Thermal Agents:
Cold and Heat

Physical Principles of Thermal Transfer

- **Specific Heat**
  - Specific heat is the amount of energy required to raise the temperature of a given weight of a material by a given number of degrees (F or C)
  - Materials with a high specific heat hold more energy than materials with a low specific heat
  - Agents with higher specific heat are applied at lower temperatures
    - Ex – Paraffin bath is applied at lower temperature than hot pack

- **Modes of Heat Transfer**
  - Conduction: Heat Transfer by Direct Contact Such as Hot Packs and Cold Packs
    - Rate of Heat Transfer by Conduction
      - \[ \text{[(contact area) x (thermal conductivity) x (temp difference)] / tissue thickness} \]
      - Thermal conductivity = rate at which a material transfers heat
Physical Principles of Thermal Transfer

Modes of Heat Transfer

Guidelines for Heat Transfer by Conduction
- The greater the temperature difference, the faster the rate of heat transfer
- Materials with higher thermal conductivity transfer heat more rapidly than those with lower thermal conductivity
- The larger the area of contact, the greater the total heat transfer
- The thicker the tissue, the slower the rate of heat transfer

Convection: Heat Transfer by Circulation of a Medium of a Different Temperature Such as Fluidotherapy, Whirlpool, Blood Circulation
- Convection – heat transfer due to direct contact between a circulating medium and another material of a different temperature
Physical Principles of Thermal Transfer

- Modes of Heat Transfer
  - Conversion: Conversion from One Type of Energy to Another Such as Ultrasound, Diathermy, and Metabolism
    - Conversion of a non-thermal form of energy (physical/mechanical, electrical, or chemical) to a thermal form of energy

- Radiation: Exchange of Energy Directly without an Intervening Medium Such as Infrared Lamp
  - Radiation – transfer of energy without direct contact

- Evaporation: Absorption of Energy as the Result of Conversion of a Material from a Liquid to a Vapor State Such as Vapocoolant Sprays
  - During evaporation, energy is absorbed when a solid is converted to a liquid or a liquid is converted to a gas/vapor (sweating)
  - Vapocoolant sprays result in cooling of an area due to evaporation
Vapocoolant Spray

Cold- Cryotherapy

- Hemodynamic Effects
  - Initial Decrease in Blood Flow
  - Later Increase in Blood Flow
  - Ice bath results
  - Cold induce vasodilatation
  - Hunting response
Cold- Cryotherapy

- Neuromuscular Effects
  - Decreased Nerve Conduction Velocity
    - As temperature decreases, nerve conduction velocity decreases

- Increased Pain Threshold
  - Gate Control Theory
    - Cold increases activity of the non-nociceptive fibers causing inhibition of nociceptive fibers

- Altered Muscle Strength
  - Short cooling can result in increased strength
  - Long cooling can result in decreased strength
Cold- Cryotherapy

- Neuromuscular Effects
  - Decreased Spasticity
    - Decrease in motor neuron & muscle spindle activity
  - Facilitation of Muscle Contraction
    - Facilitates motor neuron activity by stimulating cutaneous sensory receptors
    - Lasts for only a short period of times (seconds)

- Metabolic Effects
  - Decreased Metabolic Rate
    - "Slows" or controls inflammation
    - Can slow healing
    - Cryotherapy is used for management of inflammatory diseases such as OA and RA

- Uses of Cryotherapy
  - Inflammation Control
    - Slows metabolism
    - Reduces edema
    - Reduces pain
Cold- Cryotherapy

- Uses of Cryotherapy
  - Edema Control
    - Due to vasoconstriction

- Uses of Cryotherapy
  - Pain Control
    - Gate Control
      - Theory - Cold increases activity of the cutaneous thermal receptors (non-nociceptive fibers) causing inhibition of nociceptive fibers

- Uses of Cryotherapy
  - Modification of Spasticity
    - Decrease in reflexes
    - Duration - 5 – 30 mins
    - 30 mins for severe spasticity
Cold-Cryotherapy

- **Uses of Cryotherapy**
  - **Facilitation**
    - Quick icing may be used to elicit desired motor patterns

- **Cryokinetics and Cryostretch**
  - Cryotherapy is used to minimize sensation (numbness) prior to exercise/stretching to decrease pain perception

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Cold-Cryotherapy

- **Contraindications for Cryotherapy**
  - **Cold Hypersensitivity**
    - Elevated patches which are red or pale
  - **Cold Intolerance**
  - **Cryoglobulinemia** – aggregation of serum proteins limiting circulation
    - Associated w/ lupus & RA
Cold Hypersensitivity

Cold-Cryotherapy

- Contraindications for Cryotherapy
  - Raynaud’s Disease/Phenomenon
    - Sudden pallor & cyanosis followed by redness (mainly seen in the distal extremities)
  - Over Regenerating Peripheral Nerves
  - Over an Area With Circulatory Compromise or Peripheral Vascular Disease

Raynaud’s Disease/Phenomenon
Cold-Cryotherapy

- Precautions for Cryotherapy
  - Apply Cryotherapy with Caution:
    - Over a Superficial Main Branch of a Nerve
    - Over an Open Wound
    - When Treating Patients with Hypertension
    - When Treating Patients with Poor Sensation or Mentation
    - When Treating Very Young and Very Old Patients

Cold-Cryotherapy

- Adverse Effects of Cryotherapy
  - Tissue Death
  - Frostbite
  - Nerve Damage
  - Unwanted Vasodilatation

Cold-Cryotherapy

- Application Techniques
  - Sequence of Sensations in Response To Cryotherapy
    - Intense Cold
    - Burning
    - Aching
    - Analgesia and numbness
Heat-Thermotherapy

- Effects of Heat
  - Hemodynamic Effects
    - Vasodilatation
  - Neuromuscular Effects
    - Changes in Nerve Conduction Velocity and Firing Rate
  - Increased Pain Threshold
Heat-Thermotherapy

- Effects of Heat
  - Neuromuscular Effects
    - Changes in Muscle Strength

- Effects of Heat
  - Metabolic Effects
    - Increased Metabolic Rate

- Effects of Heat
  - Altered Tissue Extensibility
    - Increased Collagen Extensibility
Heat-Thermotherapy
- Uses of Superficial Heat
  - Pain Control

Heat-Thermotherapy
- Uses of Superficial Heat
  - Increased ROM and Decreased Joint Stiffness

Heat-Thermotherapy
- Uses of Superficial Heat
  - Accelerated Healing
Heat-Thermotherapy

- Uses of Superficial Heat
  - Infrared Radiation for Psoriasis and Dermal Ulcers

Heat-Thermotherapy

- Contraindications for the Use of Thermotherapy
  - Acute Injury or inflammation
  - Recent or Potential Hemorrhage
  - Thrombophlebitis
Heat-Thermotherapy

Contraindications for the Use of Thermotherapy
- Impaired Sensation
- Impaired Mentation
- Malignancy
- Infrared Irradiation of the Eyes

Precautions for the Use of Thermotherapy
- Pregnancy
- Impaired Circulation
- Poor Thermal Regulation
- Edema

Precautions for the Use of Thermotherapy
- Cardiac Insufficiency
- Metal in the Area
- Over an Open Wound
- Over Areas Where Topical Counterirritants Have Recently Been Applied
Heat-Thermotherapy

- Adverse Effects Of Thermotherapy
  - Burns
  - Fainting
  - Bleeding
  - Skin and Eye Damage from IR Radiation