Structure & Function of Skeletal Muscle
Think-Pair-Share

- What do you already know about muscles?
- Where do they attach?
- What do they do?
“When a muscle contracts, it knows no direction – it simply shortens.” –Lippert

Muscles are attached to bones and to describe the relative points of attachment, we use the terms origin and insertion.
Muscle Terminology continued

- **Muscle Origin**
  - The proximal attachment (the point of attachment that is closest to midline when in anatomic position)
  - Typically, the more stable point of connection (meaning when the muscle contracts, the origin will stay in place and the other end where the muscle attaches will do the “moving”)

Lippert p39; Mansfield p37
Muscle Terminology continued

- **Muscle Insertion**
  - The distal attachment (the point of attachment that is farthest from midline when in anatomic position)
  - The more moveable attachment point for the muscle
  - This attachment moves toward the more stable origin

Lippert, p39; Mansfield, p37
Muscle Terminology continued

- **Action** = the joint motion that occurs as a result of muscle shortening
- **Innervation** = the nerve supply to the muscle
Muscle Terminology continued

- **Agonist** = a muscle or muscle group that causes the specific movement (aka prime mover)
- **Antagonist** = a muscle or muscle group that can oppose the action of the agonist

Lippert, p48
**Example: Elbow FLEXION**

- **Agonist**
  - The muscle performing the task

- **Antagonist**
  - The opposing muscle to the task being performed
Example: Elbow EXTENSION

- **Agonist**
  - The muscle performing the task

- **Antagonist**
  - The opposing muscle to the task being performed
Muscle Terminology continued

- **Prime Mover** =

- **Assisting Mover** = a muscle that is not as effective as the prime mover, but does assist in providing that same motion.

Lippert, p48
Muscle Terminology continued

- **Co-Contraction**
  - Agonist and Antagonist contract simultaneously
  - Provide stabilization

Lippert p48; Mansfield p38
Muscle Terminology

- **Synergists**
  - Muscles that work together

- **Force Couple**
  - Muscles that work together in opposite directions to produce torque in the same rotational direction

Anatomic Force Couple

Mansfield p38
Muscle Terminology continued

- Mono-articular muscles:

- Bi-articular muscles:
Muscles have the following properties:

- Irritability
- Contractility
- Extensibility
- Elasticity

To better understand these properties, you need to know that muscles have a normal resting length.

**Normal resting length** = the length of a muscle when there are no forces or stresses placed upon it.

Lippert, p42
Functional Characteristics of Muscle continued

- **Irritability**
  - The ability to respond to a stimulus
  - A muscle contracts when stimulated.
**Contractility**

- The ability to contract, producing tension between the origin and insertion of the muscle.

- **Muscle may:**
  - Stay the same length
    - *(isometric)*
  - Shorten
    - *(concentric)*
  - Lengthen
    - *(eccentric)*
Contractility continued

An active muscle develops force in only one of the following 3 ways:

<table>
<thead>
<tr>
<th>How</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>By shortening</td>
<td>Concentric</td>
</tr>
<tr>
<td>By resisting elongation</td>
<td>Eccentric</td>
</tr>
<tr>
<td>By remaining at a constant length</td>
<td>Isometric</td>
</tr>
</tbody>
</table>

Lippert, p42
Contractility continued

CONCENTRIC Contraction

- The distance between the origin and insertion is decreasing
- The internal torque produced by the muscle is greater than the external torque produced by an outside force.
Contractility continued

**ECCENTRIC Contraction**

- The origin and insertion become farther apart.
- The muscle is attempting to contract, but is simultaneously pulled to a longer length by a more dominant external force.
- The external torque, often generated by gravity, exceeds the internal torque produced by muscle.
- Most often, gravity or a held weight is allowed to “win,” effectively lengthening the muscle in a controlled manner.

Lippert, p45
Contractility continued

**ISOMETRIC Contraction**

- The muscles remains the same length
- The origin and insertion remain the same distance to each other
- The muscle generates an internal torque equal to the external torque
- There is no motion or change in joint angle

Lippert, p45
Functional Characteristics of Muscle continued

- **Extensibility**
  - The ability to stretch (or lengthen) when a force is applied.

Lippert p42
Functional Characteristics of Muscle continued

- **Elasticity**
  - The ability to recoil, or return to a normal resting length once the stimulus or force to stretch or shorten has been removed.
Muscle Names

- **Location**
- Shape
- Action
- Number of heads
- Attachments
- Direction of the fibers
- Size of the muscle

Lippert, p40
Muscle Names

- Location
- **Shape**
- Action
- Number of heads
- Attachments
- Direction of the fibers
- Size of the muscle

Rhomboids
Located beneath the trapezius muscle

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seated Rows</td>
<td>Bent-over Rows with palms neutral (Reverse Flys)</td>
</tr>
<tr>
<td>T-Bar Row</td>
<td>Bent-over Rear Dels with palms down (High Rows)</td>
</tr>
<tr>
<td>Bent-over</td>
<td></td>
</tr>
</tbody>
</table>

Lippert, p40
Muscle Names

- Location
- Shape
- **Action**
- Number of heads
- Attachments
- Direction of the fibers
- Size of the muscle

Extensor Indicis

Lippert, p40
Muscle Names

- Location
- Shape
- Action
- **Number of heads**
  - *Biceps Brachii*
  - *Triceps Brachii*
- Attachments
- Direction of the fibers
- Size of the muscle

Lippert, p40
Muscle Names

- Location
- Shape
- Action
- Number of heads
- **Attachments**
  - Sternocleidomastoid
- Direction of the fibers
- Size of the muscle

Lippert, p40
Muscle Names

- Location
- Shape
- Action
- Number of heads
- Attachments
- **Direction of the fibers**
  - Vastus Medialis Obliquus (VMO)
- Size of the muscle

Lippert, p40
Muscle Names

- Location
- Shape
- Action
- Number of heads
- Attachments
- Direction of the fibers
- Size of the muscle
  - Pectoralis Major

Lippert, p40
The Sarcomere = The basic contractile unit of muscle
- It is composed of two main protein filaments
  - Actin
  - Myosin

Mansfield, p38
Sliding Filament Theory: the most popular model that describes muscular contraction

The thick myosin filament contains numerous heads which attach to the thinner actin filaments and create actin-myosin bridges.
What is a muscle’s “long axis”? 
Muscle Anatomy continued

Muscle Fiber Arrangement

- Muscle fibers are arranged either parallel or oblique to the muscle’s long axis.
- The fiber arrangement and shape are important indicators of a muscle’s specific action.

<table>
<thead>
<tr>
<th>Parallel</th>
<th>Oblique</th>
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<tbody>
<tr>
<td>Strap</td>
<td>Unipennate</td>
</tr>
<tr>
<td>Fusiform</td>
<td>Bipennate</td>
</tr>
<tr>
<td>Rhomboidal</td>
<td>Multipennate</td>
</tr>
<tr>
<td>Triangular</td>
<td></td>
</tr>
</tbody>
</table>
Fiber Arrangement

- **Parallel**
  - Tend to be longer
  - Have a greater range of motion
Fiber Arrangement

- **Oblique**
  - Shorter
  - More numerous (Dense)
    - Great strength

Lippert, p41
Fiber Arrangement

Parallel

- Strap Muscles
- Long and thin with fibers running the entire length of the muscle
- Examples: sartorius, rectus abdominis, SCM

Lippert, p41
Fiber Arrangement
Parallel
- Fusiform Muscles
- Wider in the middle and tapers at both ends
- Most fibers run the entire length of the muscle
- Examples: brachioradialis, biceps, brachialis
Muscle Anatomy continued

- Fiber Arrangement: **Parallel**
  - Rhomboid muscle
    - Four sided
    - Usually flat
    - Broad attachments at each end
      - Pronator teres
      - Gluteus maximus
      - Rhomboids in the shoulder girdle

Lippert, p41
Muscle Anatomy continued

- **Fiber Arrangement:** Parallel
- **Triangular Muscle**
  - Narrow attachment on one end (*insertion*)
  - Broad attachment on the other end (*origin*)
- Pectoralis major

Lippert, p41
Fiber Arrangement: Oblique

Unipennate

- Fibers arranged in a pattern that resembles one side of a feather
- Short fibers attaching diagonally into a central tendon
- Tibialis posterior
Fiber Arrangement: **Oblique**

**Bipennate**
- Short fibers that attach bilaterally into a central tendon
- Featherlike in appearance
  - Rectus femoris
  - Rectus abdominus

Lippert, p41
Fiber Arrangement: Oblique

Multipennate
- Muscles have many tendons with oblique muscle fibers in between them
  - Deltoid
  - Subscapularis

Lippert, p41
Line of Pull

The direction of a muscle’s force is referred to as its line of pull.

This determines its action

- If a muscle crosses a joint, it acts on that joint

Mansfield, p41
If the muscle’s line of pull is anterior to the medial-lateral axis of motion, what movement will occur at that joint when the muscle contracts?
If the muscle’s line of pull is posterior to the medial-lateral axis of motion, what movement will occur at that joint when the muscle contracts?
“There is an optimum range of a muscle within which it contracts most effectively.”

- Lippert, p42
Muscle: Length-Tension Relationship

- **Active Length-Tension Relationship**
  - Strength of the muscle is the least when the muscle is in its shortest position and also when it is in its longest position.
  - Strength is greatest at mid-length.

Mansfield, p42-43
Active & Passive Insufficiency

- **Active Insufficiency**
  - The point at which a muscle cannot shorten any farther because the tension within the muscle becomes insufficient at both extremes.
  - It occurs to the agonist (the muscle that is contracting).
  - Example: hamstring

Lippert, p43 & Mansfield, p45
Passive Insufficiency

- Occurs when a muscle cannot be elongated any farther without damage to its fibers.
- It occurs to the antagonist (the muscle that is relaxed and on the opposite side of the joint from the agonist)
- Example: hamstring

Lippert, p43 & Mansfield, p45
Passive Insufficiency

- **Tenodesis** *(based upon passive insufficiency)*
  - while resting the elbow on a table, flexing the wrist will have a tendency to extend the fingers

Lippert, p44
Tenodesis (due to passive insufficiency)
- Supinating the forearm and extending the wrist will have a tendency to flex the fingers

*This can help someone either grasp something or release something…

Lippert, p44
#1. Guestimate how many times you can lift a 12 pound bowling ball from the floor to the table in a 30 second period of time.
#2. Guestimate how many times you can lift a #2 pencil from the floor to the table in a 30 second period of time.
Speed Matters:

- **Concentric activation**
  - Muscle produces less force as the speed of the muscle contraction increases
  - You can repeatedly lift lighter versus heavy objects at great speed
  - The muscle cannot produce force at great speeds when the objects are heavy
Speed Matters:

- **Isometric activation** creates greater force than any speed concentric contraction
- **Eccentric activation**
  - Force production increases slightly as the speed of the elongation increases

Mansfield, p44
Closed Chain
- The distal segment is fixed (closed)
- The proximal segment moves
- Lower Extremity example:
- Upper Extremity Example:

Open Chain
- The proximal segment is fixed (remains stationary)
- The distal segment is free to move
- Lower Extremity Example:
- Upper Extremity Example:
Due to the adaptability of muscular tissue:

- Muscle will assume the length most common to it
- A muscle held in a shortened position over time will ________
- A muscle held in an elongated position over time will ________
Immobility can cause muscle tightness and/or loss of motion.

Severe loss of motion can lead to joint contracture.
- The joint is incapable of permitting full motion.
Clinical Considerations: Muscular Tightness

- A muscle held in an elongated position over time will _______________
- Which muscles are elongated?
- How does that affect muscle activation?

Mansfield, p46
Clinical Considerations: Muscular Tightness

- A protective mechanism:
  - This is referred to as **muscle guarding**
  - The muscular system “tightens” to help protect the body from further injury however;
    - Circulation is impaired
      - Metabolites build up
      - Pain results
    - Edema results

Lippert, p32
### Clinical Considerations: Stretching Muscular Tissue

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Action</th>
<th>Stretch Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrocnemius</td>
<td>Ankle PF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knee Flex</td>
<td></td>
</tr>
<tr>
<td>Hamstring</td>
<td>Knee flex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hip ext</td>
<td></td>
</tr>
<tr>
<td>Quad</td>
<td>Hip Flex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knee ext</td>
<td></td>
</tr>
<tr>
<td>Abdominals</td>
<td>Trunk Flex</td>
<td></td>
</tr>
</tbody>
</table>
As a general principle, optimal stretching of a muscle requires the person to hold a limb in a position that is ____________ to all of the muscle’s actions.

Mansfield, p47
- Mono-articular muscles
- Bi-articular muscles

What does this mean and how do we stretch them?
# Clinical Considerations: Muscle Strengthening

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Action</th>
<th>How to Strengthen it Concentrically</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrocnemius</td>
<td>Ankle PF</td>
<td></td>
</tr>
<tr>
<td>Hamstring</td>
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</tbody>
</table>
As a general principle, concentric strengthening of a muscle requires the person to move a joint in the direction that is _______________ as the muscle’s actions.
Mono-articular muscles

Bi-articular muscles

How do we strengthen a mono-articular muscle at a joint where there is also a bi-articular muscle that has the same action?
ID type of contraction

- http://www.youtube.com/watch?v=uO_CNYidOw0
- http://www.youtube.com/watch?v=GWvJ14cwwKU
- http://www.youtube.com/watch?v=9jvJvPrayXU
- http://www.youtube.com/watch?v=GypwmdhMVcc
References