Skeletal Muscle Fibers: Different Types Exist in Nature

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   • White = light = lot of glycogen
   • Red = dark = lot of myoglobin, more fat = different taste and texture
### Skeletal Muscle Fibers: Different Types Exist In Nature

A. Color: light meat (chicken or turkey breast) & dark meat (turkey leg and thigh)
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B. Contractile Properties (Fast Twitch, Slow Twitch)

C. Metabolic Properties (Oxidative, Glycolytic)

D. Integrated Nomenclature (SO, FOG, FG)

E. Myosin Properties
   - Type I, Type II, Type IIa,b,c,x

### Slow, Fast, “TWITCH”

- In vivo muscle **twitch** preparation
  - Find volunteer
  - Replace SEMN with electrical stimulator on named nerve
  - Determine voltage necessary to get a mechanical response in muscle i.e. force
    - record force
  - TWITCH: A recording of a suprathreshold electrical input (stimulus) and resulting mechanical response (external force)
Muscle Twitch Preparation

Latent period:
- Sarcolemma and T tubules depolarize
- $Ca^{2+}$ released into cytosol
- Cross bridges begin to cycle but no visible shortening of muscle
- Take stretch out of connective tissue

Contraction:
- Sarcomeres shorten as a result of myosin cross bridge cycling
- Muscle gets to "peak" tension
- Speed depends on
  - fiber type (slow-twitch fibers or fast-twitch fibers) when load is constant
  - load when fiber type is constant

Relaxation:
- $Ca^{2+}$ actively transported back into terminal cisternae lateral sacs
- Cross bridge cycling decreases and ends
- Tension is reduced, muscle returns to original length
  - Fast relaxes faster
  - Slow relaxes slower
Fiber Characteristics

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<th></th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
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<tr>
<td>Contractile (Twitch):</td>
<td>ST</td>
<td>FTa</td>
<td>FTx</td>
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<tr>
<td>Metabolic</td>
<td>SO</td>
<td>FOG</td>
<td>FG</td>
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<td><strong>Structural aspects</strong></td>
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<tr>
<td>Muscle fiber diameter</td>
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<td>Large</td>
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<td>Mitochondrial density</td>
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<td>Twitch (contraction) time</td>
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<tr>
<td>Relaxation time</td>
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<td>Phosphocreatine stores</td>
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<td>Glycogen stores</td>
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<tr>
<td>Triglyceride stores</td>
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<td>Low</td>
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<tr>
<td>Myosin-ATPase activity</td>
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<td>High</td>
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<tr>
<td>Glycolytic enzyme activity</td>
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<td>High</td>
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<tr>
<td>Oxidative enzyme activity</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
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</tbody>
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Muscle fiber types cross section

All the fibers in a unit are the same fiber type

Skeletal Muscle Fibers are arranged in motor units which exist in different types with different somatic efferent motor neuron properties

<table>
<thead>
<tr>
<th>Muscle Fibers</th>
<th>Twitch properties</th>
<th>Metabolic properties</th>
<th>Name based on twitch and metabolic properties</th>
<th>Other nomenclature</th>
<th>Somatic Efferent Motor Neuron to unit’s fibers</th>
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<tr>
<td></td>
<td>Slow</td>
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<td>SO</td>
<td>ST, Type I</td>
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<td>FTA, FTA, Type IIA</td>
<td>Neuron size</td>
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<td>Glycolytic</td>
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<td>FTx, FTX, Type IIX</td>
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<td>Recruitment threshold</td>
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Motor units

- 1 SEMN and all fibers innervated
  - All fibers in unit same type
    - units have different twitch pattern
    - All fibers in unit have same dominant ATP pathway
    - All fibers in unit have same Myosin and Calcium ATPase activity
    - Each unit works all or none
    - Units have different threshold for excitation
All of the fibers in a motor unit are the same FIBER TYPE

Motor Units are activated (Recruited) according to a Size Principle

- Small motor units have relatively thin alpha motor neurons whose threshold is close to resting potential so they are first to be recruited in a movement
  - they are made up of Slow Twitch fibers
  - they are fatigue resistant

- Fast twitch units have relatively thick alpha motor neurons whose threshold is not close to resting potential, so they are “harder” to recruit
  - they are made up of Fast Twitch fibers
  - they are easily fatigued
  - there are two types of fast twitch motor units in humans
    - IIa
    - IIx
Size principle

As the force or speed of movement increases, the size of the motor units recruited increases to allow greater and more rapid force production.

Fiber type varies

- between muscles in an individual
  - triceps vs biceps

- between individuals in a muscle
  - quadriceps of world class sprinters
  - quadriceps of world class marathon runner
Type of unit varies between muscles

- Cross-country skiing
- Long-distance running
- Running 100-200 m

Muscle fiber composition (% ST fibers)
Maximal oxygen consumption (mL · kg⁻¹ · min⁻¹)
Fiber Type is Genetic

• Twin Studies
• Fiber Status depends on training
  – Optimize biologic potential by specific training
  – Specific Adaptation Imposed Demand “SAID”
PRINCIPLE