Essentials of Strength Training & Conditioning

Neuromuscular Anatomy and Adaptations to Conditioning

Chapter 2

Neuromuscular Anatomy & Physiology

- **Motor Unit** – a motor neuron and all of the muscle fibers that it innervates ; the basic functional entity of muscular activity
- **Motor Neuron** – nerve that travels from the spinal cord to the target muscle; generally has numerous terminal branches to innervate many muscle fibers; when a motor neuron fires, all fibers it innervates become activated
  - Precision muscles may have a ratio of muscle fibers to motor neuron that approaches 1:1
  - Large muscle group muscle fibers may have hundreds of fibers controlled by one motor neuron
- Motor neuron Action Potential arrives at all of the motor end plates innervated by neuron; this causes a release of neurotransmitter Acetylcholine (Ach); Ach diffuses across the neuromuscular synapses and electrochemically excites the sarcolemma, causing contraction of all of the muscle fibers
- **All or None Principle** – when an action potential has enough strength to activate a muscle fiber, it activates all muscle fibers supplied by the motor neuron

Neuromuscular Anatomy & Physiology (cont.)

- **Twitch –** a short period of activation of the muscle fibers within the motor unit, stimulated by an action potential
  - If a second twitch occurs before the muscle fiber relaxes, the Force generated summates
  - Decreasing the time interval between twitches results in greater Force summation
- **Tetanus** – when continued stimulation of a muscle fiber results in twitches occurring simultaneously without relaxation; this is the largest amount of Force that the muscle fiber and motor unit can generate
  - "Russian Stimulation" is an electrical stimulation training technique that utilizes an outside electrical charge to generate large amounts of Force within a muscle to increase lifting potential, and therefore increasing the training effect
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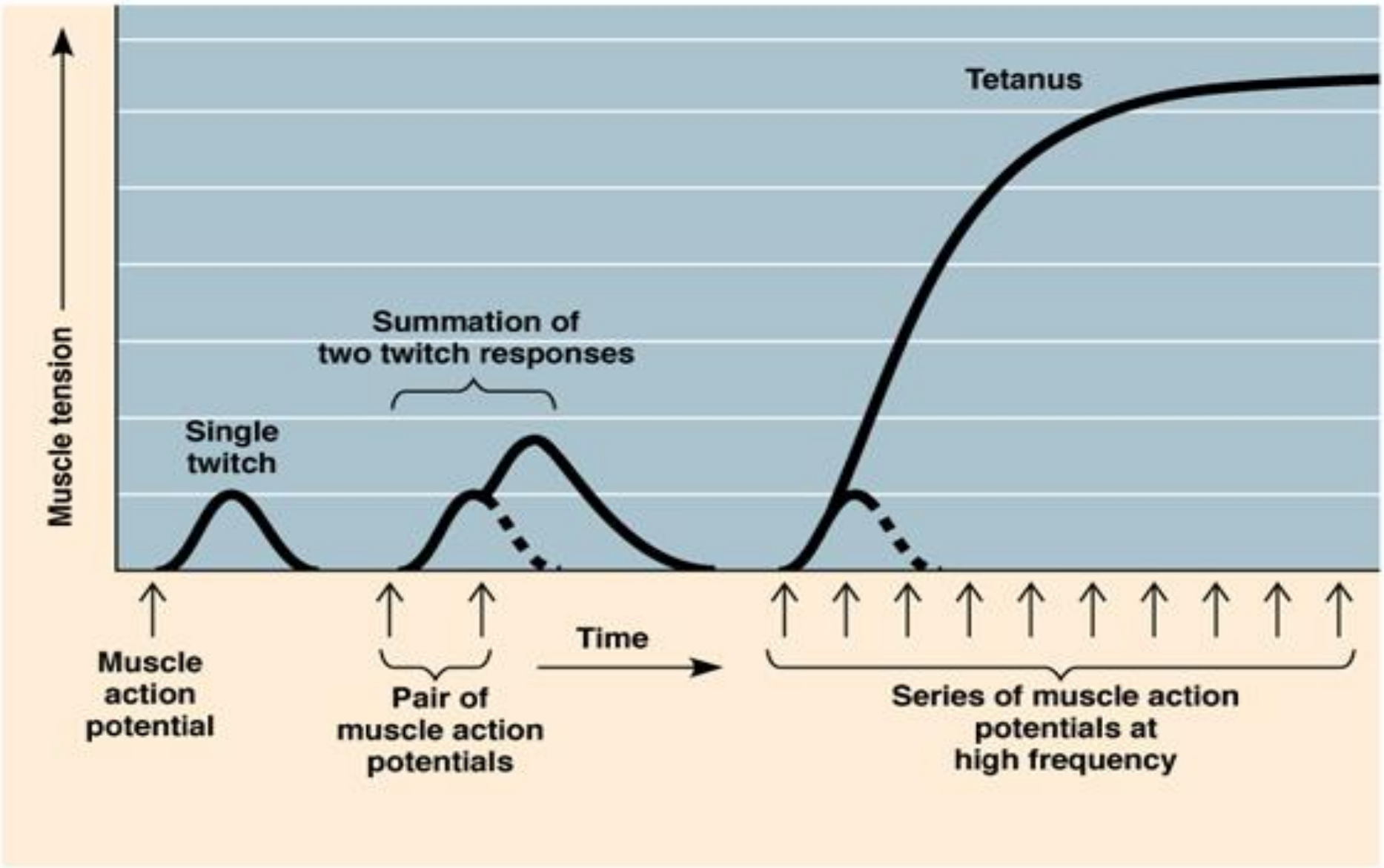
Muscle Twitch – Summation - Tetanus



Major Characteristics of Muscle Fiber Types

Characteristic	Type I	Type IIa	Type IIb
Contraction Speed	Slow	Fast	Fast
Force production	Low	Intermediate	High
Power Output	Low	High	High
Endurance	High	Intermediate / Low	Low
Aerobic enzymes	High	Intermediate / Low	Low
Anaerobic enzymes	Low	High	High
Fatigability	Low	Intermediate / High	High
Capillary density	High	Intermediate	Low
Fiber diameter	Small	Intermediate	Large
Mitochondria density	High	Intermediate	Low
ATPase activity	Low	High	High
Myoglobin	High	Low	Low
Color	Red	White (intermediate)	White

Motor Unit Recruitment Patterns During Exercise

- Muscle Force output varies over a wide gradation in order to allow for appropriate use of force to carry out activity in a smooth, controlled manner
- **Frequency of Activation** – by decreasing the time interval between muscle twitches, greater force production is attained; most commonly used in precision muscles (i.e. hand, eye)
- **Recruitment** – increasing the number of motor units activated to produce greater Force or carry out a particular movement; most commonly used in large muscle groups (thigh, gluteals, arms, trunk)
- Increasing frequency of contraction and increasing recruitment occur simultaneously when great Force production is required
- Depending on the physiological need, different types of muscle fibers are recruited, based on the fibers characteristics

Relative Involvement of Muscle Fiber Types in Sport Events

Event	Type I	Type II
100-m sprint	Low	High
800-m run	High	High
Marathon	High	Low
Olympic Weightlifting	Low	High
Barbell squat	High	High
Soccer	High	High
Field Hockey	High	High
Football wide receiver	Low	High
Football lineman	High	High
Basketball	Low	High
Distance cycling	High	Low

Proprioception

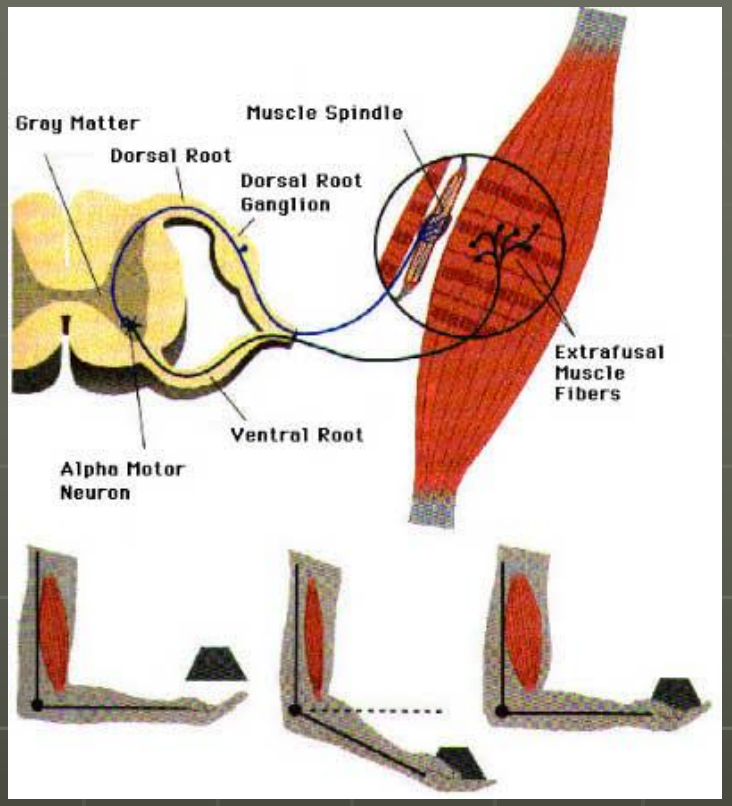
- **Proprioceptors** – specialized sensory receptors located within joints, muscles, and tendons; sensitive to pressure and tension; relay info regarding muscle dynamics to the central nervous system
  - Provide the nervous system with info to allow for performance of complex coordinated movements; maintains muscle tone

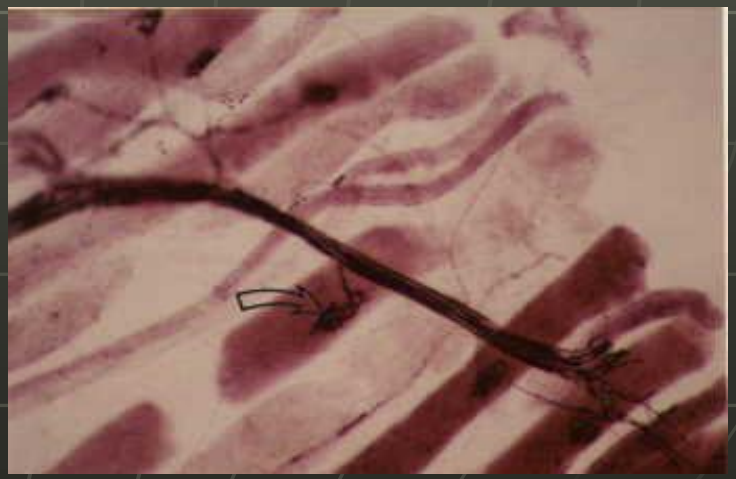
- **Kinesthetic Sense** – spatial awareness; conscious appreciation of the body in 3 dimensions; once learned, most proprioception is sub-consciously controlled

- Two most common proprioceptors are the Muscle Spindle and the Golgi Tendon Organ

Muscle Spindle

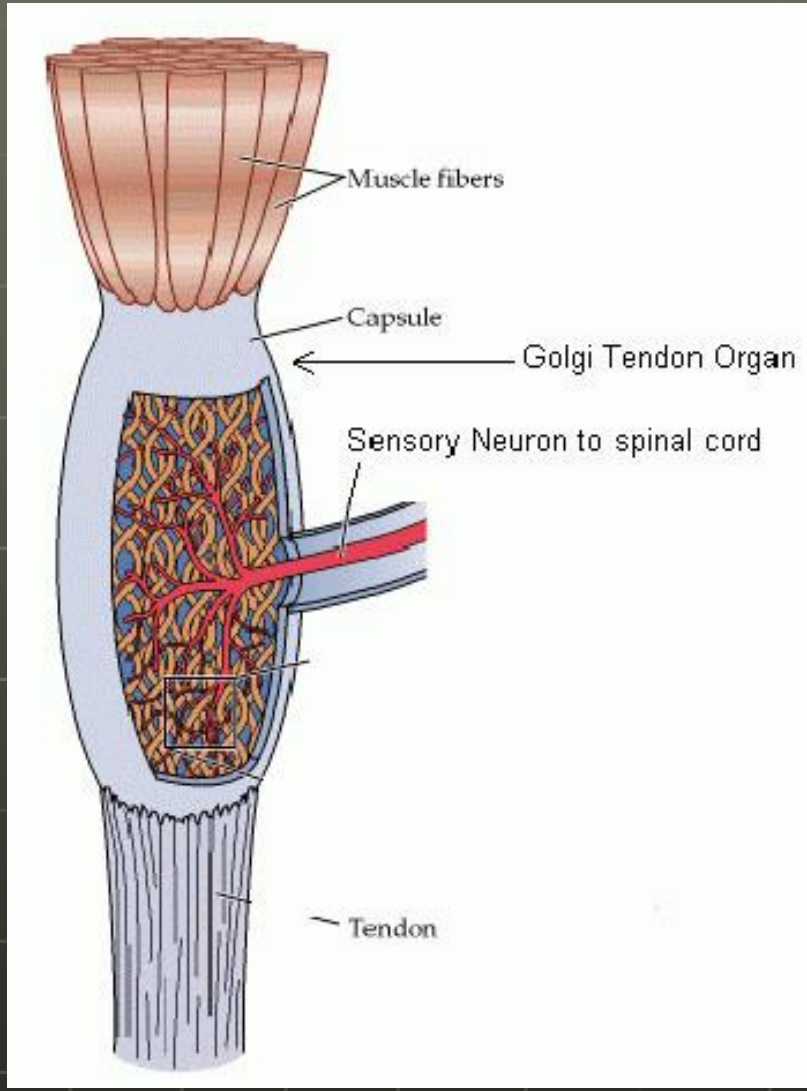
- **Muscle Spindle** – (intrafusal fiber)
  - Specialized muscle fibers that run parallel to normal muscle fibers (extrafusal fiber) within a fasiculus; provide info regarding muscle length and rate of length change
  - Muscle stretch activates the spindle which sends a signal to the spinal cord via an afferent (sensory) neuron; at the cord the afferent transfers the signal to an efferent (motor) neuron, which sends an action potential to the muscle, causing contraction (if AP is great enough) of the muscle fibers
  - Spindles indicate the degree to which the muscle must be activated to overcome the given resistance
  - Precision muscles have a greater concentration of muscle spindles than larger muscles





Golgi Tendon Organ

- **Golgi Tendon Organs** – (GTO) proprioceptors located within the tendon of a muscle and in contact with extrafusal muscle fibers; activated by stretch of tendon
  - Stretch activation of the GTO results in the same type of neuronal pathway activation as muscle spindle activation, however the neurons activated are inhibitory, that is, they inhibit muscular contraction, reducing tension within the muscle
  - GTO's provide protection from excess loads



Major Adaptations to Resistance vs. Aerobic Endurance Training

Variable	Resistance Training	Aerobic Endurance Training
Size of muscle fibers	Increase	No change
Number of muscle fibers	No change	No change
Movement speed	Increase	No change
Strength	Increase	No change
Aerobic capacity	No change	Increase
Anaerobic capacity	Increase	No change