Muscle Function During Acute Exercise

Chapters 8 & 19
(pp. 393-397)
Acute Force Production

Just Right

Too Much
Without making any permeant changes to the neuromuscular system, what could cause the muscle to generate more or less force?
1. ACh released, binding to receptors
2. Action potential reaches T tubule
3. Sarcoplasmic reticulum releases Ca^{2+}
4. Active-site exposure, cross-bridge binding
5. Contraction begins
A single muscle with IIb, IIa, and I muscle fibers.
Motor Units

Note the order of recruitment
Motor Units
Motor Units

Number (and order) of MU
Motor Units

Number (and order) of MU

Frequency
Motor Units

- **Single Twitches**
- **Summation**
- **Tetanus**

Graphs showing the force of contraction over time.
Motor Units

Diagram showing the relationship between force and stimuli, with labels for 'Simple Twitches', 'Summation', and 'Tetanus'.
Motor Units

Note the frequency of stimulation
Motor Units

1. The number (and type) of Motor Units

2. The Frequency of stimulation
## Fiber Arrangement

<table>
<thead>
<tr>
<th>Classification</th>
<th>Example</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal</td>
<td>Sartorius</td>
<td><img src="image1" alt="Diagram" /></td>
</tr>
<tr>
<td>Fusiform</td>
<td>Biceps brachii</td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
<tr>
<td>Radiate</td>
<td>Gluteus medius</td>
<td><img src="image3" alt="Diagram" /></td>
</tr>
<tr>
<td>Unipennate</td>
<td>Tibialis posterior</td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
<tr>
<td>Bipennate</td>
<td>Gastrocnemius</td>
<td><img src="image5" alt="Diagram" /></td>
</tr>
<tr>
<td>Circular</td>
<td>Orbicular oculi (and sphincters)</td>
<td><img src="image6" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Stronger
Muscle Length

Graph showing the relationship between relative tension and percent rest length. The diagram indicates that:

- **1.65 μm**: Less than optimal length, fewer cross-bridge interactions = reduced tension development.
- **2.25 μm**: Optimal length, maximal cross-bridge interaction = maximal tension development.
- **3.65 μm**: Greater than optimal length, no cross-bridge interaction = no tension development.
Speed of Contraction

- **Fast Contraction**
- **Low Force**

Graph showing the relationship between velocity of movement (degrees/sec) and force.
Speed of Contraction

- **Fast Contraction**
  - Low Force
- **Slow Contraction**
  - Low Force
  - Force
  - Velocity of movement (degrees/sec)
  - < 50% FT
  - > 50% FT
Speed of Contraction

- Fast Contraction
  - < 50% FT
  - > 50% FT

- Slow Contraction
  - Force: Low to High

Velocity of movement (degrees/sec)
Speed of Contraction

- **Fast Contraction**
  - Low Force: High Force
  - High Force: Faster movement

- **Slow Contraction**
  - Low Force: Slow movement
  - High Force: Slow movement
Force Regulation Summary

Motor Units

Number

Frequency

Fiber Arrangement

Muscle Length

Speed of Contraction
Myths
Myths

1. A bigger muscle is not always the stronger muscle.
Myths

1. **A bigger muscle is not always the stronger muscle.**

2. **Stronger is not always better.**

   - **Strength = force produced**
   - **Power = force produced x distance / time**
Muscle Fatigue

How is fatigue defined?
Types of Fatigue

1. Central fatigue

2. Peripheral fatigue

Fig 19.2
Peripheral Fatigue

Sites of Central Fatigue
- Central Nervous System
  - Brain
  - Spinal cord
  - Neuron

Sites of Peripheral Fatigue
- Peripheral Nervous System
  - Peripheral nerve
  - Alpha motor neuron
- Skeletal Muscle Fibers
  - Neuromuscular junction (NMJ)
  - Muscle fiber
  - T tubule
  - Sarcolemma
  - Sarcoplasmic reticulum
  - Ca^{2+}-troponin
  - A^*M
  - ATP

Electrophysiological considerations

Contractile considerations
Peripheral Fatigue

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ATP
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Electrophysiological considerations

Contractile considerations
Peripheral Fatigue
Peripheral Fatigue

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Skeletal Muscle Fibers

Neuromuscular junction (NMJ)
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Sarcoplasmic reticulum

Electrophysiological considerations
Contractile considerations

ATP

Ca^{2+}•troponin A•M
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Sites of Peripheral Fatigue

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Sarcolemma
T tubule
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A-M

Electrophysiological considerations

Contractile considerations

ATP
Muscle Soreness

Acute Soreness

Acid build up

Edema
Delayed Onset Muscle Soreness (DOMS)

Proposed Model to Explain Delayed Muscular Soreness

Strenuous Exercise

1. Structural damage to muscle cells
2. Calcium leaks out of sarcoplasmic reticulum
3. Protease activation—results in breakdown of cellular proteins
4. Inflammatory response
5. Edema and pain
Delayed Onset Muscle Soreness (DOMS)
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**NOT due to lactic acid!**
Delayed Onset Muscle Soreness (DOMS)

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Delayed Onset Muscle Soreness (DOMS)

**NOT due to lactic acid!**
Myth Buster

- Lactic acid does not cause delayed onset muscle soreness

- Lactate, the major by-product of lactic acid, is removed or cleared within hours after exercise