READ CHAPTER 14 IN YOUR TEXTBOOK: ***KINESIOLOGY You are responsible for the content in it related to slides: 4-12; 14-21; 26-46 and the slides themselves***

THE SLIDE COMMENTARY FROM THE POWERPOINT PRESENTATION:

4. ● Generally, smaller motor units are innervated by smaller motor neurons and contain red, slow-twitch muscle fibers.

5. ● What determines the degree of a partial contraction?

   The number of motor units that contract and also the number of muscle fibers in those motor units.

6. ● In a broad sense, how are longitudinal muscles classified?

   They are classified according to shape.

7. ● *A* represents a fusiform-shaped muscle, *B* is a strap muscle, and *C* is a rectangular-shaped muscle

8. ● The illustration on the left shows rhomboidal-shaped muscles, while the one on the right shows a triangular-shaped muscle. What is another word that describes triangular-shaped muscles?

   They are sometimes referred to as fan-shaped muscles.

9. ● The word *pennate* means featherlike.

● The various prefixes refer to the placement of fibers along the tendon.

10. ● Can you categorize these pennate muscles?

   A *is a unipennate muscle,* B *is a bipennate muscle and* C *is a multipennate muscle.*

11. ● If a pennate and longitudinal muscle of the same overall size are compared, they will contain the same mass of muscle tissue.

12. ● It may help to think of passive tension as a rubber band. When a rubber band is stretched, its natural elasticity creates a pulling force that will pull on whatever is holding the band in the stretched position.

16. ● What happens when a muscle's number of cross-bridges decreases?

   The strength of the muscle's contraction decreases.

17. ● One of the best examples of active insufficiency can be found in the extrinsic finger flexor muscles of the arm/forearm (more on this later).

●
●

18. ● *A* shows a shortened sarcomere, and *B* shows a sarcomere at resting length.

- Note that inaccessible binding sites result in fewer myosin-actin cross-bridges being able to form when the sarcomere is shortened. This results in a weaker contraction.

19. ● This illustration shows a lengthened sarcomere. Note the fact that the inaccessible binding sites result in fewer myosin-actin cross-bridges being able to form when the sarcomere is lengthened.

20. ● Why are these wrist positions weak?

    The photograph on the left shows shortened active insufficiency and the one on the right shows lengthened active insufficiency.

21. ● Why is this position stronger than the previous two?

    The hand is in a neutral position, allowing for maximum contraction because of the greater number of myosin-actin cross-bridges in the sarcomeres.

22. ● Because a muscle is composed of many sarcomeres, the relationship between the tension and length of a sarcomere can be extrapolated to the relationship between the length and tension of an entire muscle.

23. ● What is the passive tension when the sarcomere is at resting length?

    It's nonexistent, or zero.

24. ● Why is working a muscle at a much lengthened state dangerous?

    It can lead to tearing or disruption of muscle tissue.

25. ● This is an illustration of the force-velocity relationship curve. This curve correlates the tension force that a muscle can develop relative to its velocity (i.e., speed) of contraction. Concentric contraction is shown on the right; eccentric contraction on the left. Regarding concentric contraction, the slower a muscle contracts, the stronger its contraction force; the faster a muscle contracts, the weaker its contraction force.

26. ● Is leverage an intrinsic or extrinsic factor?

    It is an extrinsic factor.

27. ● Examples of external forces, other than the force due to gravity, that are often encountered when exercising include spring forces, forces due to resistance tubing, and forces due to therabands.

28. ● Why does movement occur in this scenario?

    Because a force acts on a lever.

29.

30. ● The picture on the left shows a simple lever.

● How are the two people, who have such different weights, able to balance on the seesaw in the illustration on the right?

Leverage. The 100-pound person's weight has the mechanical advantage of the longer lever arm.

31. ● Which muscle has greater leverage in this situation?

Muscle B has greater leverage because it is taking advantage of a longer lever arm.

34. ● What sort of angle can be described as perpendicular?

A 90-degree angle, also known as a right angle, is perpendicular.

35. ● Simple trigonometry can figure out what percentage of a muscle's pulling force contributes to the motion that is occurring.

36. ● Whatever portion of a muscle's line of pull does not contribute to motion at the joint instead contributes to stability of the joint by pulling the bone along its long axis into the joint. In this illustration, the 86% of the muscle's pulling force that is lost due to motion is valuable because it adds to the stability of the joint, protecting the joint from injury.

37. ● The previous definition did not account for the angle of a muscle's pull, hence the need for this refinement.

38. ● Which muscle, the one on the left or the one on the right, has a longer lever arm?

The muscle on the right has a longer lever arm.

39. ● The resistance to movement would be whatever force resists the motion from occurring.

40. ● Can you categorize each of these levers?

From top to bottom, these are first-, second-, and third-class levers.

41. ● The extensor musculature acting on the head is an example of a first-class lever.

42. ● What role is performed by the toes in the illustration on the right?

The toes provide the axis of motion for this action at the metatarsophalangeal joints.

43. ● Since the brachialis is a third-class lever, it has less leverage, but the advantage of less leverage is that it gains the ability to move the forearm quickly through its range of motion.

44. ● Needing to generate contraction strength when the muscle is at a mechanical disadvantage increases the risk of muscular strain.

45. ● What is the resistance force (R) here?

The weight of the hand and forearm provide the resistance force R here.

46. ● Which of these is the safest method for lifting a heavy object?

The squat bend with the trunk remaining vertical is the safest method for lifting a heavy object.

DEFINITIONS:

active insufficiency (p. 485)
active tension (p. 485)
axis of motion (p. 490)
bipennate muscle (p. 482)
effort arm (p. 490)
external forces (p. 490)
extrinsic strength (p. 482)
fan-shaped muscle (p. 482)
first (1st)-class lever (p. 494)
force-velocity relationship curve (p. 489)
fusiform-shaped muscle (p. 482)
Henneman size principle (p. 481)
internal forces (p. 490)
intrinsic strength (p. 482)
lengthened active insufficiency (p. 485)
length-tension relationship curve (p. 485)
lever (p. 480)
lever arm (p. 490)
leverage (p. 480)
longitudinal muscle (p. 482)
mechanical advantage (p. 491)
mechanical disadvantage (p. 496)
moment arm (p. 490)
multipennate muscle (p. 482)
muscle fiber architecture (p. 482)
optimal angle of pull (p. 492)
passive tension (p. 185)
pennate muscle (p. 482)
pennation angle (p. 485)
rectangular-shaped muscle (p. 482)
resistance to movement (p. 494)
rhomboidal-shaped muscle (p. 482)
second (2nd)-class lever (p. 494)
shortened active insufficiency (p. 485)
sphincter muscle (p. 482)
spindle-shaped muscle (p. 482)
spiral muscle (p. 482)
squat bend (p. 497)
stoop bend (p. 497)
strap muscle (p. 482)
third (3rd)-class lever (p. 494)
triangular-shaped muscle (p. 482)
unipennate muscle (p. 482)

QUESTIONS TO ASK YOURSELF:

Why can muscles have partial contractions, given that muscle fibers always follow the all-or-none response law?
Guidelines:
One possible response is that individual muscle fibers must contract 100% or not contract at all, but muscles are made up of individual fibers. Not every fiber in a muscle must contribute to create motion.

Why is leverage important in determining the force of a muscle contraction?
Guidelines:
One possible answer is that leverage is an important extrinsic factor that determines whether or not the muscle has a mechanical advantage.

Why is a seesaw a good example of a first-class lever?
Guidelines:
One possible answer is that, on a seesaw, the force applied and the resistance to movement are on opposite sides of the axis of movement.

THINGS THIS CHAPTER SHOULD ENABLE YOU TO DO (I WOULD LOOK CLOSELY AT THESE QUESTIONS AND DISCOVER SOME ANSWERS:

1. Describe how a muscle can have a partial contraction, and explain the meaning of the Henneman size principle.
2. Explain the difference between the intrinsic strength of a muscle and the extrinsic strength of a muscle.
3. Describe the various types of muscle fiber architecture, and explain the advantages and disadvantages of longitudinal versus pennate muscles.
4. Describe active tension and passive tension of a muscle.
5. Explain the relationship between the sliding filament mechanism and shortened active insufficiency and lengthened active insufficiency.
6. Give an example of shortened active insufficiency and lengthened active insufficiency.
7. Interpret the length-tension relationship curve for active tension, passive tension, and total tension of a muscle.
8. Explain the meaning of the active, passive, and total tension curves of the length-tension relationship curve.
9. Describe the relationships among the concepts of the sliding filament mechanism, active length-tension relationship curve, and active insufficiency.
10. Explain the relationship between leverage and the extrinsic strength of a muscle.
11. Describe the advantage and disadvantage of a muscle with greater leverage.
12. Define the terms *internal force* and *external force*, and give an example of each.
13. Explain why a muscle with an attachment that has a less than optimal angle of pull loses extrinsic strength.
14. Explain how to determine the lever arm of a muscle.
15. List the three classes of levers, and give a mechanical object and muscular example of each one.
16. Define the resistance force to a muscle's contraction, and give two examples of a resistance force.
17. Sketch the region of the body where a muscle is contracting, and draw the arrows that represent the force of the muscle contraction and the resistance force that opposes the muscle contraction.
18. Define the key terms of this chapter.
19. State the meanings of the word origins of this chapter.

Section 14.1 addresses the concept of a muscle having a partial contraction. The strength of a muscle contraction is a measure of its pulling force. Because sarcomeres are the functional units that do the pulling when a muscle contracts, the strength of a muscle contraction is ultimately determined by counting how many sarcomeres are contracting (this is actually a measure of the muscle's active tension force; its passive tension force is discussed in Sections 14.3 and 14.5). However, this number of sarcomeres cannot realistically be counted; therefore we speak of the number of muscle fibers that contract or perhaps even more simply of the number of motor units that contract. Keep in mind that motor units do not contain the same number of muscle fibers and that muscle fibers do not all contain the same number of sarcomeres. (Note: At the end of the chapter, it is stated that the very best determinant of the (active) pulling force of a muscle is the number of cross-bridges between actin and myosin.)

- The spotlight box in this section begins the discussion of intrinsic (internal) and extrinsic (external) factors that affect the strength of a muscle's contraction. The concept of extrinsic factors is discussed later in this chapter in Sections 14.6 through 14.9. Addressing this spotlight box now is a nice introduction to the later sections.
- **Section 14.2** covers the architecture of a muscle. The architecture is defined by the orientation of the fibers within the muscle. The two main types are longitudinal and pennate.
- The big picture of longitudinal versus pennate should not be lost. This concept is covered in the last bulleted piece of information in the section: *Therefore, a longitudinal muscle is generally better suited for a greater range of motion contraction but with less force; whereas a pennate muscle is generally better suited for greater strength contraction over a shorter range of motion*.
- **Section 14.3** examines active tension and passive tension of a muscle. When most people think of the strength that a muscle generates, they usually think only of the active tension created by the sliding filament mechanism. However, the natural elastic recoil of the fascia of a muscle can create a passive tension force. This type of tension occurs when the muscle is stretched.
- It will be important to understand passive tension when we get to Section 14.5 and examine the length-tension relationship curve, because passive tension increases the pulling force (i.e., tension) of a muscle as the muscle's length changes.
- **Section 14.4** examines the concept of active insufficiency.
- In Section 14.1, we concluded that the best way to determine the strength of a muscle is to count the number of myosin-actin cross-bridges. In this section, we see that the number of cross-bridges that form varies depending on the length of the sarcomere. Fewer myosin-actin cross-bridges means less strength (hence the term *insufficiency*). If the sarcomere is shortened with fewer myosin-actin cross-bridges, then it is called *shortened active insufficiency.* If it is lengthened with fewer myosin-actin cross-bridges, then it is called *lengthened active insufficiency*.

To help visualize this concept, look at the PowerPoint slide of the illustrations (Figure 14.3 *A, B, and C*).

- The importance of the concept of active insufficiency is that the strength of a muscle's active tension force lessens when the muscle is shortened and when it is lengthened. The active tension force of a muscle is greatest around the resting length of the muscle. This action has repercussions for the position that a client should take when doing an exercise; it also affects the position that a client should take when resisting during PIR stretching (also known as CR or PNF stretching).
- This concept is also necessary to understand the length-tension relationship curve covered in Section 14.5.

- **Section 14.5** covering the length-tension relationship curve synthesizes the information presented in Sections 14.3 and 14.4 of this chapter.
- The length-tension relationship curve is a curve that relates the tension (i.e., pulling force) that a muscle can generate to the length of the muscle (just as the name implies). We have seen (in Section 14.4) that the active tension decreases when the muscle is much shorter or much longer. We have seen (in Section 14.3) that the passive tension increases as the muscle becomes longer. If we put these factors together, then we can form the length-tension relationship curve!
- **Section 14.6** examines the leverage of a muscle, which begins our discussion in detail of the extrinsic (external) factors of a muscle that affect its strength. (This concept was first brought up in the spotlight box in Section 14.1.) No matter what pulling force strength a muscle can generate internally via the sliding filament mechanism, the actual force that pulls on the muscle's attachment to move it axially around the joint is strongly affected by the lever arm (leverage) that the muscle has. Because the leverage is a factor that is outside of the muscle itself, it is called an extrinsic factor.
- The seesaw example of leverage and lever arms used in this section is an example that works for most people, probably because most of us played on seesaws when we were young. Another example that helps visualize the concept of lever arms is the location of a doorknob on a door. A doorknob is always far away from the hinges. The hinges are the axis of motion for the door, and the farther the doorknob is from the axis, the greater the leverage for opening and closing the door will be. How difficult opening and closing a door would be if the doorknob were on the other side of the door, near the hinges? Another similar example is a revolving door. With a revolving door, we have the choice to push anywhere on the revolving door, yet we intuitively know to push at the point that is farthest from the hinges, maximizing the leverage.
- In addition to the advantage of a muscle having good leverage, there is also a disadvantage (decreased speed of movement of the body part). **The spotlight box at the end of the section nicely sums up the relative advantages and disadvantages of muscles with good leverage and the muscles with poor leverage.**
- **Section 14.7** goes into more depth on the subject of leverage by considering the angle of pull that a muscle has at its point of attachment. The optimal angle of pull is always perpendicular to the lever itself. Any other angle of pull decreases the effective ability of the pulling force of the muscle on the bony attachment to move the bone axially at the joint. A refined definition of a lever arm is then presented based on this knowledge.
- Kinesthetic exercise: A door can be used to demonstrate the idea of how a muscle loses effective strength if its pulling angle is not perfectly perpendicular to the lever arm. Tie a string or rope around a doorknob and try to open or close the door by pulling on the doorknob with three angles of pull. Make one of the angles of pull perpendicular to the door; make the second angle of pull approximately

45 degrees off of perpendicular; and make the third angle of pull nearly in line with the door itself. The fact that the perpendicular angle of pull is the least effortful toward opening or closing the door should be kinesthetically clear; the angle of pull that is 45 degrees off of perpendicular will be more difficult; and the angle of pull that is approximately in line with the door will be the most difficult.

- **Section 14.8** covers the three classes of levers.
- As a shortcut to remember this information, remembering this knowledge by remembering a good real-life example of each one of these classes of levers might be best for the students. These examples are shown in Figures 14.14, 14.15, and 14.16: seesaw, wheelbarrow, and tweezers, respectively. Interestingly, many muscles are third-class levers, meaning that they do not have great leverage for moving their attachment. However, by virtue of this characteristic, they can move the attachment quickly. In a life or death situation, speed of contraction may well be more important than strength of contraction!
- **Section 14.9** advances the focus on leverage to examine the leverage of the forces of resistance to a muscle's contraction. Effectively, the same concepts that were explained pertaining to the leverage of a muscle's force need simply be applied to the force of resistance that the muscle meets.
- The spotlight box in this section of the textbook applies the concept of leverage to holding a weight. The farther the weight is held from the body, the greater leverage it has, requiring a greater force on the part of our musculature to hold it up. This concept can be applied when we give advice to our clients about how to best hold and carry objects.
- Another spotlight box in this section applies the concept of leverage to bending over. The stoop bend and two versions of the squat bend are discussed. Clients will often come in and state that they were picking something up from the floor when their backs "went out." These clients often go on to say that they cannot understand it because the object they were picking up was so small and light (e.g., a towel or key). I try to explain to these clients that the weight of the object they were bending to pick up was irrelevant. In reality, by bending over in a stoop bend or a squat bend with the trunk inclined forward, the real resistance force against which their back muscles had to work was the weight of their own trunks. These clients were, in effect, lifting their own trunks. The farther forward their trunks went, the greater the leverage and therefore the greater the stress was on their back extensor musculature to support the trunk from falling to the ground! Applying this knowledge of always trying to keep the center of weight of a body part over the body part below it is extremely valuable. This statement is true whether we are giving advice to our clients or whether we are applying these principles to our own body biomechanics when we work.