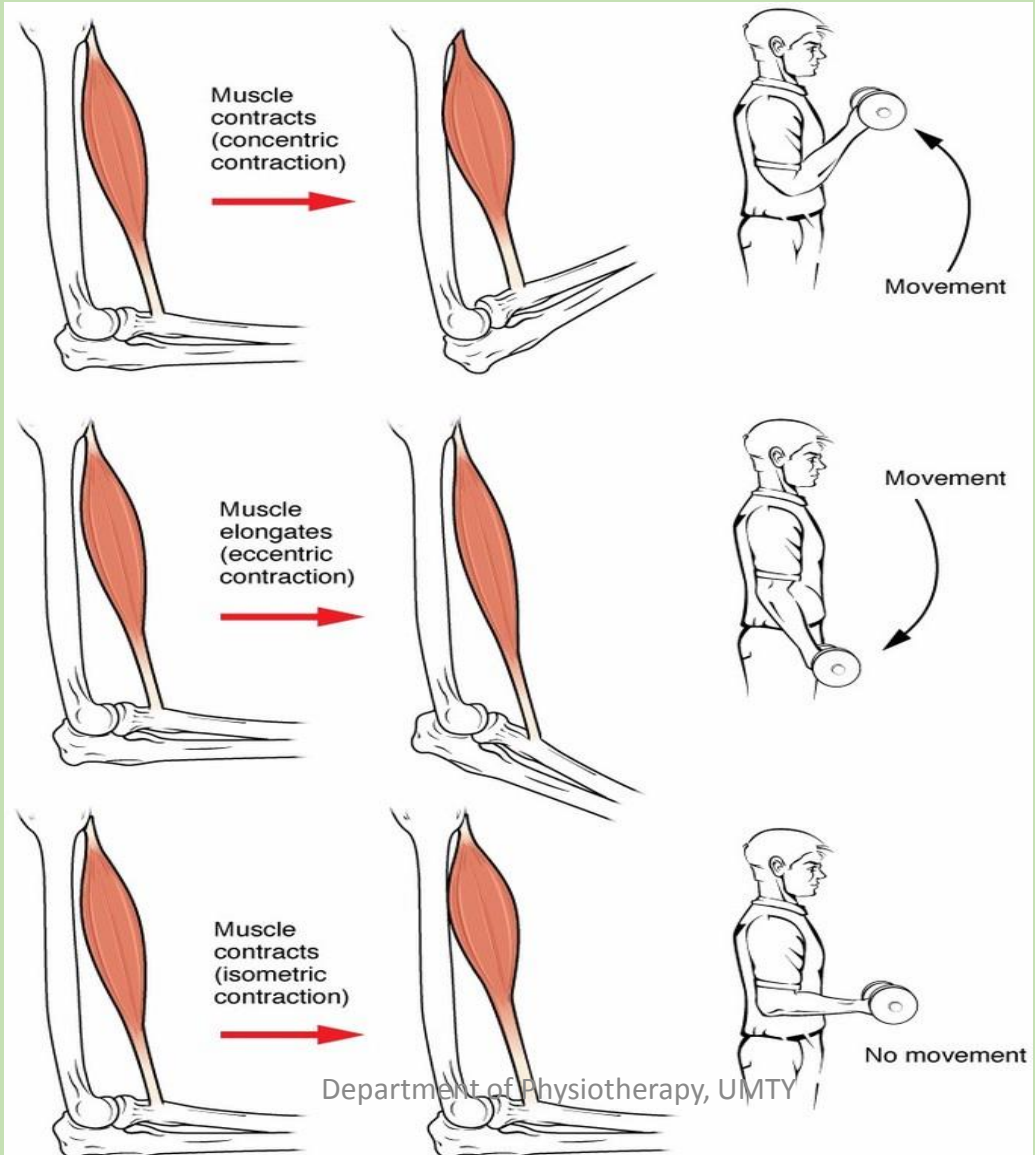
- eg. The quadriceps muscle when the body is being lowered to sit. OR

- The elbow flexors when the glass of water is lowered to the table.

- Eccentric contractions decelerate body segments and provide shock absorption as when landing from a jump or in walking.

Muscle Activation or Terminology of Muscle Contractions

Concentric, eccentric and isometric



Muscle Activation or Terminology of Muscle Contractions

4. Isokinetic

- iso,=equal,kinetos= moving
- Occurs when **the rate of movement is constant.**
- An electromechanical device (an isokinetic dynamometer) has been developed
- That limits the rate of movement of a crank-arm or a pulley to some preset angular velocity
- Regardless of the force exerted by the contracting muscle

Muscle Activation or Terminology of Muscle Contractions

Isokinetic dynamometer



Muscle Activation or Terminology of Muscle Contractions

4. Isokinetic

- The axis of rotation of the crank arm of isokinetic device is aligned with the anatomic axis of moving joint.

- The device **controls the speed of body movement** without permitting acceleration to occur.

- During isokinetic exercise the resistance accommodates the external force at the skeletal lever so that the muscle maintains the maximum output throughout the full range of motion.

Muscle Activation or Terminology of Muscle Contractions

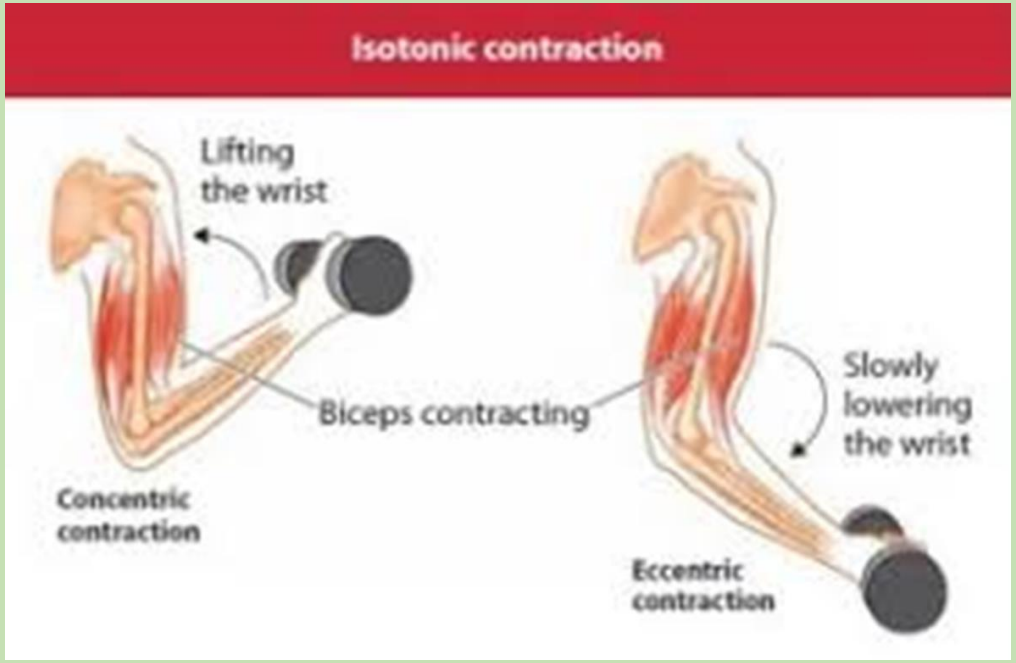
5. Isotonic

- Iso= equal, tonus=tension
- The term was used to refer to the contraction of a muscle detached from the body and lifting a load vertically against gravity.
- Isotonic contractions occur when muscles are acting through the lever systems of the body.
- The tension requirements of the muscle change continuously with changing leverage and the torque exerted by the weight changes with changing joint angles.

Muscle Activation or Terminology of Muscle Contractions

5. Isotonic

- Isotonic contractions maintain constant tension in the muscle as the muscle changes length.
- This can occur only when a muscle's maximal force of contraction exceeds the total load on the muscle.
- Isotonic muscle contractions can be either concentric (muscle shortens) or eccentric (muscle lengthens).



Anatomic action of Muscles

Anatomically, muscles are described by their

- Proximal attachment (origin)
- Distal attachment (insertion)
- Actions in producing specific joint motion

Anatomic action of Muscles

- It is important to recognize that these factors can be used to predict muscle function only under the limited circumstances in which all of the following occur:
  1. The proximal attachment is stabilized
  2. The distal attachment moves toward the proximal attachment (concentric contraction)
  3. The distal attachment moves against gravity or resistance
  4. The muscle acts alone

Anatomic action of Muscles

- These circumstances rarely occur in normal function for several reasons:
  1. Proximal attachment moves toward the fixed distal attachment (closed kinematic chain)
  2. Contractions are often eccentric or isometric
  3. Movement of the distal segment often assisted by force of gravity
  4. Muscle seldom if ever acts alone, they more often act conjointly with other muscles

Functional Terminology of Muscle Activity

- Many different terms can be found to classify the function of muscles as they act in joint motion.

1. Agonist

- A contracting muscle (or muscle group) that is considered to be the principle muscle producing a joint motion or maintaining a posture is referred to as agonist or prime mover.

Functional Terminology of Muscle Activity

1. Agonist

- A contracting muscle (or muscle group) that is considered to be the principle muscle producing a joint motion or maintaining a posture is referred to as agonist or prime mover.
- Agon=contest
- Agonist contracts actively to produce a concentric, isometric, or eccentric contraction.

Functional Terminology of Muscle Activity

Antagonist

- Is a muscle (or muscle group) that possesses the opposite anatomic action of the agonist.
- Anti= against
- Is a non contracting muscle that neither assists nor resists the motion
- Passively elongates or shortens to permit the motion to occur.
- Eg. In wrist flexion, when the palm is facing the table top, the wrist extensors are the agonists and the wrist flexors are antagonists.
- The classification is reverses when the forearm is supinated and (wrist is flexed against gravity), the wrist flexors are agonists and wrist extensors are antagonists.

Functional Terminology of Muscle Activity

Synergist

- A muscle may be defined as a synergist whenever it contracts at the same time as the agonist.
- Syn=with, together, ergon=work
- The action may be identical, or nearly identical to that of the agonist.
- A synergist may rule out an unwanted action of a primemover
- Eg. *The wrist extensor preventing wrist flexion when the long flexors of the fingers contract to close the hand.*

Functional Terminology of Muscle Activity

Synergist

- Synergists act is to stabilize proximal joints for distal joint movement
- They work isometrically at joints that are not being moved by the agonists to stabilize the proximal joint, allowing the desired motion at the more distal segment to occur.
- Muscles work more often as synergists than as either agonists or antagonists.

Functional Terminology of Muscle Activity

Synergist

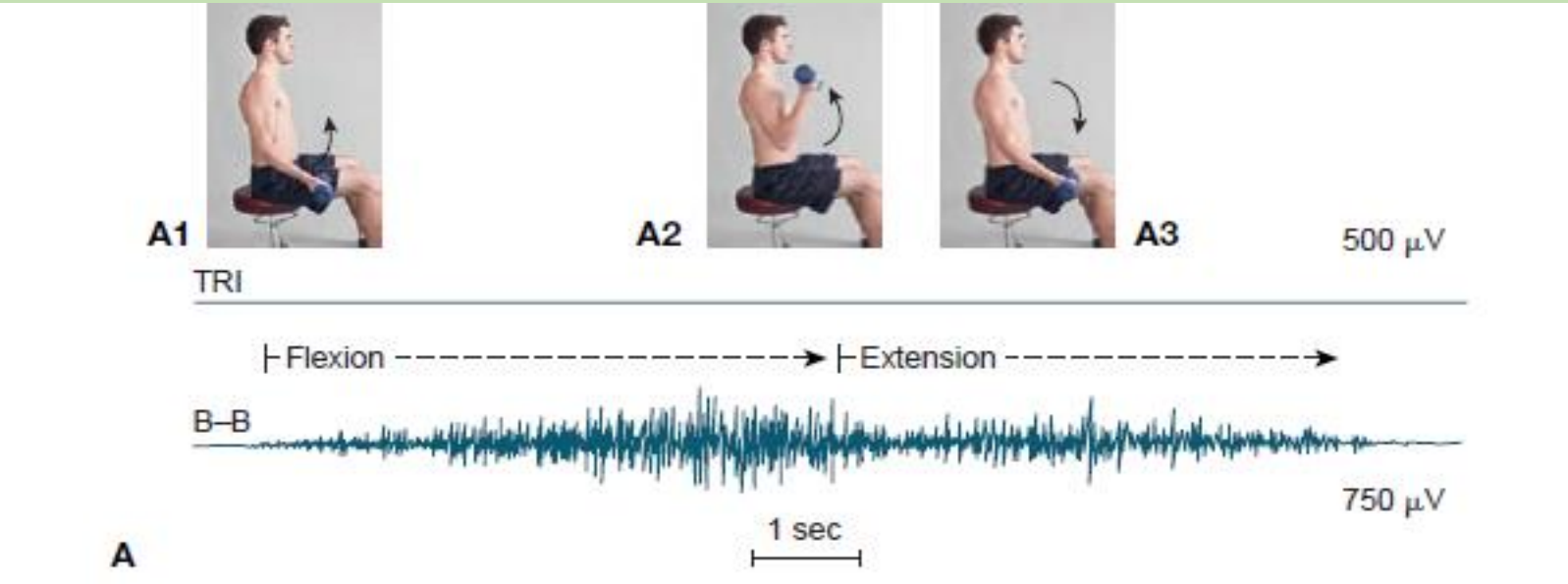
- This important function is needed because when the agonist contract, its force is distributed equally to both its distal and proximal attachments.
- For the desired movement to occur in one segment, the other segment must be fixed.
- *Eg. Close the hand and grip forcefully. Even when the forearm is resting on the table, strong isometric contractions can be palpated in muscles of the forearm, arm, shoulder, scapula and trunk*.

EMG activity of triceps and biceps brachi

- The relationships of muscles as agonists, antagonists, and synergists are not constant.
- They vary with the activity, position of the body, and the direction of the resistance which the muscle must overcome.
- These changing relationships are illustrated in the EMG recordings.

EMG activity of triceps and biceps brachi

(A)Subject seated with 10lb weight in hand

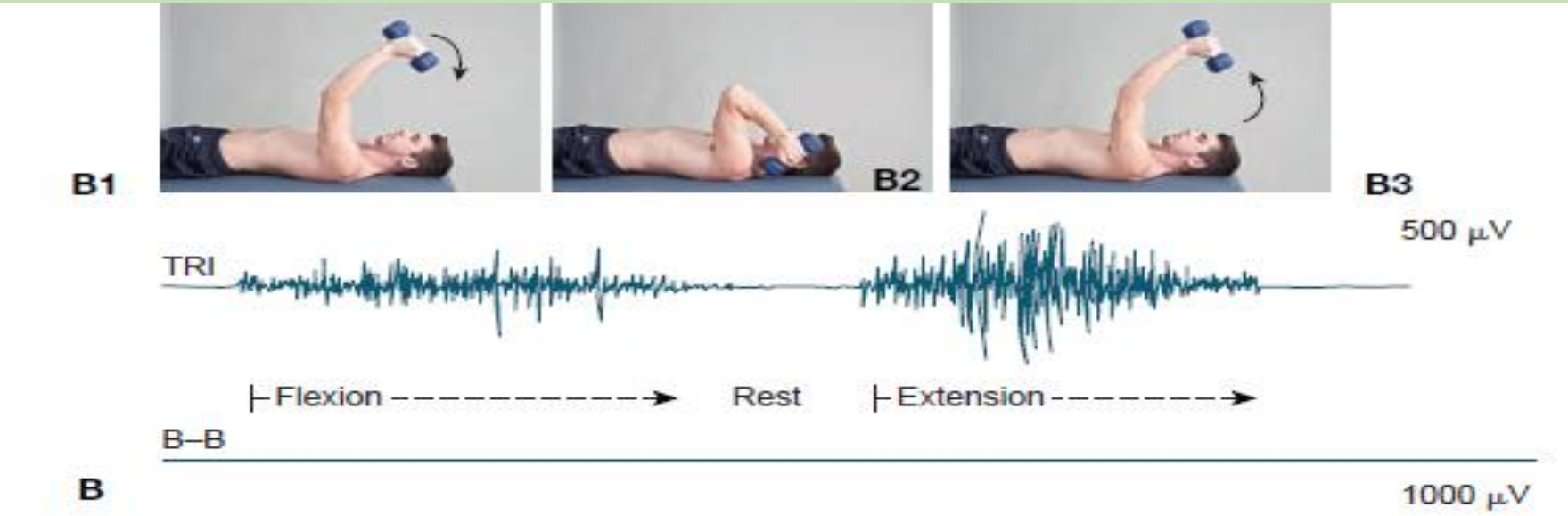


(Fig. A1) the elbow flexors contract concentrically as agonists

(Fig.A2)The antagonistic extensors are relaxed to elongate and permit elbow flexion motion.

(Fig.A3)As the elbow extends to lower the load to the side, the flexors perform an eccentric activity and are still classified as agonists

(B) Subject supine with the shoulder in 90º of flexion with 10 lb resistance in hand



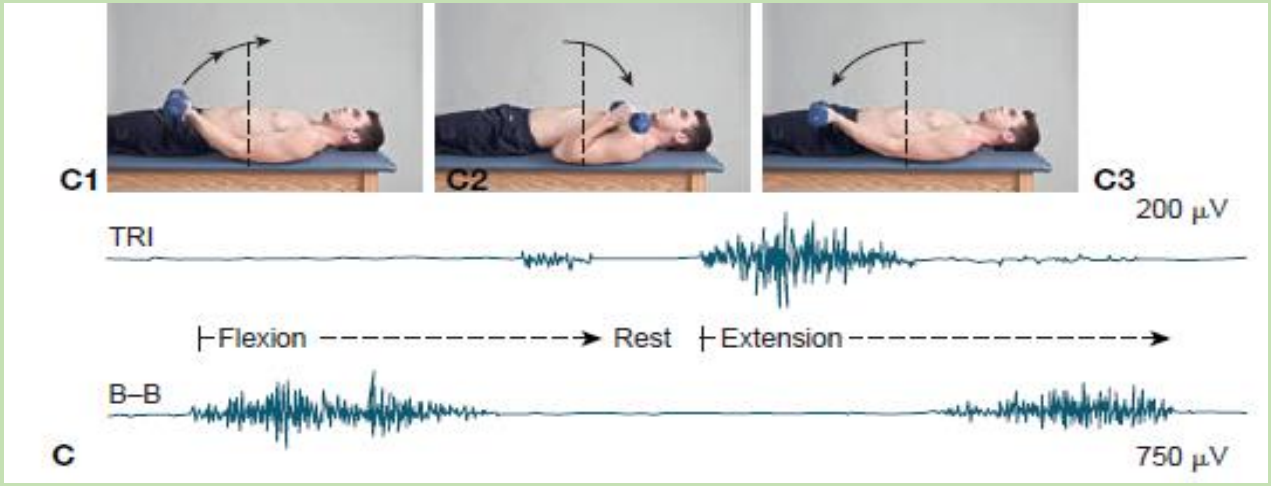
Performs elbow flexion and extension

(Fig. B1)the elbow extensors are the agonists for elbow flexion (eccentric contraction)

(Fig. B2)for elbow extension (concentric contraction)

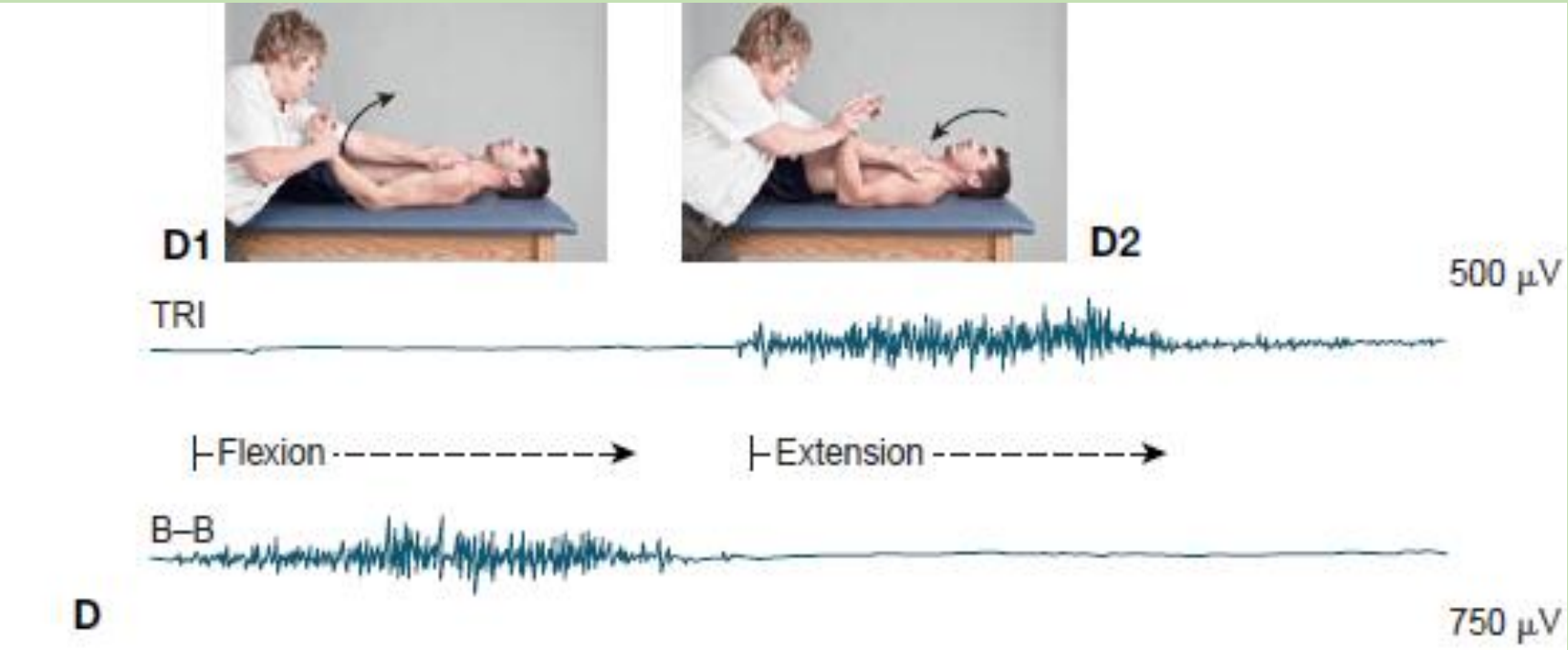
(Fig.B3) the flexors are the antagonists and remain relaxed for both motions.

(B) Subject supine with the shoulder in anatomic position with 10 lb weight in hand



- (Fig.C1) the biceps-brachialis muscles are the agonists for the first part of elbow flexion,
- (Fig.C2)As the elbow passes 90º, the direction of the resistance force changes, and the triceps becomes the agonist
- (Fig.C3). The agonist for elbow extension from this position to 90º is the triceps, but once the elbow moves on the other side of to 90º, the elbow flexors (eccentric contraction) control the elbow movement to the starting position

(D) Subject supine working against manual resistance during concentric muscle activity



Application of manual resistance throughout the motion of flexion (Fig. D1) and then extension (Fig. D2)

Passive Excursion of muscles

- The paired agonist-antagonist relationship of muscles in lever system requires that each muscle have the ability to accommodate and change length both passively and actively to permit motion.

- For example measure changes of 3 to 4 inches (8 to 10 cm) in the length of quadriceps and hamstring muscles during normal walking.

Passive Excursion of muscles

- The functional excursion of a muscle is defined as that distance the muscle is capable of shortening after it has been elongated as far as the joint(s) over which it pass allows.
- Weber (1851) found that some could shorten to 34% of the longest length, and others could shorten to 89%
- The highest excursion were for those muscles that cross more than one joint, e.g., hamstrings.
- For example, Boys measured an excursion of 3 inches (8 cm) for the flexor digitorum profundus muscle when the middle finger and wrist were moved from full wrist and finger flexion to full extension of these joints.

Passive insufficiency

- When muscles become elongated over two or more joints simultaneously, they may reach the state of passive insufficiency and not allow further motion by the agonist.
- This antagonistic limitation of motion can be demonstrated with hip flexion with able body subject.
- The hip can be flexed to 115 to 125 degrees when the knee is also flexed, but when the knee is kept in extension hip flexion is limited to 60 to 80 degrees because of passive insufficiency of hamstring muscles, which are now stretched over hip and knee.

Passive insufficiency

- In another example, if the ankle dorsiflexes to 15º when the knee is flexed, but when the knee is extended, the amount of dorsiflexion is reduced because of passive insufficiency of the gastrocnemius muscle which is now stretched over the knee and ankle.
- Passive insufficiency may occur normally, as demonstrated in these examples.
- However, passive insufficiency may also occur in pathological conditions.
- Certain pathologic conditions may cause muscles and tendons to lose their normal range of excursions.
- Examples of these conditions include muscle tightness, spasticity, scar tissue shortening from trauma or surgery, and adhesion of tendons to their sheaths.

Passive insufficiency

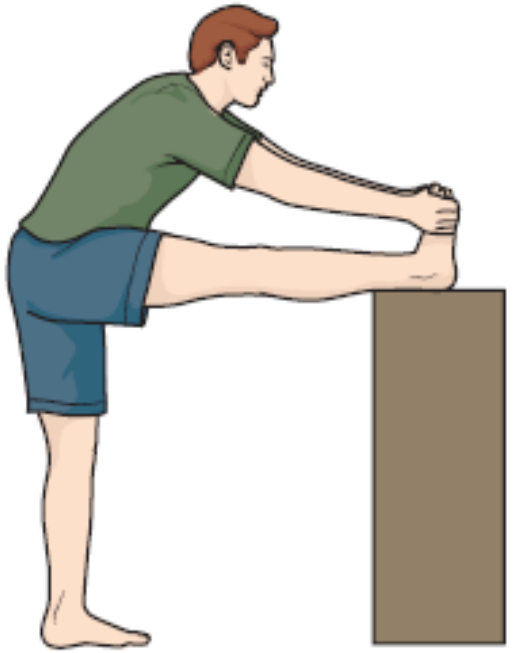
- Thus, even though an agonist may contract strongly, motion may be significantly limited by passive insufficiency of its antagonist.
- This restriction is commonly seen in patients with cerebrovascular accidents (hemiplegia) who have spasticity of finger flexors.
- Even though these patients may have voluntary control of finger extensors, they are unable to open the hand because of limitation in lengthening of the finger flexors.

Passive insufficiency



A

Abnormal passive insufficiency



B

Normal passive insufficiency

Figure 4.14 Normal passive insufficiency and abnormal passive insufficiency of hamstrings. Passive insufficiency of a muscle will limit its opposing muscle's ability to contract since the lengthening muscle is unable to stretch any farther.

Tendon Action of Muscle

- Passive tension of muscles that cross two or more joints may produce passive movements of those joints.
- This effect is called tendon or **tenodesis** (Gr. *tenon,* tendon; *desis,* a binding together) action of muscle.
- In able-bodied subjects, the effect is seen when the individual flexes and extends the wrist while keeping the hand relaxed.
- When the wrist flexes, the relaxed fingers extend because of the passive tension of the extensor digitorum, which elongates over the wrist and fingers.
- When the wrist extends, the fingers passively flex because of the tension of the flexor digitorum profundus and superficialis muscles (Fig.).

Tendon Action of Muscle

Tenodesis occurs in the long finger flexors and extensors with movement of the wrist.

A) The hand and wrist in a resting position.

B) B) As the wrist flexes, the passive insufficiency of the long finger extensors causes the fingers to move into extension.

C) C) As the wrist extends, the passive insufficiency of the long finger flexors moves the fingers passively into flexion.

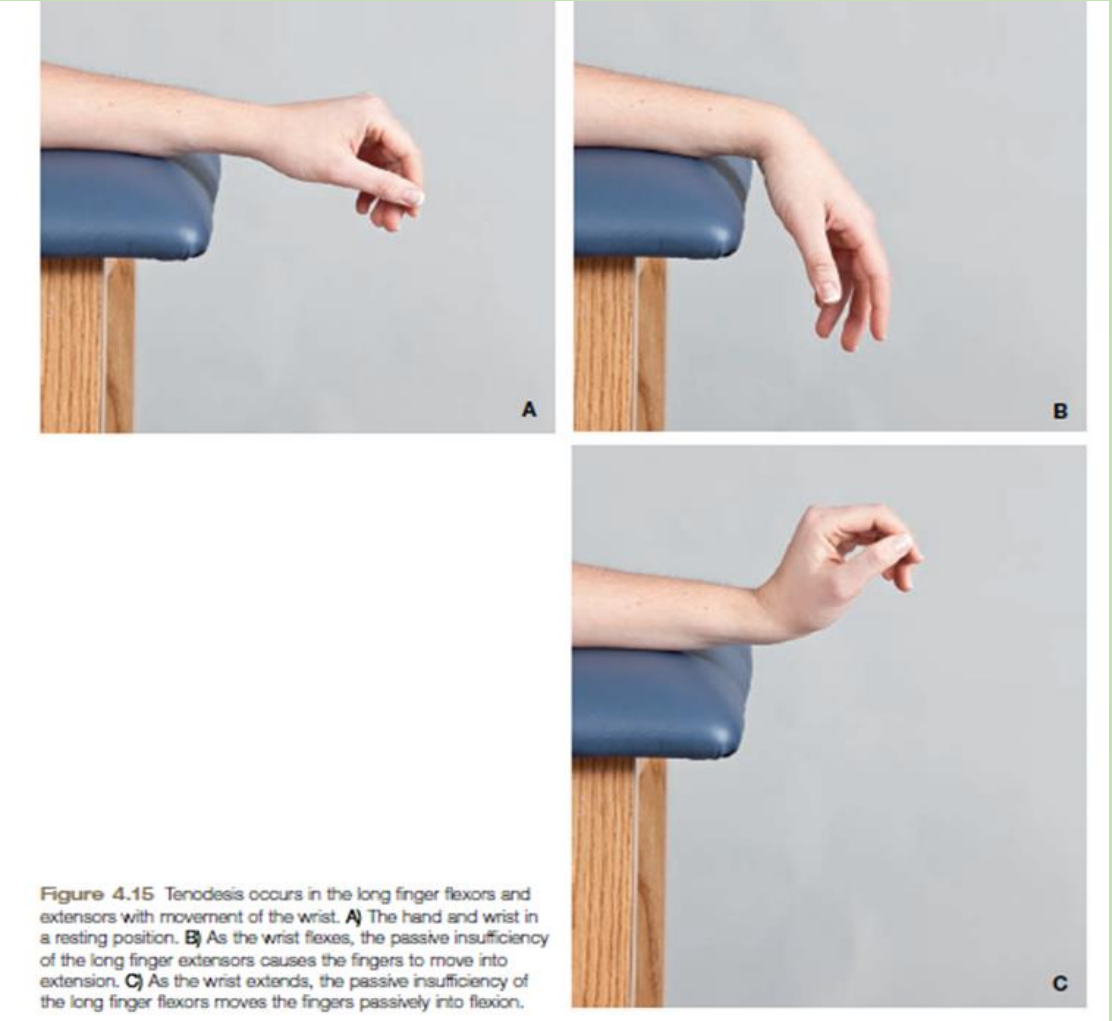


Figure 4.15 Tenodesis occurs in the long finger flexors and extensors with movement of the wrist. **A)** The hand and wrist in a resting position. **B)** As the wrist flexes, the passive insufficiency of the long finger extensors causes the fingers to move into extension. **C)** As the wrist extends, the passive insufficiency of the long finger flexors moves the fingers passively into flexion.

Tendon Action of Muscle

- This tenodesis action is sometimes used functionally by patients with tetraplegia who have motor function loss at a C-6 level.
- These individuals are able to contract wrist extensor muscles but have paralysis of finger muscles.
- When the wrist flexes, the fingers extend by passive insufficiency of the extensors so the hand can be placed over an object.
- As the individual actively extends the wrist, the passive tension of the
- finger flexors produces increasing force on the object so it may be picked up and held in the hand. If selective shortening of the long finger flexors has been permitted to occur, several pounds of grasping force can be generated.

References

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Thank You!