Lecture Objectives

1. Discuss general muscle physiology
2. Understand types of therapy and rational for exercise prescriptions
3. Understand types of modalities available for use with therapy and at home
4. Know indications and contraindications for modalities
Therapeutic Exercise

DeLateur defined therapeutic exercise as bodily movement prescribed to correct an impairment, improve musculoskeletal function, or maintain a state of well-being.

Therapeutic Exercise

Goals:

- Increase strength
- Increase endurance
- Increase coordination
- Increase proprioception
- Increase flexibility
- Decrease pain
- Weight loss/appearance
- Improve function
- Decrease spasticity
- Cardiopulmonary rehabilitation/deconditioning/general health
- Injury recovery
- Treat and prevent disease

Therapeutic Exercise

Factors Affecting Strength:

- Muscle length
- Lever arm
- Angle of pull
- Site of Origin
- Site of Insertion
- External Factors
- Motivation

*Strength can vary in the same day for the same task by 10-20%*
Therapeutic Exercise

- Young-Middle age men can increase strength 40%
- Woman can increase strength by 15% (which is only fair since they are stronger in most other aspects)

Muscle Physiology

- Sarcosomes
- Z lines
- Thin filaments
- Thick filaments
- I bands
- A bands
### Types Of Muscle Fibers

**Type I Fibers**
- High Oxidative Potential
- Low intensity, long duration activities (slow-twitch)
- High resistance to fatigue

**Type II Fibers (2 types)**
- Lower Oxidative Potential
- High Intensity, short duration activities (fast twitch)
- Low Resistance to fatigue

**Type II fibers**
- Muscle Hypertrophy and Atrophy mainly occur in Type II fibers

#### Types of Muscle Fibers

<table>
<thead>
<tr>
<th>Fatigue</th>
<th>Metabolism</th>
<th>Type IIa</th>
<th>Type IIb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistant</td>
<td>Oxidative/Glycolytic</td>
<td></td>
<td>Glycolytic</td>
</tr>
</tbody>
</table>

#### Types of Strengthening Exercises

<table>
<thead>
<tr>
<th>Description</th>
<th>ISOTONIC</th>
<th>ISOMETRIC</th>
<th>ISOKINETIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>Weight Lifting (biceps curls)</td>
<td>Pushing against wall</td>
<td>Does not exist in nature</td>
</tr>
<tr>
<td>Advantage</td>
<td>Strengthen at full ROM, Low Cost</td>
<td>No joint movement, Less painful/injuries</td>
<td>Strengthens at full ROM</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Joint Movement, Injury risk</td>
<td>Decrease local muscle blood supply, Increase BP</td>
<td>High Cost</td>
</tr>
</tbody>
</table>

**Description**
- Visible Joint Movement
- Variable Speed
- No joint movement
- Constant Speed
- Cybex, Nautilus
- Does not exist in nature
Types of Strengthening Exercises

- Eccentric and Concentric Contractions can occur in the setting of isotonic or isokinetic exercises
  - Eccentric: Muscle lengthening against resistance
    - Fast eccentric contractions generate greatest force
    - Causes more tissue destruction
    - Energy Efficient/Low Metabolic Cost
  - Concentric: Muscle shortening against resistance
    - Generates little force
    - High metabolic cost

Physical Modalities... are adjuvant treatments!
<table>
<thead>
<tr>
<th>Modalities</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Thermotherapy</td>
<td>Heat</td>
<td>Cold</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Superficial (Hot packs, Fluidotherapy, Hydrotherapy)</td>
<td>Deep (Ultrasound, Shortwave diathermy, Microwave)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manual Therapy (Traction, Massage, Manipulation)</td>
<td>Pressure</td>
<td>Acupuncture</td>
</tr>
</tbody>
</table>
Thermotherapy - HEAT

Heat Transfer

Mechanisms of Heat (thermal energy) Transfer

- **Conduction** - direct contact between two bodies at different temperature
  - hot pack, paraffin bath, cold packs, ice massage

- **Convection** - circulation/movement of a medium (water, air) to transfer energy by establishing a temperature gradient
  - Hydrotherapy (whirlpool), contrast baths, cold bath, whirlpool

- **Conversion** - conversion of electromagnetic radiation (non-thermal) into heat therapy
  - heat lamps, ultrasound, diathermy

Physiologic Effects of Heat

- **Hemodynamic**
  - Increased blood flow
  - Decrease chronic inflammation
  - Increase acute inflammation
  - Increase edema
  - Increase bleeding

- **Neuromuscular**
  - Increase nerve conduction velocity

- **Joint & Connective Tissue**
  - Increase tendon extensibility
  - Decrease joint stiffness

- **Miscellaneous**
  - Decreased Pain
<table>
<thead>
<tr>
<th>Physiatric Indications for Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Chronic musculoskeletal processes</td>
</tr>
<tr>
<td>• Reduction of muscle spas,</td>
</tr>
<tr>
<td>• Myofascial pain reduction</td>
</tr>
<tr>
<td>• Reduction in joint stiffness, contractures</td>
</tr>
<tr>
<td>• Arthritis</td>
</tr>
<tr>
<td>• Chronic inflammations</td>
</tr>
<tr>
<td>• Superficial thrombophlebitis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contraindications to heat therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Arterial Insufficiency</td>
</tr>
<tr>
<td>• Bleeding disorders</td>
</tr>
<tr>
<td>• Impaired sensation</td>
</tr>
<tr>
<td>• Inability to communicate pain</td>
</tr>
<tr>
<td>• Malignancy</td>
</tr>
<tr>
<td>• Acute trauma or inflammation</td>
</tr>
<tr>
<td>• Scar Tissue</td>
</tr>
<tr>
<td>• Edema</td>
</tr>
<tr>
<td>• Poor thermal regulation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thermotherapy - Superficial Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Limited tissue temperature in skin and subcutaneous fat (1-2 cm depth)</td>
</tr>
<tr>
<td>• Best for superficial joints (hands, feet) with less adipose covering</td>
</tr>
</tbody>
</table>
Thermotherapy - Superficial Heat

1. **Hot Packs**
2. **Heating Pads**
3. **Radiant Heat**
4. **Fluidotherapy**

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**Thermotherapy - Superficial Heat**

1. **Hot Packs** (Hydrocollator) heated bags filled with silicon dioxide
   - Increases temperature 3.3 °C at 1cm of depth and 1.3 °C at 2cm of depth
   - Used for up to 30 minutes, wrapped in towels, can be dangerous
   - Avoid lying on hydrocollator → capillary flow decreases and local cooling effect lost

2. **Heating Pads** - Constant heat - electric pads and pads with circulating fluids
   - Largest potential for burns in patients with decreased adipose tissue who lie on pad

3. **Radiant Heat** – infrared lamps
   - Distance from lamp to skin is 45-60cm (18-24 inches)
   - Used in patient who can not tolerate the weight of hot packs

4. **Fluidotherapy** – hot air is blown through a container holding fine cellulose particles (bed of beads or corn husks)
   - Good for hands and feet
Thermotherapy - Superficial Heat

Danger, Danger Danger!
Hot packs (or electric heating pads) should lie on the patient...
Increased risk of burns and erythema ab igne

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Thermotherapy - Deep Heat

- Produced by conversion of electromagnetic energy into heat
- Best for heating of deeper structures (ligaments, muscles and joint capsules) – with depth of 3-5cm

1. Ultrasound (8cm)
2. Short Wave Diathermy (4-5cm)
3. Microwave Diathermy (1-4cm)
**Thermotherapy - Deep Heat - Ultrasound**

- Conversion of acoustic energy to thermal energy
- Absorption in bone (30%) > tendon > skin > muscle > fat
- GREATEST HEATING AT BONE-MUSCLE INTERFACE
- Heating depth up to 8cm

- Indications:
  - Degenerative Arthritis and joint contracture (deep joints)
  - Bursitis
  - Tendinitis
  - Subacute Trauma

**Contraindications**

- General Heat Contraindications
- PACEMAKER
- TUMOR
- ARTHROPLASTIES
- Reproductive Organs
- Eyes
- Heart
- Spinal Cord
- Immature Skeleton
- Poor Circulation
- Impaired Sensation

**Therapeutic Use**

- Frequency: 0.8-1.1 MHz
- Intensity:
  - W.H.O. recommended ranges: 0.5-2.0 W/CM²
  - Clinical range for tendonitis/bursitis: 1.2-1.8 W/CM²
- Duration: 5-10 minutes per site
- Location: Deep Joints (Hip, Sacroiliac)

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## Thermotherapy - Deep Heat - Shortwave Diathermy

- **Conversion of electromagnetic energy to thermal energy**
- Most commonly used frequency: **27.12 MHz**
- Heating depth of **4-5 cm**
- Treatment time of **20-30 minutes**
- May be **Inductive or Capacitive**
  - **Inductive**:
    - Used in **WATER RICH** tissues (superficial muscle and skin)
    - Applicators consist of induction coils in semirigid housing
    - Indicated for heating of superficial muscles
  - **Capacitive**:
    - Used in **WATER POOR** tissues (fat, bone)
    - Treatment areas placed between two capacitor plates
    - Indicated for heating of superficial fat and deeper muscles

## Thermotherapy - Deep Heat - Microwave Diathermy

- **Conversion of microwave electromagnetic energy to thermal energy**
- Heats **1-4 cm** in depth
- **Limited clinical use because it is cataractogenic**
- May speed resolution of hematomas

## Indications:
- Superficial Muscle Pain
- Chronic Prostatitis
- Pelvic Inflammatory Disease

## Contraindications:
- General Heat Precautions
- Metal (Jewelry, pacemakers, IUDs, surgical implants)
- Contact lenses
- Reproductive organs
- Skeletal Immaturity
Summary of Deep Heat / Diathermy

<table>
<thead>
<tr>
<th></th>
<th>Ultrasound</th>
<th>Shortwave</th>
<th>Microwave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism</td>
<td>Sound Waves</td>
<td>Radio waves</td>
<td>Microwave</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.8-1.1 MHz</td>
<td>27.12 MHz</td>
<td>915-2450 MHz</td>
</tr>
<tr>
<td>Heating Depth</td>
<td>8 cm</td>
<td>4-5 cm</td>
<td>1-4 cm</td>
</tr>
<tr>
<td>Indications</td>
<td>Chronic Inflammation</td>
<td>Superficial Muscle</td>
<td>Chronic Prostatitis</td>
</tr>
</tbody>
</table>

Radar guns suspected of causing cancer in officers who use them
Thermoheparpy - COLD

Physiologic Effects of Cryotherapy

- Hemodynamic
  - Decrease Blood Flow (vasoconstriction)
  - Decrease acute inflammation
- Neuromuscular
  - Decrease nerve conduction velocity
  - Decrease muscle spasticity
- Joint & Connective Tissue
  - Decrease tendon extensibility
  - Increase Joint stiffness
- Miscellaneous
  - Decreased Pain

Contraindications to Cryotherapy

- Cold Intolerance
- Arterial insufficiency
- Impaired Sensation
- Inability to communicate pain
- Cryopathies
- Cryoglobulinemia
- Raynaud disease
### Physiatric Indications for Cryotherapy
- Inflammatory musculoskeletal conditions (tendonitis, bursitis, capsulitis, sprains, strains)
- Acute traumatic conditions
- Component of spasticity management
- Acute treatment of minor burns

### Mechanisms of Cold Transfer
- **Conduction:**
  - Cold Pack
  - Ice Massage
- **Convection:**
  - Cold Baths/whirlpool
- **Evaporation:**
  - Vaporcoolant sprays

### Modalities
- **Thermotherapy (Heat and Cold)**
- **Hydrotherapy**
- Light Therapy (UV radiation, Laser)
- Electrotherapy
- Manual Therapy (Traction, Massage, Manipulation)
- Pressure
- Acupuncture
<table>
<thead>
<tr>
<th>Hydrotherapy</th>
<th>Modalities</th>
<th>Light Therapy – UV radiation</th>
</tr>
</thead>
</table>
| External application of hot or cold water in any form for treatment of disease | - Thermotherapy (Heat and Cold)  
- Hydrotherapy  
- Light Therapy (UV radiation, Laser)  
- Electrotherapy  
- Manual Therapy (Traction, Massage, Manipulation)  
- Pressure  
- Acupuncture | - Ultraviolet A wavelengths commonly used (2000-4000 Å)  
- Effect due to photochemical reaction in the skin resulting in alteration of DNA and cell proteins  
- Physiologic Effects:  
  - Increase vascularization of wound margins  
  - Local skin hyperemia and exfoliation  
  - Bactericidal on motile bacteria  
- Determine each individual's MED (minimal erythemal dose) |

- Whirlpool Baths/Aquatherapy:  
  - Immerse large portions of body to experience a vertical antigravity effect on major joints  
- Shower Carts:  
  - Wound debridement  
- Contrast Baths  
  - Neuropathic pain (Complex Regional Pain Syndrome)
### Light Therapy – UV radiation

- Most commonly used for treatment of psoriasis
- UVA UV lightbox is used in the treatment, which can be just as harmful as UVB or UVC
- Overall use has dramatically dropped after a link with skin cancer established

### Light Therapy – Laser

- L.A.S.E.R. (light amplification by stimulated emission of radiation)
- Low level laser does not produce thermal effect
- Mechanism of action unclear
- Conflicting and limited evidence for efficacy

### Modalities

- Thermotherapy (Heat and Cold)
- Hydrotherapy
- Light Therapy (UV radiation, Laser)
- Electrotherapy
- Manual Therapy (Traction, Massage, Manipulation)
- Pressure
- Acupuncture
Electrotherapy

- Use of electricity to stimulate a nerve of muscle transcutaneous using electrodes

- Types of electrotherapy used in clinical practice
  - Transcutaneous nerve stimulation (TENS)
  - Neuromuscular electrical stimulation (NMES)
  - Iontophoresis

Electrotherapy - TENS

- Programmable devise applies electrical signals via electrodes attached to the patient's skin → stimulates nerve fibers for symptomatic relief of pain

- Typically place electrodes over areas of greatest pain

- Treatment lasts 30mins-1 hour

- No clear time limit to treatment
**Electrotherapy - TENS**

**Mechanism of Action**

1. **Placebo effect (>30% of patients)**
   - Gate Control Theory
     - Stimulation of la myelinated afferent fibers "close the gate" on transmission of pain via A-delta or C fibers

2. **Gate Control Theory**
   - Stimulation of la myelinated afferent fibers "close the gate" on transmission of pain via A-delta or C fibers

3. **Release of endogenous opioids**
   - Pain relief can be reversed by use of Naloxone...??

**Settings of TENS (Frequency & Amplitude)**

- **Conventional (High Frequency, Low Amplitude)**
  - MOST EFFECTIVE!!!
  - Amplitude adjusted to produce minimal sensory discomfort
  - Especially good for neuropathic pain

- **Acupuncture (Low Frequency, High Amplitude)**
  - Amplitude high enough to produce muscle contraction
  - Useful for acute musculoskeletal complaints

**Electrotherapy - Iontophoresis**

- Transdermal delivery where charged substance (commonly anti-inflammatory) is propelled through skin using a low electrical current

- Common use is anti-inflammatory to superficial bursa or tendon (plantar fasciitis)
Phonophoresis
- Uses US to facilitate transdermal migration of topical medications
- Same precautions as ultrasound
- Most common agent is 1%-10% hydrocortisone (mix it with coupling gel)
- Efficacy not really proven

Table 1. Iontophoresis Cross-reference

<table>
<thead>
<tr>
<th>Drug</th>
<th>Charge +/-</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>Negative</td>
<td>Calcium deposit</td>
</tr>
<tr>
<td>Chloride</td>
<td>Negative</td>
<td>Scar tissue</td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>Negative</td>
<td>Inflammation/bursitis</td>
</tr>
<tr>
<td>Calcium</td>
<td>Positive</td>
<td>Muscle spasm/muscle dysfunction</td>
</tr>
<tr>
<td>Hydrocortisone</td>
<td>Positive</td>
<td>Anti-inflammatory steroid/myositis</td>
</tr>
<tr>
<td>Zink oxide</td>
<td>Positive</td>
<td>Anti-inflammatory</td>
</tr>
<tr>
<td>Salicylates</td>
<td>Negative</td>
<td>Arthritis/myalgia</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Positive</td>
<td>Tenosynovitis</td>
</tr>
<tr>
<td>Atropine sulphate</td>
<td>Positive</td>
<td>Hyperhidrosis</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Positive</td>
<td>Muscle relaxant</td>
</tr>
<tr>
<td>Zink oxide</td>
<td>Positive</td>
<td>Wound healing/antiseptic</td>
</tr>
</tbody>
</table>

Modalities
- Thermotherapy (Heat and Cold)
- Hydrotherapy
- Light Therapy (UV radiation, Laser)
- Electrotherapy
- Manual Therapy (Traction, Massage, Manipulation)
- Pressure
- Acupuncture
**Manual Therapy - Traction**

**Cervical Spine**
- Flexed posture: 20-30 degrees to open neural foramina
- 25-50lbs of tractive force

**Lumbar Spine**
- Neutral Lumbar positioning
- >50-100lbs of force

**Manual Therapy - Traction**

**Contraindications:**
- Cervical:
  - Ligamentous instability, Atlantoaxial instability, verteobasilar insufficiency
  - Lumbar:
  - Pregnancy, Cauda Equina, Aortic Aneurysm, Restrictive lung disease

**Manual Therapy - Massage**

**Effleurage:**
- Gliding movement of the skin WITHOUT deep muscle movement
- Used for muscle relaxation

**Petrissage**
- Kneading movement
- Increase circulation, decrease edema, muscle relaxation

**Tapotement**
- Percussion
- Used for chest therapy and postural drainage

**Contraindications:**
- Malignancy, open wounds, cellulitis, DVT
QUESTIONS

Resources

*Exercise Physiology: Basis of Human Movement in Health and Disease*, Brown, Miller, and Eason
*Exercise Physiology: Nutrition, Energy and Human Performance*, McArdle, Katch, and Katch
*Textbook of Therapeutic Exercises*, Narayan