

# Heat: Beyond the Basics

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## Course Overview

- This course presents current information about the use of heating modalities as a therapeutic intervention including physiologic effects, influence of heat on soft tissue, emerging applications of heat for the cardiovascular system, and efficacy of commercial and over the counter delivery methods.

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## Course Rationale

- The purpose of this course is to present course participants with evidence based contemporary information about the application of superficial and deep heat to address impairments limiting functional activity performance. Refreshing knowledge on this modality and understanding current application trends will allow the therapist and assistant to more effectively combine these passive interventions with active therapeutic techniques to maximize patient outcomes and progression toward therapeutic goals.

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## Goals and Objectives

- Describe the physiologic effects of local and systemic heat modalities.
- Describe the influence of heat on soft tissue and pain perception.
- Compare current evidence on the efficacy of hot packs, ultrasound, and shortwave diathermy.
- Compare over the counter delivery methods of superficial heat.
- Identify the proposed benefits of whole body heat stress for cardiovascular and metabolic health.
- Summarize the considerations for heat applications related to sport participation and delayed onset muscle soreness.
- Detail the proposed benefits of heat application for peripheral artery disease.
- Detail the role of thermotherapy in palliative care.
- Identify considerations in sequencing interventions to maximize the benefits of heat applications.
- Recognize safety considerations when applying heating modalities.

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## Disclaimer

- Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations.

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## Course Outline and Schedule

Topic	Time
Physiologic Effects of Heat	0:00-0:10
Contraindications and Precautions	0:11-0:20
Heat Modalities	0:21-0:25
Hot Pack and Fluidotherapy	0:26-0:30
Ultrasound, Diathermy, and Hydrotherapy	0:31-0:40
Over the Counter Applications	0:41-0:45
Heat Wraps	0:46-0:50
Interactive Discussion of Clinical Applications	0:51-1:00
Topical Analgesics	1:01-1:20
Therapeutic Heat Indications	1:21-1:25
Soft Tissue Tightness	1:26-1:30
Delayed Onset Muscle Soreness	1:31-1:40
Spasticity	1:41-1:50
Interactive Discussion of Clinical Applications	1:51-2:00
Hyperthermia and Performance	2:01-2:05
Heat Stress	2:06-2:10
Heat Acclimatization	2:11-2:20
Occupational Heat Exposure	2:21-2:25
Whole Body Heat Stress	2:26-2:30
Cardiovascular Disease	2:31-1:35
Peripheral Arterial Disease	2:36-2:40
Myopathy	2:41-2:45
Emerging Heat Applications	2:46-2:50
Interactive Discussion of Clinical Applications	2:51-3:00

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## Historical Perspective

**Egyptians**

- Sun therapy

**Greeks**

- Sand baths

**Hippocrates**

- Hot water relaxation of tense skin

**Today**

- Hot packs
- Paraffin
- Fluidotherapy
- Whirlpool
- Diathermy

Diamandopoulos, A. A., & Goudas, P. C. (2001). Substitution of renal function through skin catharsis: evidence from the classical period to the middle ages. *Kidney International*, 59(4), 1580-1589.

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## Physiologic Effects of Heat

**Vasodilation**

- ↑ capillary blood flow
- ↑ cell membrane permeability
- ↑ clearing of metabolic waste
- ↑ oxygen and nutrient supply

**Tissue Temperature Rise (TTR)**

- Increased joint capsule, ligament, muscle extensibility
- Increased collagen elasticity
- Decreased soft tissue viscosity

**Increased Metabolic Rate**

- ↑ phagocytosis
- ↑ inflammatory process

**Increased Nerve Conduction**

- ↑ pain threshold
- analgesia
- sedation of nerve endings

**Decreased Muscle Spindle Firing**

- relaxation of muscle spasm

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## Intensity of Heating

• Tissue temperature rise is necessary to achieve the physiologic effects.

- Mild**
  - 1°C
  - Increases metabolic rate
- Moderate**
  - 2-3°C
  - More significant metabolic effect, increases circulation, decreases pain
- Vigorous**
  - 4°C
  - Significantly increases metabolic rate and circulation, altered viscoelastic properties of collagen

**Consider This**

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## Rebound Phenomenon

• Local tissue react in a predictable manner to the application of heat to prevent injury.

```

    graph TD
      A[Heat absorbed] --> B[Protective vasoconstriction]
      B --> C[Constant treatment intensity]
      C --> D[Temperature gradient stabilizes]
      D --> A
  
```

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## Depth of Penetration

Tissue	Intervention	Outcome
Triceps Surae 2013	Hot Pack vs. SWD 2.82°C / 3.69°C	SWD greater TTR and dissipation

Superficial

- 1°C at 3 cm

Deep

- >4°C at 3 cm

Hawkes AR, Draper DD, Johnson AW, Dieder MT, Rigby JH. Heating capacity of rebound diathermy and moist hot packs at superficial depths. *J Athl Training*. 2013;48(4):471-476. doi:10.4085/1962-6050-48.3.04

Draper DD, Harris ST, Schulthies S, Durrant E, Knight KL, Ricard M. Hot-pack and 1-MHz ultrasound treatments have an additive effect on muscle temperature increase. *J Athl Train*. 1996;33(1):21-24.

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*"Guidelines that are available appear subjective and limited in experimentally based knowledge."*

### Contraindications and Precautions

- Malignancy
- Circulatory impairment
- Sensory Impairment
- Acute trauma
- Bleeding
- Altered skin integrity
- Cognitive impairment
- Pregnancy
- Infection
- Edema
- Metal in the area

- Topical analgesic
- Transdermal or topical medications

Batavia, M. (2004). Contraindications for superficial heat and therapeutic ultrasound: do sources agree?. *Archives of physical medicine and rehabilitation*, 85(6), 1006-1012.

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### Classifications of Rehabilitation for Patients with Cancer

**Preventive**  
After diagnosis of potentially life limiting condition | Mitigate functional decline

**Restorative**  
Long-term impairment not expected | Return patients to pre-morbid functional status

**Supportive**  
Disease and impairments progressing | Augment self-care ability and mobility

**Palliative**  
Terminally ill patients | Maintain quality of life, relieve symptoms, prevent complications

Montagnini, M., Javier, N. M., & Ritchie, C. (2017). Physical therapy and other rehabilitation issues in the palliative care setting. *UpToDate (online series)*. Waltham, MA: UpToDate.

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### Cancer Contraindications and Precautions

- Standard screening questions should be incorporated into the physical examination.

**Stage**  
I-III | IV

**Heat**  
NOT directly over site of cancer | Also, NOT in proximity to adjuvant treatment

**Therapy Goals**  
Function | Palliative

Wilson, A., Ensign, G., Flyte, K., Moore, M., & Ratliff, K. (2018). Physical Agents for Cancer Survivors: An Updated Literature Review. *Rehabilitation Oncology*, 36(2), 132-140.

Keitani, M., Kaimberger, F., Pazarara, A., Hasenbichl, T., Wagner, B., Palma, S., ... & Crevenna, R. (2019). Typical aspects in the rehabilitation of cancer patients suffering from metastatic bone disease or multiple myeloma. *Wiener klinische Wochenschrift*, 1-9.

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### Breast Reconstruction

- Post operative loss of sensation leaves skin in the area of breast reconstruction vulnerable to thermal damage.
- Patient education should emphasize long term caution avoiding direct sun exposure and use of heating devices.

Faulkner, H. R., Colwell, A. S., Liao, E. C., Winograd, J. M., & Austen, W. G., Jr (2016). Thermal Injury to Reconstructed Breasts from Commonly Used Warming Devices: A Risk for Reconstructive Failure. *Plastic and reconstructive surgery*. *Global open*, 4(10), e1033. doi:10.1097/GOX.0000000000001033

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### Palliative Care

- With informed consent, the patient may decide the pain-relieving effects of heat to improve quality of life outweigh the potential adverse effects.

**Pain relief**  
**Muscle relaxation**

**Increased blood volume**  
**Increased metabolic catalysts**

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### Transdermal Medications

- Drug-in-adhesive-matrix-based products, are designed for extended release delivery through the skin to elicit systemic effects.
- Heat alters drug release rate, skin barrier properties, and dermal clearance delivering excess drug load.

**Steady drug release**

**Permeates stratum corneum barrier**

**Diffusion into dermal capillaries**

Hao, J., Ghosh, P., Li, S. K., Newman, B., Kasting, G. B., & Raney, S. G. (2016). Heat effects on drug delivery across human skin. *Expert opinion on drug delivery*, 13(5), 755-768.

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## Professional Liability

**Physical Therapy**

- Improper management
- Improper exercise performance
- Improper biophysical agent performance
- Failure to supervise

**Occupational Therapy**

- Improper biophysical agent performance
- Improper management
- Failure to supervise
- Improper behavior

CNA HPSO. (2016). Physical Therapy Professional Liability Exposure: 2016 Claim Report. [http://www.hpso.com/Documents/pdfs/CNA\\_PT\\_CS\\_020116\\_CF\\_PROD\\_ASIZE\\_ONLINE\\_040417\\_SEC.pdf](http://www.hpso.com/Documents/pdfs/CNA_PT_CS_020116_CF_PROD_ASIZE_ONLINE_040417_SEC.pdf)  
 CNA HPSO. (2016). Occupational Therapy Claim Report. [https://hpso.com/Documents/pdfs/CNA\\_CLS\\_OT\\_032917\\_CF\\_PROD\\_ONLINE\\_SEC.pdf](https://hpso.com/Documents/pdfs/CNA_CLS_OT_032917_CF_PROD_ONLINE_SEC.pdf)

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## Burn Claims

• A recurring theme in paid indemnity for burns is failure to properly monitor patients with neurological deficits and patients left unattended.

Burn Severity	Total Indemnity	Average Indemnity
Severe	\$2,097,322	\$95,333
Moderate	\$1,325,037	\$36,325
Mild	\$229,500	\$19,125

CNA HPSO. (2016). Physical Therapy Professional Liability Exposure: 2016 Claim Report. [http://www.hpso.com/Documents/pdfs/CNA\\_PT\\_CS\\_020116\\_CF\\_PROD\\_ASIZE\\_ONLINE\\_040417\\_SEC.pdf](http://www.hpso.com/Documents/pdfs/CNA_PT_CS_020116_CF_PROD_ASIZE_ONLINE_040417_SEC.pdf)  
 CNA HPSO. (2016). Occupational Therapy Claim Report. [https://hpso.com/Documents/pdfs/CNA\\_CLS\\_OT\\_032917\\_CF\\_PROD\\_ONLINE\\_SEC.pdf](https://hpso.com/Documents/pdfs/CNA_CLS_OT_032917_CF_PROD_ONLINE_SEC.pdf)

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## Erythema Ab Igne (EAI)

- Asymptomatic, brownish-red hyperpigmented reticular dermatosis with telangiectasias develops in areas exposed to excessive or prolonged heat sources.
- Treatment involves removing exposure to the heat source with long term monitoring as there may be an association with cutaneous malignancy.

Consider This

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## Sensation and Skin Integrity Precautions

- The patient must have clear instructions on what to expect and how to react.
  - What pre-treatment data collection is required?
  - How hot should it feel?
  - What should they do during the treatment?
  - How to they get clinician's attention?
- Skin inspection must be performed post treatment.
  - Should skin inspection be performed during the intervention?
  - What do should be documented?

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## Hot Pack

- Layers of toweling should be sufficient to control the transfer of heat for tissue temperature rise but no damage the skin.
  - How many layers?
  - Can the patient lay on the hot pack?

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## Fluidotherapy

- Forced air convection of heated cellulose particles allows the performance of active range of motion and irregular surface area heating.

Diagnosis	Intervention	Outcome
Rheumatoid arthritis	Fluidotherapy vs. joint protection and exercise program	No difference in grip, pain, stiffness. Improved function in joint protection/exercise group

Erding Gündüz, N., Erdem, D., Kızı, R., Solmaz, D., Önen, F., Ellidokuz, H., & Gübıhar, S. (2019). Is dry heat treatment (fluidotherapy) effective in improving hand function in patients with rheumatoid arthritis? A randomized controlled trial. *Clinical Rehabilitation*, 33(3), 485-493.

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## Therapeutic Ultrasound (US)

- It is traditionally accepted that higher frequency leads to greater attenuation and less depth of penetration for heating effects.
- Research suggests that intensity and time parameters relative to tissue composition should be the primary considerations to ensure sufficient heat generation for physiologic response.

Demmink, J. H., Helden, P. J., Hobaak, H., & Enwemeka, C. (2003). The variation of heating depth with therapeutic ultrasound frequency in physiotherapy. *Ultrasound in medicine & biology*, 29(1), 113-118. Copyright Jodi Gootkin 2021

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## US Outcomes

Diagnosis	Outcome
Patellofemoral pain syndrome (2001)	Pain - NO clinically important effect
Hip and knee osteoarthritis (2010)	Knee pain/function - small effect?
Acute ankle sprain (2011)	LIMITED clinical importance
Chronic low back pain (2014)	Pain/quality of life - NO evidence Short term function - NOT clinically important
Rotator cuff tendinopathy (2015)	NO greater benefit than placebo

Brosseau, L., Casimiro, L., Welch, V., Milne, S., Shea, B., Judd, M., ... & Tugwell, P. (2001). Therapeutic ultrasound for treating patellofemoral pain syndrome. *Cochrane Database of Systematic Reviews*, (4).  
 Rutjes, A. W., Nuesch, E., Sterchi, R., & Juni, P. (2010). Therapeutic ultrasound for osteoarthritis of the knee or hip. *Cochrane Database of Systematic Reviews*, (1).  
 van den Bekerom, M. P., van der Windt, D. A., ter Riet, G., van der Heijden, G. J., & Bouter, L. M. (2011). Therapeutic ultrasound for acute ankle sprains. *Cochrane Database of Systematic Reviews*, (6).  
 Ebadi, S., Henschke, N., Ansari, N. N., Fallah, E., & van Tulder, M. W. (2014). Therapeutic ultrasound for chronic low-back pain. *Cochrane Database of Systematic Reviews*, (3).  
 Desmeules, F., Boudreau, J., Roy, J. S., Dionne, C., Frémont, P., & MacDermid, J. C. (2015). The efficacy of therapeutic ultrasound for rotator cuff tendinopathy: A systematic review and meta-analysis. *Physical Therapy in Sport*, 16(3), 276-284. Copyright Jodi Gootkin 2021

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## US Contraindications

- Do not perform over epiphyseal plates of growing bones?

Saber, A. A., & Saber, A. (2017). Therapeutic ultrasound: Physiological role, clinical applications and precautions. *Journal of Surgery*, 5(3), 61-9.  
 Barreto, A. A., Barreto, R. K. A., Pereira, H. D. R., & Hosone, W. S. (2011). Effects of therapeutic ultrasound on longitudinal growth of the femur and tibia in rats. *Acta Ortopédica Brasileira*, 19(3), 132-136.  
 Lyon, R., Liu, X. C., & Meier, J. (2003). The effects of therapeutic vs. high-intensity ultrasound on the rabbit growth plate. *Journal of orthopaedic research*, 21(5), 865-871. Copyright Jodi Gootkin 2021

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## Capacitive Resistive Electric Transfer (CRET)

- Combines diathermy capacitive reactions on muscles and soft tissues with resistive reactions on bones, tendons, and joints to induce vasodilation and tissue temperature rise.
  - TECARtherapy® (Transfer of Electricity Capacitive and Resistive)
  - Indiba® Activ Therapy (Radiofrequency diathermy)
- Therapist moves the active electrode on the treatment area and the inactive electrode is secured on a distant body region.
- During the intervention, the clinician alternates between the two delivery modes.

Hanavold, M. (2014). The effectiveness of Capacitive Resistive Diathermy (TECARtherapy®) in acute and chronic musculoskeletal lesions and pathologies. *European Journal of Scientific Research*, 118(3), 336-340. Copyright Jodi Gootkin 2021

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## CRET Outcomes

- Researchers theorize that the deeper increase in circulation is conducted to adjacent tissues allowing for prolonged heating and physiologic response.

Treatment Area	Intervention	Outcome
Hamstrings	CRET vs. HP vs. sham	TTR CRET slightly higher ROM CRET greater than HP/sham Hemoglobin greater in CRET/HP
Paraspinals	CRET vs. HP vs. sham	TTR and Hemoglobin greater in CRET
Knee Osteoarthritis	CRET vs. sham	VAS, MMT, WOMAC, CRET greater

Yokota, Y., Tashiro, Y., Suzuki, Y., Tasaka, S., Matsushita, T., Matsubara, K., & Aoyama, T. (2017). Effect of capacitive and resistive electric transfer on tissue temperature, muscle flexibility and blood circulation. *J. Nov. Physiother*, 7(325), 2.  
 Tashiro, Y., Hasegawa, S., Yokota, Y., Nishiguchi, S., Fukutani, N., Shirooka, H., ... & Sonoda, T. (2017). Effect of capacitive and resistive electric transfer on haemoglobin saturation and tissue temperature. *International Journal of Hyperthermia*, 33(6), 696-702.  
 Coccietta, C. A., Sale, P., Ferrara, P. E., Specchia, A., Alcauro, G., Ferrero, G., & Rosconi, G. (2019). Effects of capacitive and resistive electric transfer therapy in patients with knee osteoarthritis: a randomized controlled trial. *International Journal of Rehabilitation Research*, 42(2), 106-111. Copyright Jodi Gootkin 2021

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## Hydrotherapy

- Full body warm water immersion alters multiple system physiologic responses.
  - Cardiovascular**
    - Lower heart rate and blood pressure
    - Increased cardiac output
  - Respiratory**
    - Increased oxygen transport and tidal volume
  - Neurologic**
    - Improved postural stability
    - Decreased disability, fatigue, depression
  - Musculoskeletal**
    - Decreased pain and increased mobility
  - Gastrointestinal**
    - Anorectal disorders pain relief
  - Genitourinary**
    - Reduced labor pain and shorter contraction length

Moovenhan, A., & Nivehiha, L. (2014). Scientific evidence-based effects of hydrotherapy on various systems of the body. *North American journal of medical sciences*, 6(5), 199-209. doi:10.4103/1947-2714.13295511 Copyright Jodi Gootkin 2021

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### Equipment Maintenance

- Routine maintenance and calibration should be documented.
- Temperature of hydrocollator unit and paraffin must be verified and recorded.

**Hot Pack**  
How long to rewarm?  
What is the rotation routine?

**Paraffin**  
Wash hand before dipping?  
Reuse wax?

**Shortwave Diathermy**  
Generating output?

**Ultrasound**  
Transducer broken?

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### Over the Counter (OTC) Heat Products

- Multiple products are designed to directly deliver heat and its associated benefits or induce physiologic responses to alter pain perception.

```

graph TD
    OTC[OTC] --> Moist[Moist]
    OTC --> Dry[Dry]
    OTC --> Topical[Topical Analgesics]
    Moist --> Gel[Gel or moist pack]
    Moist --> Water[Water immersion]
    Dry --> Electric[Electric heating pads]
    Dry --> Chemical[Chemical wrap]
    Dry --> Beans[Bean and rice bags]
    Topical --> Cream[Cream]
    Topical --> Patch[Patch]
    
```

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### Dry vs. Moist Heat

- Moist heat may be more beneficial at increasing elasticity and circulation with deeper penetration.

Impairment	Intervention	Outcome
DOMS	Chemical dry vs. moist immediate or 24 hours post-exercise	Decreased pain, preservation of strength for both
Gait	Heating pad vs. moist heat	Increased step width with moist No difference in foot pressure

Petrofsky, J., Berk, L., Salm, G., Khawassah, I. A., Hui, T., Granada, M., ... Lee, H. (2013). Moist heat or dry heat for delayed onset muscle soreness. *Journal of clinical medicine research*, 2(6), 416-425. doi:10.4021/jocmr1517w  
Shim, J. M. (2014). The effects of wet heat and dry heat on the gait and feet of healthy adults. *Journal of physical therapy science*, 26(2), 183-185.

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### Heat Wraps

- ThermoCare® heat wraps are light weight, self-adhesive air-activated, single-use products delivering dry heat.

Location	Heat Wrap	Control
Skin	7.48	-1.15
Muscle	3.19	-1.99
Joint Capsule	2.62	-2.1

<https://www.thermacare.com/faq/faq-heatwraps-general>  
Draper, D. O., & Hopkins, T. J. (2008). Increased intramuscular and intracapsular temperature via ThermoCare Knee Wrap application. *Medical Science Monitor*, 14(6), P17-P111.

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### Chemical Reaction

- Iron oxidation reaction generates “real” heat.

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### Patient Education

- Ensure removal of wraps and patches product before diagnostic procedures and treatments when metal is contraindicated.
- Avoid concurrent use with additional external heat application.

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### OTC Topical Medications

Corticosteroids	<ul style="list-style-type: none"> <li>Hydrocortisone</li> <li>Pruritis</li> </ul>
NSAID	<ul style="list-style-type: none"> <li>Ibuprofen, Diclofenac</li> <li>Osteoarthritis, ophthalmic</li> </ul>
Pain Reliever	<ul style="list-style-type: none"> <li>Lidocaine, Benzocaine</li> <li>Cuts, burns, minor surgery</li> </ul>
Topical Analgesic Rubefacient	<ul style="list-style-type: none"> <li>Capsaicin, Methyl Salicylate</li> <li>Musculoskeletal and neuropathic pain</li> </ul>

www.health.utah.gov/pharmacy/ptcommittee/files/Criteria%20Review%20Documents%2012\_13/Topical%20Analgesics%20and%20Anesthetics%20Drug%20Class%20Review.pdf Copyright Jodi Gootkin 2021

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### OTC Topical Analgesics

- OTC topical muscle and joint pain relievers are available as single- or combination-ingredient products in various formulations include creams, lotions, ointments, liniments, herbal oil, and patches.

The diagram consists of two large arrows pointing in opposite directions. The left arrow is labeled 'Transdermal Systemic distribution' and the right arrow is labeled 'Topical Local effect'.

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### Topical Analgesics

- Read labels for active ingredients!

A central red hexagon labeled 'Brands' is surrounded by six other hexagons: 'Generic' (yellow), 'Tiger Balm®' (orange), 'IcyHot®' (brown), 'Capzasin®' (dark red), 'Salonpas®' (green), and 'Bengay®' (orange).

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### Active Ingredients

- Several combinations are common with varying dosages of each active ingredient.

The diagram shows four trapezoidal shapes representing combinations of ingredients:
 

- Yellow trapezoid: • Menthol
- Dark red trapezoid: • Menthol, • Methyl salicylate
- Orange trapezoid: • Menthol, • Methyl salicylate, • Camphor
- Brown trapezoid: • Capsaicin

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### Topical Analgesic Mechanism of Action

- There is primarily speculation as to the mechanism of action.
- Elevated tissue temperature is NOT the mechanism of action.

A pie chart divided into five segments: 'Neurotransmitters' (dark red), 'Placebo' (yellow), 'Inflammatory mediators' (brown), 'Counterirritant effect' (orange), and 'Circulation' (green).

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### Counterirritant Effect

- Active ingredients produce either cooling or warming sensations.
  - Cooling - Camphor and Menthol
  - Warming - Capsaicin and Methyl Salicylate

The diagram shows a flow from three boxes on the left ('Rubbing application', 'Warm or cool sensation', 'Skin irritation') to a central box ('Afferent fiber stimulation'), which then points to a final box ('Gating Pain').

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### Capsaicin

- Thermal stimulation
- TRPV1 binding
- Nociceptor activation
- Somatic pathway paresthesia perception
- Nerve defunctionalization
- Pain relief

• It is speculated that antinociceptive effects are related to attenuated nerve transmission, counterirritant effect, deplete neurotransmitters and substance P.

Frias, B., & Merighi, A. (2016). Capsaicin, nociception and pain. *Molecules*, 21(6), 797.  
Fattori, V., Hohmann, M., Rossanets, A., Pinho-Ribeiro, F., & Verri, W. (2016). Capsaicin: current understanding of its mechanisms and therapy of pain and other pre-clinical and clinical uses. *Molecules*, 21(7), 844. Copyright Jodi Gootkin 2021

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### Menthol

- TRPM8 activation
- Cooling sensation
- Reduced nerve transmission

- Naturally derived from the peppermint plant, menthol may alter nerve transmission, elicit a counterirritant effect, induce circulatory changes and provide a central analgesic effect.

https://www.medscape.com/viewarticle/911728\_5 Copyright Jodi Gootkin 2021

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### Menthol Mechanism of Action

- Menthol may serve as an insulator and is often included in preparations to serve as a penetration enhancer for other compounds.

Evaporation → Cooling → Hunting response → Vasodilation

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### Camphor

- Analgesic effects appear to occur through activation of heat and cold sensitive receptor channels and with repeated stimulation desensitize neurons.
- Ingestion leads to rapid toxicity with neurologic symptoms.

Wishart DS, Feunang YD, Guo AC, Li EJ, Marcu A, Grant JR, Sajed T, Johnson D, Li C, Sayeeda Z, Assempour N, Iynkkaran I, Liu Y, Maciejewski A, Gale N, Wilson A, Chin L, Cummings R, Le D, Poon A, Knox C, Wilson M. DrugBank 5.0: a major update to the DrugBank database for 2018. *Camphor*. <https://www.drugbank.ca/drugs/DB11345> Copyright Jodi Gootkin 2021

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### Methyl Salicylate

- A derivative of salicylic acid, it is speculated that the mechanism of action is related to inhibition of prostaglandin formation, increased circulation, or counterirritant effect.

Wintergreen oil

- Flavoring → Gum Toothpaste, Mints
- Analgesic → Topical preparations

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### Methyl Salicylate Drug Interactions

- Individuals with aspirin sensitivity are at risk for severe urticaria and angioedema.
- Combining with aspirin can increase serum concentrations to toxic levels.
- Anticoagulant medications combined with methyl salicylate may lead to elevated international normalized ration values (INR) and gastrointestinal bleeding.

Chan, T. Y. (1996). Potential dangers from topical preparations containing methyl salicylate. *Flumun & experimental toxicology*, 15(9), 747-750. Copyright Jodi Gootkin 2021

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### Toxicity FDA Requirements

- High concentrations of wintergreen oil is toxic requiring FDA mandated packaging warnings for products containing greater than 5% methyl salicylate.
  - “For the temporary relief of minor aches and pains of arthritis and rheumatism.”
  - “Caution: If pain persist for more than 10 days, or redness is present, or in conditions affecting children under 12 years of age, consult a physician immediately.”
  - “Keep out of reach of children.”

FDA Section 201.314 <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=201.314> Copyright Jodi Gootkin 2021

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### Methyl Salicylate Toxicity

- Accidental ingestion and percutaneous absorption of excessive concentrations can lead to multisystem compromise with potential life-threatening consequences.

Salicylate


- GI
- CNS
- Renal
- Hepatic
- Hematopoietic
- Metabolic alterations
- Pulmonary edema

Maharaj, V. R., Paul, J. F., & Finkelstein, Y. (2016). Sweet and Minty: A 2 Year Old With a Fatal Household Ingestion. *Pediatric emergency care*, 32(12), 892-896. Copyright Jodi Gootkin 2021

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### Ingestion Toxicity


- When ingested methyl salicylate and camphor are rapidly absorbed in the gastrointestinal tract.
- In overdose cases, elimination rates are compromised by ongoing absorption.
- Cautious with children as ingestion can lead to toxicity.



1 teaspoon

Wintergreen oil

➤➤



22 tablets

Adult aspirin

FDA Sec. 201.303 <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=201.303> Copyright Jodi Gootkin 2021

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### Percutaneous Toxicity

- Overapplication in frequency and quantity may exceed safe dosages.
- Increased rate of absorption through vasodilation or increased blood flow to the region can lead to systemic poisoning.
- Caution when combining multiple OTC products that may contain the same active ingredients.
- Fetal risk exists with use during pregnancy.

FDA Sec. 201.303 <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=201.303> O'MALLEY, P. A. T. R. I. C. I. A. (2008). Sports cream and arthritic rubs: the hidden dangers of unrecognized salicylate toxicity. *Clinical Nurse Specialist*, 22(1), 6-8. Copyright Jodi Gootkin 2021

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### Signs of Toxicity

- Individuals with the history of exposure and symptoms should be referred to the emergency department for immediate care.

Chronic	Acute	Symptoms
Prolonged use More CNS Symptoms	Overdose More GI Symptoms	Hematemesis Tachypnea Dyspnea Tinnitus Lethargy Seizures Confusion Dermal irritation

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### Management of Toxicity

Exposure	Referral to Emergency Department	
Interventions	Ingestion	Percutaneous
	Activated charcoal	Wash skin
	Medical management	Medical management

Chyka, P. A., Erdman, A. R., Christianson, G., Wax, P. M., Boozo, L. L., Manoguerra, A. S., ... & Scharman, E. J. (2007). Salicylate poisoning: an evidence-based consensus guideline for out-of-hospital management. *Clinical toxicology*, 45(2), 95-131. Copyright Jodi Gootkin 2021

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## Skin Burns From OTC Products

- According to the FDA, rare but serious skin burns ranging from first- to third-degree chemical burns have occurred where topical OTC products for the relief of mild muscle and joint pain have been applied.
- Use caution applying to areas where skin on skin contact occurs.
- Do not use heat near the application area.
- Do not apply under bandaging or occlusive dressing.

<https://www.fda.gov/drugs/drug-safety-and-availability/fda-drug-safety-communication-rare-cases-serious-burns-use-over-counter-topical-muscle-and-jointdata>

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## OTC Pain Outcomes

- Research has been unsuccessful in demonstrating the efficacy of nonprescription preparations to modulate pain.

Diagnosis	Intervention	Outcome
Musculoskeletal pain	Methyl Salicylate vs. capsaicin cream vs. placebo	Low quality evidence and sparse data
Myofascial pain syndrome	NSAID patch alone or with TENS, heat pad, or topical capsaicin	No statistical difference in pain

Lisi, D. (2019) OTC Transdermal Analgesic Patches in Pain Management. *US Pharmacist*, 2019;44(3):15-21.  
Kim, D. H., Yoon, K. B., Park, S., Jin, T. E., An, Y. J., Schepis, E. A., & Yoon, D. M. (2014). Comparison of NSAID patch given as monotherapy and NSAID patch in combination with transcutaneous electric nerve stimulation, a heating pad, or topical capsaicin in the treatment of patients with myofascial pain syndrome of the upper trapezius: a pilot study. *Pain Medicine*, 15(12), 2128-2138.

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## OTC Muscle Outcomes

- The goal of the intervention needs to be considered as different physiologic effects appear to be achieved with the various OTC heat products.

Application Method	Skin Temp.	Muscle Temp.	Skin Blood Flow	Muscle Blood Flow
Heat Wrap	↑	↑	↑	↑
Hot Patch	↓	↓	↓	↓
Menthol	↓	↓	↓	↓
Hot Cream	↓	↓	↓	↑
Menthol/Methyl Salicylate	↓	↓	↓	↑

Petrofsky, J. S., Laymon, M., Berk, L., & Bains, G. (2016). Effect of ThermoCare HeatWraps and Icy Hot Cream/Patches on Skin and Quadriceps Muscle Temperature and Blood Flow. *Journal of chiropractic medicine*, 15(1), 9-18. Copyright Jodi Gootkin 2021

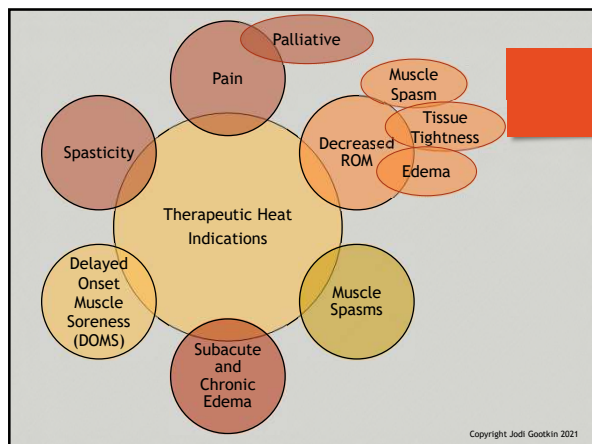
57

## Capsaicin Outcomes

Diagnosis	Intervention	Outcome
Neuropathic pain	Capsaicin cream vs. placebo	Without meaningful effect
Diabetic peripheral neuropathy Post-herpetic neuralgia HIV neuropathy	Capsaicin patch vs. placebo	Improved pain and sleep quality
Non-diabetic peripheral neuropathic pain	Capsaicin patch vs. Oral Pregabalin	Non-inferior pain relief

Simpson, D. M., Robinson-Papp, J., Van, J., Stoker, M., Jacobs, H., Snijder, R. J., ... & Katz, N. (2017). Capsaicin 8% patch in painful diabetic peripheral neuropathy: a randomized, double-blind, placebo-controlled study. *The Journal of Pain*, 18(1), 42-53.  
Derry, S., & Moore, R. A. (2012). Topical capsaicin (low concentration) for chronic neuropathic pain in adults. *The Cochrane database of systematic reviews*, 2012(9), CD010111.  
Derry, S., Rice, A. S., Cole, P., Tan, T., & Moore, R. A. (2017). Topical capsaicin (high concentration) for chronic neuropathic pain in adults. *Cochrane Database of Systematic Reviews*, (1).  
Haanpää, M., Crucci, G., Nurmiö, T. J., McBride, W. T., Docu Axelaradi, A., Bostikov, A., ... & Abdulahad, A. K. (2016). Capsaicin 8% patch versus oral pregabalin in patients with peripheral neuropathic pain. *European Journal of Pain*, 20(2), 316-328. Copyright Jodi Gootkin 2021

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## Role of superficial Heat in Rehabilitation

*“Don’t employ passive physical agents except when necessary to facilitate participation in an active treatment program.”*

~APTA Choosing Wisely Recommendation

*“Don’t use physical agent modalities (PAMs) without providing purposeful and occupation-based intervention activities.”*

~AOTA Choosing Wisely Recommendation

<http://integrity.apta.org/ChoosingWisely/SThings/References/>  
<http://www.choosingwisely.org/societies/american-occupational-therapy-association-inc/>

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## Pain Management Outcomes

- The application of heat may be beneficial along with patient education as a non-pharmacological strategy for short term relief of musculoskeletal pain.

Diagnosis	Intervention	Outcome
Low back pain (LBP)	Superficial heat	Acute Recommended Chronic Not Recommended
Cervical pain	Superficial Heat or Ultrasound	Acute/Chronic No benefit
Knee osteoarthritis	Superficial heat	Improved pain and function

Chou, R., Côté, P., Randhawa, K., Torres, P., Yu, H., Nordin, M., ... & Cedraschi, C. (2018). The Global Spine Care Initiative: applying evidence-based guidelines on the non-invasive management of back and neck pain to low-and middle-income communities. *European Spine Journal*, 27(6), 951-960.  
Sehar, N., Rajah, H., Hussain, H., & Ahmed, S. (2018). EFFECTS OF MOIST HEAT THERAPY PRE AND POST BACK EXTENSION EXERCISES ON NON-SPECIFIC BACK PAIN IN MIDDLE AGED FEMALES. *International Journal of Rehabilitation Sciences (IJRS)*, 7(02), 2-6.  
Graham, N., Gross, A. R., Carlesso, L. C., Santaguida, P. L., MacDermid, J. C., Walton, D., & Ho, E. (2013). Suppl 4: An ICON Overview on Physical Modalities for Neck Pain and Associated Disorders. *The open orthopaedics journal*, 7, 440.  
Yildirim, N., Filiz Ilusoy, M., & Bodur, H. (2010). The effect of heat application on pain, stiffness, physical function and quality of life in patients with knee osteoarthritis. *Journal of clinical nursing*, 19(7-8), 1113-1120.

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## Soft Tissue Tightness

- The density and organization of collagen and elastin allow muscles and tendons to resist tensile force.

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## Extensibility

- Several mechanisms may contribute to increased muscle length achieved through stretching after heat application.

Historical	Current
Collagen extensibility Connective tissue viscosity	Altered sensation Increased stretch tolerance

Nakano, J., Yamabayashi, C., Scott, A., & Reid, W. D. (2012). The effect of heat applied with stretch to increase range of motion: a systematic review. *Physical Therapy in Sport*, 13(3), 180-188.  
Bleakley, C. M., & Costello, J. T. (2013). Do thermal agents affect range of movement and mechanical properties in soft tissues? A systematic review. *Archives of Physical Medicine and Rehabilitation*, 94(1), 149-163.

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## Extensibility Outcomes

- Tissue temperature rise must be combined with stretching to achieve greater improvements in ROM.

Modality	Outcome
SWD vs. HP vs. no heat	Ankle DF ROM increase 1.8* vs. 0.7* vs. -1.1*
HP/Static vs. HP/Hold-Relax vs. HP	Hamstring ROM increase 11.7* vs. 8.1* vs. 1.3*

Robertson VJ, Ward AR, Jung P. The effect of heat on tissue extensibility: a comparison of deep and superficial heating. *Arch Phys Med Rehabil*. 2005;86(4):819-825  
Ahmed, H., Iqbal, A., Anwer, S., & Alghadir, A. (2015). Effect of modified hold-relax stretching and static stretching on hamstring muscle flexibility. *Journal of physical therapy science*, 27(2), 535-538.

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## “Stretching Window”

- Window is when temperature is >3°C degrees which appears to be within the first 3 minutes after heat application.

Tissue Temperature (°C)	Time this temperature was achieved after US
5 degrees	Immediately
4 degrees <b>Vigorous Heat</b>	1 minute 20 seconds
3 degrees	3 minutes 22 seconds
2 degrees	5 minutes 50 seconds
1 degrees	9 minutes 13 seconds
Baseline	15 minutes 55 seconds and longer

Drapear. Rate of Temperature Decay in Human Muscle Following 3 MHz Ultrasound. 1995

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## Sequencing Stretching

- Simultaneous heating and stretching has proven to demonstrate a larger effect in range of motion gain over stretching alone.

Bleakley, C. M., & Costello, J. T. (2013). Do thermal agents affect range of movement and mechanical properties in soft tissues? A systematic review. *Archives of Physical Medicine and Rehabilitation*, 94(1), 149-163.

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### Delayed Onset Muscle Soreness (DOMS)

- New or increased exercise levels lead to muscle soreness and pain accompanied by stiffness, tenderness, and decreased strength.
- Current prevailing theory is sarcomere damage.

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### Post Exercise Heating for DOMS

- Tissue temperature rise achieved with immediate prolonged post exercise heating correlates to improved healing evidenced through
  - Low granulocyte concentrations
  - Decreased fascial swelling
  - Preserved muscle strength
  - Decreased pain and soreness

Petrofsky, J. S., Laymon, M., Berk, L., Al-Nakhli, H. H., Banth, A., Eisentrout, A., ... & Batt, J. (2012). Pilot study: physiological evidence that heat reduces pain and muscle damage in delayed-onset muscle soreness. *Clinical Practice*, 9(6), 639.  
 Petrofsky, J., Berk, L., Bains, G., Khowalid, I. A., Hui, T., Granado, M., ... Lee, H. (2013). Moist heat or dry heat for delayed onset muscle soreness. *Journal of clinical medicine research*, 5(6), 416-425. doi:10.4021/jocmr1521w  
 Petrofsky, J., Berk, L., Bains, G., Khowalid, I. A., Lee, H., & Laymon, M. (2017). The efficacy of sustained heat treatment on delayed-onset muscle soreness. *Clinical Journal of Sport Medicine*, 27(4), 329-337.

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### DOMS Heat vs. Cold

- Heat application can reduce the intensity and duration of post exercise pain and soreness.

Intervention	Heat Outcome
Immediate post treatment heat wrap vs. control	Reduced soreness @24 and 48 hours
Heat wrap pre-treatment vs. post vs. control vs. cold pack	Superior pain relief with pre and post application

Mayer, J. M., Mooney, V., Matheson, L. N., Erasala, G. N., Verna, J. L., Udermann, B. E., & Leggett, S. (2006). Continuous low-level heat wrap therapy for the prevention and early phase treatment of delayed-onset muscle soreness of the low back: a randomized controlled trial. *Archives of physical medicine and rehabilitation*, 87(10), 1310-1317.  
 Petrofsky, J. S., Laymon, M., Berk, L., Al-Nakhli, H. H., Banth, A., (2012). Pilot study: physiological evidence that heat

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### Contrast Water Therapy (CWT)

- Alternating body segment immersion in hot and cold water is theorized to enhance the individual effects of each modality stimulated vascular response.

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### CWT Outcomes

- Research demonstrates reduced muscle soreness and attenuation of strength loss of fatigued muscle.

Bieuzen, F., Bleakley, C. M., & Costello, J. T. (2013). Contrast water therapy and exercise induced muscle damage: a systematic review and meta-analysis. *PLoS one*, 8(4), e62356.  
 De Nardi, M., La Torre, A., Barassi, A., Ricci, C., & Banfi, G. (2011). Effects of cold-water immersion and contrast-water therapy after training in young soccer players. *J Sports Med Phys Fitness*, 51(4), 609-615.

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### DOMS and Diabetes

Al-Nakhli, H. H. (2011). Delayed Onset Muscle Soreness in People with Diabetes: Biomarkers and Nutritional Supplementation.

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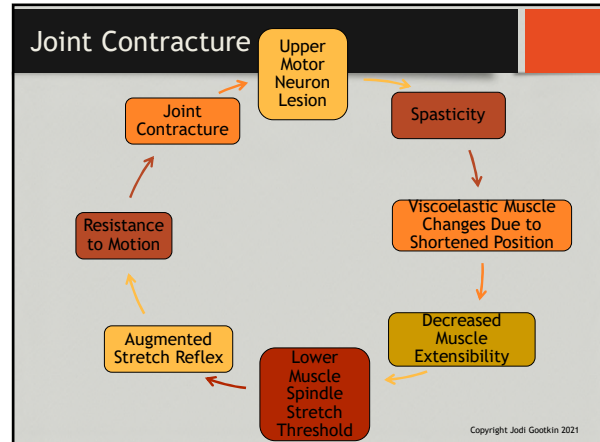
72

## Spasticity

- Following neurologic injury, velocity dependent hyperexcitability of the stretch reflex leads to increased tone in the muscle.
- Presentation can be generalized, regional or focal creating resistance to the active motion required for functional task performance and balance strategies to avoid falls.

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## Physiologic Response to Heat

- While cooling is a well documented intervention to diminish spasticity, warming issues may alleviate the neurogenic and biomechanical component of spasticity.

Smania, N., Picelli, A., Munari, D., Geroin, C., Ianes, P., Waldner, A., & Gandolfi, M. (2010). Rehabilitation procedures in the management of spasticity. *Eur J Phys Rehabil Med*, 46(3), 423-38.

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## Spasticity Management

- Following interventions to diminish spasticity, the clinician must address the viscoelastic changes to periarticular structures and muscles to gain passive joint excursion.
- Encouraging active motion of the antagonist of the spastic muscle facilitates functional recovery.

Denton, A., Burn, L., Hough, A., Bugmann, G., & Marsden, J. (2016). Superficial warming and cooling of the leg affects walking speed and neuromuscular impairments in people with spastic paraparesis. *Annals of physical and rehabilitation medicine*, 59(5-6), 326-332.

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## Methods of Application

- Heat can be applied locally or systemically to influence spasticity.

- Foot bath
- Paraffin
- Neutral warmth
- Watsu

Elliott, C., Reid, S., Hamer, P., Alderson, J., & Elliott, B. (2011). Lycra® arm splints improve movement fluency in children with cerebral palsy. *Gait & posture*, 33(2), 214-219.

Bordoloi, K., & Deka, R. S. (2018). Scientific Reconciliation of the Concepts and Principles of Rood Approach. *IJHSR*, 8, 225-234.

Jacimani, M., Novak, L., & Lämmin, N. (2014). Effectiveness of hand splints in children with cerebral palsy: a systematic review with meta-analysis. *Developmental Medicine & Child Neurology*, 56(2), 138-147.

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## Environment Temperature

- Clinicians should consider the environmental temperature, surface area of skin exposure, and insulation provided by patient attire as influential factors on patient self-report of spasticity.

Phadke, C. P., Balasubramanian, C. K., Ismail, F., & Boullas, C. (2013). Revisiting physiologic and psychologic triggers that increase spasticity. *American journal of physical medicine & rehabilitation*, 92(4), 357-369.

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### Heat Exposure and Multiple Sclerosis

- Uthoff's Phenomenon is an adverse reaction to heat that leads to a pseudo-exacerbation and fatigue.

Intervention	Outcome
Resting body temperature vs. control	Resting core temperature equivalent to controls
Exercise in warm vs. hot environment	MS mild sudomotor dysfunction
Cold vs. neutral water ingestion	Greater exercise capacity with cold ingestion

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Chasing, G. (2018). Physiological Considerations of Heat Intolerance in People with Multiple Sclerosis. Masters Thesis University of Sydney

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### Hyperthermia and Muscle Performance Healthy Populations

- Resistance training in hot environments does not appear to contribute to muscle hypertrophy.
- Elevated core and muscle temperature induces adverse effects on muscle performance.

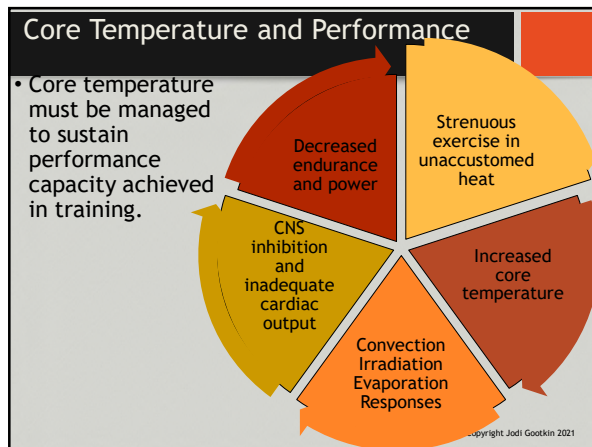
Intervention	Outcome
Resistance training 23°C vs 40°C	No increase in speed, agility, strength, muscle mass
Cycling 20°C vs. 40°C	Increased core and muscle temperature, heart rate, perceived exertion. Decline in mean power

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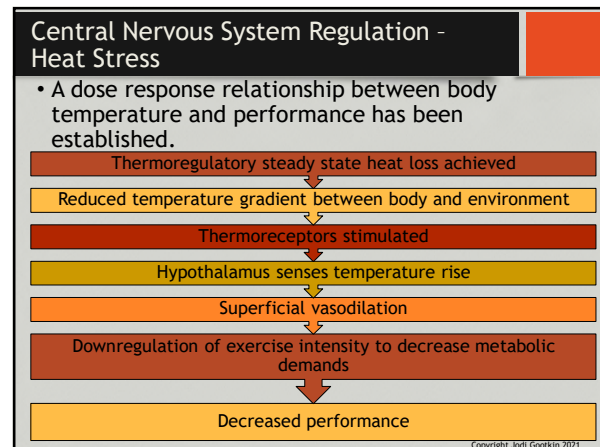
Drew, S. (2019). Effects of Resistance Training with Heat Stress on Muscle Mass, Strength and Performance. Masters Thesis Hamstead University

Drust, B., Rasmussen, P., Mohr, M., Nielsen, B., & Nybo, L. (2005). Elevations in core and muscle temperature impairs repeated sprint performance. *Acta Physiologica Scandinavica*, 183(2), 181-190.

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### Humidity

- Humidity is the percentage of moisture in the air relative to the amount it could hold if saturated at the same temperature.
- The higher the humidity, the lower the evaporative heat loss will be even if the ambient temperature is in a comfortable range.

Dry	• Sweating effective
Humid	• Sweating evaporation inhibited • Core temperature rise • Dehydration

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### Core Temperature Management Techniques

- Pre-participation climate training or during participation cooling countermeasures are employed to sustain participation at high levels.

Heat Acclimatization	• Natural heat • Controlled environment chambers • Heat retaining clothing • Sauna or Hot tub
Cooling	• Cooling Clothing • Fans • Ice Packs • Cooling Vest • Water Immersion

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Racinais, S., Alonso, J.M., Coutts, A.J., Flouris, A.D., Girard, O., González-Alonso, J., ... Péronard, J.D. (2015). Consensus Recommendations on Training and Competing in the Heat. *Sports medicine (Auckland, N.Z.)*, 45(7), 925-938. doi:10.1007/s40279-015-0343-6

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## Heat Acclimatization

- Repeated exercise-heat exposures during training facilitate physiologic adaptations to manage heat stress encountered during competition and work.

- Sweating efficiency**
  - Evaporative cooling
- Metabolic efficiency**
  - Decreased strain
- Improved cardiac output**
  - $CO = HR \times SV$
  - Increased blood-plasma volume

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## Physiologic Response to Heat Acclimatization

**Reduced**

- Core temperature
- Skin temperature
- Electrolyte loss
- Heart rate
- Whole body metabolic rate

**Improved**

- Thermal comfort
- Sweating
- Skin blood flow
- Muscle metabolism
- Muscle power
- Aerobic capacity
- Thirst
- Cardiac output

Sawka, M. N., Péronard, J. D., & Racinais, S. (2015). Heat acclimatization to improve athletic performance in warm-hot environments. *Sports Sci. Exerc.*, 28, 1-6.  
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## Training Methods

- Sessions replicating environment and activities must be stressful enough to elevate core temperature and invoking profuse sweating and circulatory responses.

**Natural heat**

- Training in similar conditions

**Controlled environment chamber**

- Replicate temperature and humidity

**Restrictive heat loss attire**

- Inhibit heat loss

**Sauna or Hot tub**

- Inhibit heat loss

Wilmsl, A. G., Gibson, O. R., James, C. A., Hayes, M., & Maxwell, N. S. (2016). Physiological and perceptual responses to exercising in restrictive heat loss attire with use of an upper-body-sauna suit in temperate and hot conditions. *Temperature*, 5(2), 162-174. J.  
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## Training Safety Considerations

- The goal is to achieve improved thermal comfort, and enhanced endurance while decreasing risk of heat induced illness.
- Performance benefits take longer to develop than physiologic responses.

Don't rely on thirst sensation

Sweat more electrolytes initially

Don't skip meals

Air conditioning okay

**Recovery**

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## Cooling Vests

- Decreasing thermal skin sensation appears to hinder CNS drive to enhance performance.

Intervention	Outcome
Cycling 30 minutes cooling 15 minutes cycling 30 minutes	Core temp and labs unchanged RPE and skin temperature decreased, power increased
30 warm-up with "pre-cooling", 5k run	MVC, membrane excitability, RPE, sweat loss unchanged and skin temperature decreased

Hasegawa, H., Chaen, Y., (2019). Wearing a cooling vest during half-time improves intermittent exercise in the heat. *Frontiers in Physiology*, 10, 711.  
Randall, A., Ross, Z., and Maxwell, S. (2015). Effect of practical precooling on neuromuscular function and 5km time-trial performance in hot, humid conditions among well-trained male runners. *J. Str. Cond. Res.* 29, 1925-1936.  
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## Occupational and Athletic Heat Stress

Heat stroke

- Core temperature rises
- Sweating mechanisms fail
- Death or permanent disability if not managed

Heat exhaustion

- Excessive sweating with water and salt loss

Rhabdomyolysis

- Prolonged exertion
- Muscle breakdown
- Heart and kidney damage

Heat syncope

- Dehydration and lack of acclimatization
- Fainting with prolonged standing or sudden rising

Heat cramps

- Depleted salt and water

Heat rash

- Excessive sweating in hot humid weather

https://www.cdc.gov/niosh/topics/heatstress/heatreillness.html  
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## Workplace Environment

- The CDC and National Institute for Occupational Safety and Health recommend employers reduce workplace heat stress.

Engineering	<ul style="list-style-type: none"> <li>Increase air velocity</li> <li>Reflective shielding</li> <li>Reduce steam, wet floors, humidity</li> </ul>
Work Practice	<ul style="list-style-type: none"> <li>Limit exposure time</li> <li>Tools to reduce manual strain</li> <li>Provide water</li> <li>Heat alert program</li> </ul>
Education	<ul style="list-style-type: none"> <li>Symptoms and care</li> <li>Buddy system</li> <li>Heat acclimatization</li> </ul>

<https://www.cdc.gov/niosh/docs/2016-106/pdfs/2016-106.pdf>  
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## CDC Recommendations

- CDC offers training suggestions, posters to print, and a free heat safety monitoring app.

<https://www.cdc.gov/niosh/topics/heatstress/default.html>  
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## Public Health Resources

- The CDC includes extreme heat information developed for vulnerable populations.

<https://www.cdc.gov/disasters/extremeheat/index.html>  
[https://www.cdc.gov/disasters/extremeheat/social\\_media.html](https://www.cdc.gov/disasters/extremeheat/social_media.html)  
<https://www.cdc.gov/cpr/infographics/beattheheat.htm>  
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## Whole Body Heat Stress

- Research is emerging on passive heat exposure to the whole body to induce exercise associated physiologic responses and mitigate declines seen in cardiovascular and metabolic disease.
  - Microvascular function
  - Endothelial function
  - Arterial stiffness
  - Oxidative stress
  - Inflammation
- Acute responses for populations who cannot engage in active exercise programs may promote long-term benefits to minimize risk of chronic disease.

**Consider This**  
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## Physiologic Response

- Current research demonstrates that physiologic responses produced with whole body heat exposure in a sauna are similar to moderate- or high-intensity physical activity.

<b>Cardiovascular</b>	<b>Hormones</b>	<b>Sympathetic Nervous System</b>	<b>Biomarkers</b>
Lower BP	Catecholamines	Norepinephrine	Glucose metabolism
Increased CO	Prolactin		Insulin resistance
Decreased cholesterol	Cortisol		Heat shock proteins
	Growth hormone		

Laukkanen, J. A., Laukkanen, T., & Kunutsor, S. K. (2018, August). Cardiovascular and other health benefits of sauna bathing: a review of the evidence. In *Mayo Clinic Proceedings* (Vol. 93, No. 8, pp. 1111-1121). Elsevier.  
Iguchi, M., Littmann, A. E., Chang, S. H., Westor, L. A., Knipper, J. S., & Shields, R. K. (2012). Heat stress and cardiovascular, hormonal, and heat shock proteins in humans. *Journal of athletic training*, 47(2), 184-190. Copyright Jodi Gootkin 2021

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## Cardiovascular Disease Outcomes

- Additional research is necessary to develop safe thresholds for sauna exposure.

Diagnosis	Outcome
Adult Congestive Heart Failure (CHF)	Improved 6-minute walk Reduced heart size
Pediatric CHF	Decreased ventricular septal defect shunt flow ratios
Ventricular Arrhythmia	Fewer PVCs
Ischemic Heart Disease	Improved defect reversibility

Hussain, J., & Cohen, M. (2018). Clinical effects of regular dry sauna bathing: a systematic review. *Evidence-Based Complementary and Alternative Medicine*, 2018. Copyright Jodi Gootkin 2021

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## Metabolic Outcomes

- Heat therapy may propose an additional management strategy to combat chronic low-grade inflammation and compromised glucose metabolism in patients with diabetes and obesity.

Modulate inflammation

• Interleukin-6 (IL-6) releases anti-inflammatory cytokines

Promote insulin sensitivity

• Nitric oxide (NO) increases glucose uptake

Hoekstra, S. P., Bishop, N. C., Faulkner, S. H., Bailey, S. J., & Leicht, C. A. (2018). Acute and chronic effects of hot water immersion on inflammation and metabolism in sedentary, overweight adults. *Journal of Applied Physiology*, 125(12), 2008-2016. Copyright Jodi Gootkin 2021  
Ely, B. R., Clayton, Z. S., McCurdy, C. E., Pfeiffer, J., & Minson, C. T. (2018). Meta-inflammation and cardiometabolic disease in obesity. *Current obesity reports*, 7(1), 1-11.

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## Peripheral Artery Disease (PAD)

- Atherosclerosis of extremity vasculature presents as intermittent claudication and exercise intolerance.
- Research is exploring two applications of heat stress for this population.
  - Can exposure substitute for exercise with positive cardiovascular responses?
  - Can exposure provide a clinical benefit to increase limb perfusion?

Impaired angiogenesis

Arterial obstruction

Reduced microvascular flow

Inflammation

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## PAD Outcomes

- With additional research, heat therapy may be a viable strategy to enhance lower limb perfusion and hemodynamic response.

Intervention	Outcomes
Sauna	Decreased VAS, improved 6-minute walk, increased ankle/brachial index (ABI)
Lower limb heat immersion	Increased limb perfusion, oxygenation, total hemoglobin and heat stress induced
Water circulating garment	Reduced BP, increased blood flow velocity, and reduced endothelin-1 concentration

Hussain, J., & Cohen, M. (2018). Clinical effects of regular dry sauna bathing: a systematic review. *Evidence-Based Complementary and Alternative Medicine*, 2018.  
Kate Nicole Thomas (2017) Harnessing heat for health: A clinical application of heat stress, *Temperature*, 4(3), 208-210.  
Neff, D., Kuhlthoelter, A. M., Lin, C., Wong, B. J., Motaganahalli, R. L., & Rosegini, B. T. (2016). Thermotherapy reduces blood pressure and circulating endothelin-1 concentration and enhances leg blood flow in patients with symptomatic peripheral artery disease. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 311(12), R392-R400. Copyright Jodi Gootkin 2021

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## Glucocorticoid-Induced Myopathy

- Glucocorticoids effectively inhibit inflammation associated with several chronic medical conditions.
- Prolonged use leads to muscle atrophy.
- In animal models, heat stress appears to modulate skeletal muscle signaling pathways to attenuate atrophy.
  - Increased muscle fiber diameter
  - Improved capillary to muscle fiber ratio
  - Increased heat shock protein level

Tsuchida, W., Iwata, M., Akimoto, T., Matsuo, S., Asai, Y., & Suzuki, S. (2017). Heat stress modulates both anabolic and catabolic signaling pathways preventing dexamethasone-induced muscle atrophy in vitro. *Journal of cellular physiology*, 232(3), 650-664.  
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## Bruising

- Subcutaneous anti-thrombotic injection to manage venous thromboembolism (VTE) leads to local bruising.
- In addition to pain, bruising impacts patients in several ways.
  - Diminish confidence in treatment
  - Damage relationship with clinician
  - Increase anxiety
  - Alter body image
  - Challenges with future injection
- Local heat application can accelerate the rate of recovery of post-injection bruising.

Baki Akpinar, R. (2013). The effect of local dry heat pack application on recovering the bruising associated with the subcutaneous injection of heparin. *Journal of clinical nursing*, 22(17-18), 2531-2535.  
Amanianyan, S., Varsaei, S., Valsmoradi, M., Haghani, H., & Sieloff, C. (2016). Effect of local cold and hot pack on the bruising of enoxaparin sodium injection site: a randomized controlled trial. *Contemporary nurse*, 52(1), 30-41. Copyright Jodi Gootkin 2021

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## Dysmenorrhea

- Menstrual Distress Questionnaire (MDQ) is a patient reported outcome measure to quantify painful menses experienced by teenagers and women.
- Superficial heating appears to induce muscle relaxation and pelvic circulation to relieve primary dysmenorrhea pain.
  - Primary
    - As prostaglandins diminish pain decreases
  - Secondary
    - Associated with endometriosis or fibroids

Moos, R. H. (1968). The development of a menstrual distress questionnaire. *Psychosomatic medicine*, 30(6), 853-867.  
Jo, J., & Lee, S. H. (2018). Heat therapy for primary dysmenorrhea: A systematic review and meta-analysis of its effects on pain relief and quality of life. *Scientific reports*, 8(1), 16092. Copyright Jodi Gootkin 2021

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## Hypothermia

- Rewarming extremities diminishes the risk of cardiovascular collapse that can occur with whole body warm immersion.
- External methods of heat application inhibit shivering to reduce metabolic demands, cardiac workload, and patient discomfort.

Intervention	Outcome
Water immersion vs. Fluidotherapy vs. Shivering	6.1°C vs. 2.2°C vs. 2°C Water immersion and fluidotherapy reduced metabolic heat production

Kumar, P., McDonald, G. K., Chikara, R., Steinman, A. M., Gardner, P. F., & Giesbrecht, G. G. (2015). Comparison of distal limb warming with fluidotherapy and warm water immersion for mild hypothermia rewarming. *Wilderness & environmental medicine*, 26(3), 406-411. Copyright Jodi Gootkin 2021

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## Sleep Quality

- The hypothalamus coordinates sleep-wake cycles and thermoregulation with correlation to circadian rhythm.
- Increased distal skin temperature signals the initiation of normal sleep.

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## Sleep Quality Outcomes

- Sleep disorders in the elderly may increase fall risk, fatigue, chronic disease, and impair cognition.

Cohort	Intervention	Outcome
Nursing home residents	Hot pack to bilateral lower extremity	Decreased sleep latency/wake episodes. Increased long-sleep
Patients on hemodialysis	Bilateral foot bath	Decreased sleep latency and daytime dysfunction. Increased sleep time

Oshima-Saeki, C., Taniho, Y., Arita, H., & Fujimoto, E. (2017). Lower-limb warming improves sleep quality in elderly people living in nursing homes. *Sleep Science*, 10(2), 87.  
Ren, L., Li, J., Zhang, X., Wang, J., Liu, W., Chen, J., & Tang, S. (2017). Herb foot-bath has improving effects on sleep quality and symptom distress of maintenance hemodialysis patients. *Biomedical Research*, 28(22), 9749-9755. Copyright Jodi Gootkin 2021

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## Conclusion

- New applications of traditional methods of heat delivery continue to expand with emerging strategies to utilize the body's ability to thermoregulate for the management of chronic disease.

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1. A tissue temperature rise of 4 degrees Celsius defines what intensity of heating?

- A. Slight
- B. Mild
- C. Moderate
- D. Vigorous

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2. Thermal applications should be avoided near application sites of adjuvant therapies for patients with what diagnosis?

- A. Cancer
- B. Low Back Pain
- C. Cardiovascular Disease
- D. Multiple Sclerosis

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3. Heat alters superficial capillary diffusion and drug release rate of medications delivered through what route?

- A. Sublingual
- B. Oral
- C. Intramuscular
- D. Transdermal

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4. The clinician notes an asymptomatic brownish-red hyperpigmented reticulated rash on the patient's skin. What condition should be documented?

- A. Raynaud's Disease
- B. Keloids
- C. Erythema Ab Igne
- D. Dermatitis Rubor

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5. What ingredient in over the counter topical analgesics may contribute to antinociceptive effects?

- A. Iron
- B. Capsaicin
- C. Cortisone
- D. Bees Wax

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6. When managing musculoskeletal pain, what is TRUE about heat application?

- A. Short term relief may be attainable
- B. Long term benefits can be expected
- C. Ultrasound is the recommended method of application
- D. It is the nonpharmacologic intervention of choice for chronic low back pain

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7. What may contribute to improvements in muscle length following combined heat with stretch interventions?

- A. decreased viscoelastic properties
- B. improved nociceptor conduction
- C. greater stretch tolerance
- D. greater muscle spindle firing

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8. What is the current theory to explain delayed onset muscle soreness?

- A. Lactic Acid Accumulation
- B. Sustained Muscle Spasm
- C. Inflammation Response
- D. Sarcomere Damage

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9. What is the term for passive heat exposure to induce exercise associated physiologic responses?

- A. Whole Body Heat Stress
B. Passive Tissue Temperature Rise
C. Full Warmth Immersion
D. Systemic Sympathetic Stimulation

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10. Enhanced lower limb perfusion following heating may contribute to improved hemodynamic responses in patients with what condition?

- A. Rheumatoid Arthritis
B. Peripheral Artery Disease
C. Chronic Renal Failure
D. Postural Hypotension

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## Heat Beyond the Basics Resources

Physical Therapy Professional Liability Exposure: 2016 Claim Report

[http://www.hpso.com/Documents/pdfs/CNA\\_PT\\_CS\\_020116\\_CF\\_PROD\\_ASIZE\\_ONLINE\\_040417\\_SEC.pdf](http://www.hpso.com/Documents/pdfs/CNA_PT_CS_020116_CF_PROD_ASIZE_ONLINE_040417_SEC.pdf)

Occupational Therapy Claim Report

[https://hpso.com/Documents/pdfs/CNA\\_CLS\\_OT\\_032917\\_CF\\_PROD\\_ONLINE\\_SEC.pdf](https://hpso.com/Documents/pdfs/CNA_CLS_OT_032917_CF_PROD_ONLINE_SEC.pdf)

American Physical Therapy Association - 5 Things PTs and Patients Should Question

<http://integrity.apta.org/home.aspx>

American Occupational Therapy Association - 5 Things PTs and Patients Should Question

<https://www.aota.org/Practice/Researchers/choosing-wisely.aspx>

Centers for Disease Control (CDC) - Heat Stress Recommendations and Resources

<https://www.cdc.gov/niosh/topics/heatstress/default.html>

OSHA NIOSH- Heat Safety Tool App

<https://www.cdc.gov/niosh/topics/heatstress/heatapp.html>

CDC - Natural Disasters and Severe Weather Extreme Heat Resources

<https://www.cdc.gov/disasters/extremeheat/index.html>

Menstrual Distress Questionnaire

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.522.3998&rep=rep1&type=pdf>

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