Introduction to Physical Agents Part II: Principles of Heat for Thermotherapy

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Objectives

After studying this lecture, the students must be able to;

- Define and classify the physical agents modalities.
- Describe physical principle of thermal agents modalities
- Differentiate between methods of heat transfer.
- Understand the physiological effects of thermotherapy.
- Offer guidelines for use of therapeutic modalities include
  - Indications and contraindications of thermotherapy
  - Precautions and adverse effects of thermotherapy
Outlines

- Introduction and history of physical agents (PA)
- Classification of physical agents modalities
- Modes of heat transfers
- Physiological effects of thermotherapy.
- Therapeutic uses (indications) of thermotherapy.
- Contraindications of thermotherapy.
- Precautions & dangerous of thermotherapy
Physical Agents Modalities (PAMs)

- Physical agents modalities (PAMs) are external form of energy (e.g. heat, cold, light, electricity, electromagnetic, sound) applied to the patients to assess in the rehabilitation process.
History of physical agents

Ancient Rome and Greece used heat and water (steam rooms, hot & cool pools) to treat ailments.

Late 19th Century Europe - natural hot springs

400 B.C. Torpedo fish were used to apply electrical shock to treat headache and arthritis.

Sunlight was used to treat TB, bone & joint diseases, dermatological problems & infection.
Modalities alone DO NOT constitute a skilled treatment.

Modalities should be used in conjunction with other therapeutic techniques to reach an established goal of rehab.

Use of physical agents as a component of rehabilitation involves the integration of appropriate interventions.

It can be used before, during or after a therapy session, to enhance the effects of other interventions.
Categories (classifications) of Physical Agents

- Electromagnetic
  - Radiation
    - Infrared radiation (IR)
    - Ultraviolet therapy (UV)
    - Low level Laser Therapy (LLLT)
  - Diathermy
    - Shortwave Diathermy (SWD)
    - Microwave Diathermy (MVD)
- Thermal
  - Thermotherapy
  - Cryotherapy
- Acoustic energy
  - Ultrasound (US)
  - Extracorporeal Shock wave therapy (ESWT)
- Electrical
  - TENS, HVPC, IFT, Faradic stimulation, DC stimulation
- Mechanical
  - Manual and mechanical traction, massage
  - Pneumatic compression therapy
Classification for Depth of penetration

- **Depths of penetration > 2 cm**
  - Deep Heating modalities
  - Microwave diathermy
  - Shortwave diathermy
  - Laser
  - Ultrasound

- **Depths of penetration 0.5-2 cm**
  - Infrared
  - Whirlpool
  - Hydrocollator

- **Superficial heating modalities**
  - Paraffin wax
  - Fluidotherapy

- **Hydrocollator, Hot packs**
Thermal Agents

Thermal agents are physical agents that causes an increase or decrease in tissue temperature.

Thermotherapy is a therapeutic application (uses) of heating modalities

Examples
- Hot packs, infrared, ultrasound
- Short wave diathermy
- Microwave diathermy
- Whirlpool, paraffin wax

Therapeutic heating modalities (Superficial and Deep) heating agents increase the skin temperature within the therapeutic range (104 - 113°F) to induce physiological effects for therapeutic benefits
Modes of energy (Heat) transfer

Objective

- Discuss the basic principles & physiological effects of transferring heat to & from patients using superficial and deep heating modalities.
Modes of energy (Heat) transfer

- Radiation
- Conduction
- Convection
- Conversion
- Evaporation
Conduction

- Ice packs
- Hot packs
- Paraffin
- Ultrasound

Rate of energy (heat) transfer by conduction is dependent on:
1. Temperature difference between materials
2. Thermal conductivity (Metal > water > bone + muscles > fat)
3. The total contact area
4. Tissue thickness
is a direct transfer of energy (heat) from higher temperature to lower temperature without the need for an intervening medium (No-contact).

Radiation

- Shortwave diathermy
- Microwave Diathermy
- Laser
- Infrared & laser
- Ultraviolet therapy

Rate of energy (heat) transfer by radiation is dependent on

1) Density, thickness, and type of radiating tissues
2) Law governing radiations
3) Intensity and size of radiation
4) Distance from radiation source
5) Duration of radiation
Convection

Modes of energy (Heat) transfer

- is a transfer of heat through direct contact between **circulating medium (air/ water)** and another material of different temperature.
  - Fluidotherapy
  - Whirlpools
  - Blood circulation
Modes of energy (Heat) transfer

Conversion

- is a conversion of **non-thermal** form of energy (**mechanical, electrical and / or chemical**) into heat.
  - Ultrasound
  - Shortwave diathermy (SWD)
  - Microwave diathermy (MWD)
Evaporation

- Heat is absorbed by the liquid on the skin surface and cools the skin as it turns into a gaseous state.
- Vapocoolant sprays
- Alcohol
- Sweating
Modes of energy (Heat) transfer

- Conduction
- Radiation
- Convection
- Conversion
- Evaporation
Non-thermal form of energy being converted into heat, => Ex: Mechanical, electrical or chemical energy; Diathermy, Ultrasound

a) Conduction  
b) Conversion  
c) Convection  
d) Evaporation

Vapocoolant spray is a form of energy transfer by Radiation  
True    false

Adipose acts as insulator, thus slowing down temp change while Muscle contains water has faster conduction of heat  
True    false
The application of physical agents primarily results in:

- Modifications of tissue inflammation and healing
- Relief of pain
- Alternation of collagen extensibility and motion restrictions
- Modification of tone abnormalities
Bio-Physiological Response (Effects) of Heat

I. Hemodynamic effects
II. Neuromuscular effect
III. Tissue Extensibility
IV. Metabolic effect
Hemodynamic Effects: Vasodilation

↑ Temperature

Inflammation

↑ Vasodilator (histamine + prostaglandin) release

Cutaneous thermoreceptors

Spinal cord dorsal root ganglion

↓ Sympathetic adrenergic activation

Smooth muscle relaxation

Vasodilation
Cellular & Blood/Fluid Responses

• Cellular —
  – ↑ temperature → ↑ cell metabolism → ↑ O₂; cell waste ↑ excreted
  – ↑ temperature → blood hemoglobin releases O₂ (106°F = twice as much O₂ released)
  – ↑ temperature → (104°-113°F) plastic deformation of collagen-rich tissues occurs more easily

• Blood & Fluid Dynamics —
  – ↑ b. flow → ↑ edema, but ↑ b. flow removes wastes, etc.
  – Triggers release of bradykinin
II - Neuromuscular Effects

1. Decreased pain and muscle spasm
2. Increased pain threshold
3. Increase nerve conduction velocity
4. Decrease conduction latency (sensory & motor).
5. Change muscle spindle firing rates

Changes in muscle strength
Muscle strength and endurance found to decrease for initial 30 minutes following heat application (superficial/deep heating)
Gradually recovers then increases for next 2 hours
Measuring muscle strength (before heat application Not after)
III-Altered Tissue Extensibility

Increase extensibility of collagen tissues (tendon, ligament, capsule) at (40-45°C) resulting in

- Relaxation of tension,
- Increase length of soft tissue,
- Increase ROM

Superficial heat alone will NOT alter viscoelastic properties of tissue

- **Heat + Stretch**
  - Result = plastic elongation of deeper tissue such as *(tendons, ligaments, joint. capsule, fascia)*.
  - Factors important determining treatment strategies
    - Temperature elevation (40-45°C)
    - Time must be maintained for 5-10 minutes.
    - Stretch exercises
Physiological Effects of Heat Therapy

**Increased**
1. Local blood flow
2. Lymphatic drainage
3. Capillary permeability
4. Metabolic rate
5. Cellular oxidation
6. Flexibility of collagen tissues
7. Respiratory rate
8. Cardiac output
9. Pulse rate

(1-6) ---- Local effects
(7-9) ---- Systemic effects

**Decreased**
1. Joint stiffness
2. Pain & muscle spasm
3. Muscle torque
4. Blood supply to internal organs
5. Blood pressure
6. Stroke volume

(1-3) ---- Local effects
(4-6) ---- Systemic effects
Considerations using Physical Agents

**Indication:** A condition(s) that could benefit from a specific therapeutic modality.

**Contraindication:** A condition(s) that could be adversely affected if a particular therapeutic modality is used.

**Precautions:** A conditions in which therapeutic modalities is applied with special care or limitations.
Therapeutic Uses of Thermotherapy (Indications)

- Subacute or chronic pain and muscles spasm
- Limitation in ROM and joint contracture
- Subacute or chronic inflammatory conditions
- Accelerate tissues healing
- Before passive mobilization and exercise
Contraindications for Thermotherapy

Acute injuries
Recent or potential hemorrhage
Impaired circulation
Poor thermal regulation
Over or around neoplasms (malignant tumor)
Over or around infected area
Precautions to Thermotherapy

- Never apply heat directly to eyes or the genitals.
- Never heat the abdomen during pregnancy.
- Very young and very old patients.
- Mental retard patients.
- Cardiac insufficiency.
- Areas with metal implants (higher thermal conductivity)
- Over area of topical anesthesia
- Dermatological anomalies.
Adverse Affects of Heat Applications

**Burns:**
- Poor technique
- Patients' inability to dissipate or detect heat
- Treatment over areas of implanted metal or open wounds

**Bleeding:** In acute trauma or hemophilia

**Fainting:** Peripheral superficial vasodilatation and decrease blood pressure.

**How to Avoid?**
MCQ- Questions

1-Hemodynamic - Neuromuscular - Metabolic
   a) Biophysiological Effects
   b) Metabolic Effects
   c) Neuromuscular Effects
   d) Hemodynamic Effects

2-Increases nerve conduction velocity - increases collagenous tissue extensibility - increases pain threshold - decreases muscular strength
   a) Neuromuscular Effects
   b) Metabolic Effects
   c) Biophysiological Effects
   d) Hemodynamic Effects

3-Hot packs - Fluidotherapy - Paraffin - Whirlpool - SW Diathermy - US
   a) Therapeutic Dosage
   b) Hemodynamic Effects
   c) Deep Heat Modalities
   d) Types of Thermal Agents