"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 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

Biceps Brachii
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
**Muscle Terminology continued**

Example: Elbow FLEXION

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

- **Antagonist**
  - The opposing muscle to the task being performed

**Muscle Terminology continued**

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

Lippert p48; Mansfield p38

Synergists
- Muscles that work together

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

Mansfield p38

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.

Lippert, p45

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

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

- Stretch a muscle and it will lengthen.
  - extensibility

- Remove the stretch, and it will return to its normal resting position.
  - elasticity

- Stimulate a muscle and it will respond, by contracting.
  - irritability
  - contractility
Then remove the stimulus and it will return to its normal resting position.

**Muscle Names**

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

---

Lippert, p42

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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

Mansfield, p38

The Sarcomere = The basic contractile unit of muscle

- It is composed of two main protein filaments
  - Actin
  - Myosin

http://www.youtube.com/watch?v=0kFmbrRJqtw

Lippert, p40
**Muscle Anatomy**

- **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.

  ![Sliding Filament Theory Diagram](Mansfield_p38)

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**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>Fiber Arrangement</th>
<th>Rectangular</th>
<th>Strap</th>
<th>Fusiform</th>
<th>Rhomboidal</th>
<th>Triangular</th>
<th>Unipennate</th>
<th>Bipennate</th>
<th>Multipennate</th>
</tr>
</thead>
</table>

Lippert p41; Mansfield p40

---

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

  ![Fiber Arrangement Diagram](Lippert_p41; Mansfield_p40)
Fiber Arrangement

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

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

- **Fusiform Muscles**
  - Wider in the middle and tapers at both ends
  - Most fibers run the entire length of the muscle
  - Examples: brachioradialis, biceps, brachialis
**Fiber Arrangement: Parallel**
- Rhomboid muscle
  - Four sided
  - Usually flat
  - Broad attachments at each end
    - Pronator teres
    - Gluteus maximus
    - Rhomboids in the shoulder girdle

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

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

---

Lippert, p41

---
**Fiber Arrangement: Oblique**
- Short fibers that attach bilaterally into a central tendon
- Featherlike in appearance
  - Rectus femoris
  - Rectus abdominus

Lippert, p41

**Fiber Arrangement: Bipennate**
- 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
There is an optimum range of a muscle within which it contracts most effectively. 

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.

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.
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

Tenodesis (based upon passive insufficiency)

- while resting the elbow on a table, flexing the wrist will have a tendency to extend the fingers

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...
**Force-Velocity Relationship**

- **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.

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

**Kinetic Chains**

- **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.

A muscle held in an elongated position over time will ____________________________

Which muscles are elongated?
How does that affect muscle activation?
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

---

As a general principle, optimal stretching of a muscle requires the therapist to hold a limb in a position that is _________ to all of the muscle’s actions.
- 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></td>
<td></td>
</tr>
<tr>
<td>Hamstring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominals</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As a general principle, concentric strengthening of a muscle requires the patient to move a joint in the direction that is ___________ as the muscle’s actions.
ID type of contraction

- http://www.youtube.com/watch?v=uO_CNY1dOw0
- http://www.youtube.com/watch?v=GWvJ14cwKU
- http://www.youtube.com/watch?v=9jyjyPrayXU
- http://www.youtube.com/watch?v=GypwmdhMVcc

References