

Chapter 32:

Physical Agent Modalities for the Hand Therapist

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- I. Definition of physical agent modalities:
 - A. “Physical agent modalities [PAMs] are those procedures and interventions that are systematically applied to modify specific client factors when neurological, musculoskeletal, or skin conditions are present that may be limiting occupational performance. PAMs use various forms of energy to modulate pain, modify tissue healing, increase tissue extensibility, modify skin and scar tissue, and decrease edema or inflammation.”^{1(p578)}
 - B. “Therapeutic modalities represent the administration of thermal, mechanical, electromagnetic, and light energies for a specific therapeutic effect (to decrease pain, increase range of motion, improve tissue healing, or improve muscle recruitment).”^{2(p4)}
- II. Types of physical agents and examples of each
 - A. Superficial Thermal (thermal agents applied to the surface of the skin that change temperature by conduction, convection, or evaporation):
 1. Heat (thermotherapy):
 - a) Hot pack
 - b) Fluidotherapy
 - c) Paraffin Bath
 - d) Whirlpool
 - e) Contrast baths
 - f) Warm water soaks
 2. Cold (cryotherapy):
 - a) Cold pack
 - b) Ice massage
 - c) Vapocoolant spray
 - d) Ice water bath/cool whirlpool
 - B. Deep thermal (agents that create a thermal response deep in the tissues by conversion)
 1. Ultrasound
 2. Diathermy
 3. Phonophoresis
 - C. Electrotherapy
 1. Transcutaneous Electrical Nerve Stimulation (TENS)
 2. Neuromuscular Electrical Stimulation (NMES)
 3. High Volt Pulsed Current (HVPC)
 4. Iontophoresis
 5. Interferential current (IFC)
 - D. Light therapy: monochromatic infrared energy (MIRE) (not covered in this chapter)
 1. Low Level Laser Therapy (LLLT)
 2. Near infrared (IR-A) super-luminous diodes (SLD)
 - E. Mechanical
 1. Sequential intermittent pneumatic compression pump
 2. Whirlpool and pulsed lavage with suction
 3. Continuous passive motion (CPM)

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- III. Role of physical agent modalities in hand therapy
 - A. Occupational Therapy:
 - 1. PAMs are part of occupational therapy only when they are “used...in preparation for or concurrently with purposeful and occupation-based activities or interventions that ultimately enhance engagement in occupation.”^{1(p578)}
 - 2. “The exclusive use of PAMs as a therapeutic intervention without direct application to occupational performance is not considered occupational therapy.”^{1(p578)}
 - B. Physical Therapy:
 - 1. “The use of physical agents/modalities in the absence of other interventions or the use of multiple physical agents/modalities with a similar physiologic effect should not be considered physical therapy...”^{3(p1)}
- IV. Competency in physical agents
 - A. Occupational Therapy – AOTA policy
 - 1. Physical Agent Modalities may be used by Occupational Therapists (OTs) or Occupational Therapy Assistants (OTAs) only when all of the following conditions are met:¹
 - a) “Demonstrated and verifiable competence”^(p579)
 - b) “Documented professional education”^(p579) including both:
 - (1) foundational education in the biological and physical sciences, and
 - (2) modality-specific education
 - c) Supervision in use until competency is demonstrated and documented
 - d) Awareness of current research findings
 - e) Compliance with state law
 - 2. Physical Agent Modalities may be used by OTAs with supervision by an OT when both the OT and OTA have demonstrated competency¹
 - 3. *Aides* (unlicensed, not certified) do not provide skilled OT services⁴
 - B. Entry-level education
 - 1. Both occupational therapy and physical therapy entry-level programs are required to provide instruction in physical agent modalities^{5,6}
- V. Heat transfer
 - A. Types of heat transfer⁷⁻⁹
 - 1. Conduction – heat is transferred from one object to another that it is touching (hot pack, paraffin, cold pack, ice cup, contrast baths)
 - 2. Convection – heat is transferred from a moving medium to another object (whirlpool, fluidotherapy)
 - 3. Conversion – one type of energy is converted to heat in the tissues themselves by friction (ultrasound, diathermy)
 - 4. Radiation – heat is transferred from one object to another without the need for a conducting medium or direct contact (infrared)
 - 5. Evaporation – heat is removed from the skin through evaporation of a liquid on the skin (vapocoolant spray). No temperature change in subcutaneous tissues⁹
 - B. Special considerations for the three most common types of heat transfer
 - 1. Conduction
 - a) Heat source has to be considerably hotter than the desired tissue target temperature because the source begins to cool as soon as conduction occurs. This temperature creates a risk for burns.
 - b) Heat by conduction changes tissue temperature based on the temperature differential between the thermal source and the tissue

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- c) Similar considerations for conduction with cryotherapy
- 2. Convection
 - a) Since the heat source is continuously replenished, the heat source is set near the desired tissue target temperature
 - b) Heat by convection will raise tissue temperature to a certain target and no higher.
 - c) Similar considerations for convection with cryotherapy
- 3. Conversion
 - a) The “heat source” is not actually hot. The energy from the source is converted to heat in the tissues.
 - b) Heat by conversion increases tissue temperature regardless of starting tissue temperature.
 - c) There is no conversion cryotherapy

VI. Superficial heat therapy

- A. Generally agreed upon effects of superficial heat⁸
 - 1. Increased metabolism in tissues
 - 2. Cutaneous vasodilation (not muscular)
 - 3. Decreased pain
 - 4. Decreased muscle spasm
 - 5. “Relaxation”
 - 6. Increased elasticity, extensibility, and flexibility of tissues
 - 7. Decreased viscosity (soften thick/brawny edema)
- B. Depth of heating
 - 1. 1-2 cm after 15-30 minutes⁸
 - 2. Deep structures beneath the adipose layer after 20 minutes¹⁰
- C. Target Temperature:^{7,8,10}
 - 1. Raise tissue temperature to between 40-45° C (104-113° F) to achieve thermal effects
 - 2. *Tissue Temperatures above 45 ° C (113 ° F) will cause tissue damage (burn)*
- D. Precautions and contraindications:⁷
 - 1. Precautions for superficial heat: (*Use caution* in these situations)
 - a) Acute injury/inflammation (heat will worsen inflammation & edema)
 - b) Pregnancy (no heat to low back or abdomen; no full body whirlpool—don’t want to overheat fetus)
 - c) Impaired circulation (decreased homeostatic effect)
 - d) Very young or very old (decreased thermal regulation)
 - e) Edema (heat can worsen edema; avoid dependant positioning)
 - f) Cardiac insufficiency (heating a large area increases the demand on the heart)
 - g) Metal in the area (may burn tissue adjacent to it; remove all jewelry)
 - h) Open wound (no insulation from skin and adipose tissue; avoid contaminating the wound)
 - i) Topical counter irritants (do not apply heat in area where these have been used)
 - j) Demyelinated peripheral nerves (do not apply heat to areas where peripheral nerves are compromised)
 - 2. Contraindications for superficial heat: (*Do not use* in these situations)
 - a) Recent or potential hemorrhage (bruising, etc.) (heat can cause the bleeding to recur)
 - b) Thrombophlebitis (heat can dislodge a clot)

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- c) Areas of impaired sensation (can cause burn without pt. knowing it)
 - d) Impaired mentation/communication
 - e) Area where there is malignancy (don't want to increase circulation or metabolic rate in this area)
 - f) Infrared irradiation to the eyes
- E. Application of superficial heat agents^{7,8}
- 1. Hot pack (Fig. 1)
 - a) Remove clothing and jewelry from the area to be treated
 - b) Use hot packs from a hydrocollator (70-75°C; 158-167°F)
 - c) Need to use 6-8 layers of dry towels between hot pack and skin (hot pack cover usually counts as 2)
 - d) Check skin after 5 minutes, especially bony prominences (remove if excessive redness or other signs of burning)
 - e) Leave in place for 10-20 minutes
 - f) Do not bear weight on hot packs
 - g) Advantages:
 - (1) Easy to use
 - (2) Can apply passive stretch during heat
 - (3) Hot packs themselves are inexpensive
 - h) Disadvantages:
 - (1) Body part is static during application
 - (2) Can be difficult to conform to body part
 - (3) Risk of burns given initial high temperature of hot pack
 - 2. Paraffin (dip and wrap method) (Fig. 2)
 - a) Remove clothing and jewelry from the area to be treated
 - b) Wash extremity to be treated
 - c) Check temperature of paraffin: 126°F for the UE^{10,11} or 116°F when treating areas of healed burns⁸
 - d) Instruct pt. to dip affected part into paraffin slowly, repeat until “glove” is formed (7-10 x)
 - e) Wrap in plastic wrap or bag
 - f) Wrap in towel, folding end over to hold heat in
 - g) Check skin after 5 minutes (remove if excessive redness is visible through paraffin or other signs of burning)
 - h) Leave on for 15-20 minutes; 20 minutes is usually needed for penetration into the joints of the hand
 - i) After 20 minutes, peel off paraffin (note that paraffin will not *feel* hot to the client after about 5 min.)
 - j) Paraffin is a very intensive heat treatment – can cause edema or stir up an inflammatory response, so elevate if edema is a concern
 - k) Do not use paraffin over an open wound
 - l) Can use paraffin in conjunction with Coban wrapping in elastic zone of end range for heat + stretch
 - m) Avoid scented wax in clinic
 - n) Advantages:
 - (1) Good contact with body contours (e.g., between fingers)
 - (2) Moistens the skin

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- (3) Low specific heat / thermal conductivity reduces risk of burn at relatively high temperatures
 - (4) Client can purchase unit for long term use at home
 - o) Disadvantages:
 - (1) Practical only for distal extremities
 - (2) Cannot be used over an open wound
 - (3) Body part is static during application
- 3. Fluidotherapy (Figs. 3 & 4)
 - a) Is a “dry whirlpool” consisting of ground corn cob particles suspended in a stream of air
 - b) Remove clothing, jewelry
 - c) Wash extremity to be treated
 - d) Pre-heat machine to 100-118°F (Usual setting 115°F—cooler if inflammation/edema is a concern)
 - e) Insert extremity through sleeve and secure sleeve around limb with velcro band
 - f) Make sure other sleeves have been closed
 - g) Turn machine on – treat for 20 minutes
 - h) Instruct patient in AROM exercises to do in machine
 - i) Adjust heat and airspeed settings as needed (higher airspeed will result in better heating, lower airspeed may be needed if allodynia is a problem)
 - j) Check on patient after 5 minutes (adjust temp as needed)
 - k) Advantages:
 - (1) Patient can perform AROM or PROM while in the heat
 - (2) Temperature can be adjusted easily
 - (3) Fluidized medium is generally perceived as soothing
 - (4) Can be used for desensitization in cases of allodynia
 - (5) Low risk of burns with convection heat because the temperature is set near the target tissue temperature.
 - l) Disadvantages:
 - (1) Machine is relatively expensive and can treat only 1 or 2 patients at a time
 - (2) Dependant limb position may be a risk for edema (though the constant massage of the particles may reduce this risk)
- 4. Warm water whirlpool
 - a) Used more for wound care/debridement than as a heating modality
 - b) Never exceed 110°F, use lower temperatures for larger areas
 - c) 92-96°F is typically used for wound care
 - d) Advantages:
 - (1) Patient can perform AROM or PROM while in the heat
 - (2) Temperature can be adjusted to meet treatment needs
 - (3) Buoyancy effect may make AROM easier
 - e) Disadvantages:
 - (1) Needs to be disinfected/sterilized between each use
 - (2) Significant risk of increasing edema due to heat with dependent positioning
 - (3) Time required to set up and clean up

Chapter 32 Figures

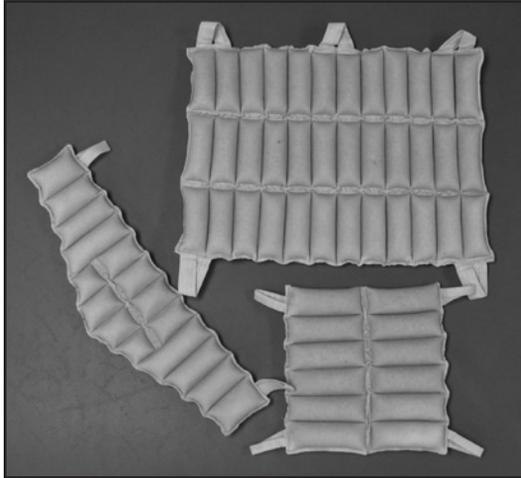


Figure 1: Hot packs



Figure 2: Paraffin Bath



Figure 3: Fluidotherapy



Figure 4: Fluidotherapy Control Panel

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- VII. Cryotherapy (superficial cold therapy)
- A. Generally agreed upon effects of cold^{7,9}
1. Vasoconstriction and decreased blood flow, followed by alternating vasodilation and vasoconstriction after ~15 minutes
 2. If applied within 24-48 hours of an acute injury:
 - a) Prevention of inflammation
 - b) Prevention of edema
 - c) Decreased secondary hypoxic injury via decreased metabolic rate
 3. Reduction in pain (due to decreased nerve conduction; increased firing threshold)
 4. Temporary decrease in spasticity or muscle spasm (cryostretch is the use of cold to reduce spasm while stretching)
 5. Initial increase in muscle strength, followed by a decrease in strength as the muscle cools
 6. Cold will make tissues stiff and inelastic (as well as mask pain), so *avoid* exercise/activity that could potentially aggravate an injury for 1-2 hours after icing
- B. Depth of cooling:
1. Cold packs will reduce skin temperature to analgesic temperatures within 1 minute; it will take 30 minutes to reduce muscle temperature by 3.5°C (6.3°F) at 4 cm deep⁹
 2. Adipose tissue can greatly slow cooling of deeper tissues with cryotherapy
- C. Target temperature:
1. Lowering skin temperature to 56°F will cause analgesia⁹
 2. Lowering nerve temperature to 50 to 59°F will decrease nerve conduction velocity by 33 to 17%, respectively⁹
- D. Precautions and Contraindications⁹
1. Precautions for cryotherapy: (*Use caution* in these situations)
 - a) Superficial main branch of a nerve (can cause axonotmesis if you freeze the nerve; reports include axonotmesis after 1 hour in a male athlete)
 - b) Open wound (do not apply to wound as cold will slow the healing process, and tissue damage may occur without the insulating skin and normal homeostatic responses)
 - c) Hypertension (cold can increase blood pressure)
 - d) Poor sensation or mentation
 - e) Very young/very old (decreased thermal regulation)
 - f) Bony prominences will succumb to frostbite quickly⁷
 2. Contraindications for cryotherapy: (*Do not use* in these situations)
 - a) Cold hypersensitivity/cold induced urticaria/cold allergy (rash, difficulty breathing)
 - b) Cold intolerance (pain/numbness/color changes)
 - c) Raynaud's disease and phenomenon (extreme vasoconstriction in response to cold)
 - d) Over regenerating peripheral nerves
 - e) Over area of impaired circulation/vascular repair/peripheral vascular disease
 - f) Cryoglobulinemia (check with physician in cases of multiple myeloma, lupus, or rheumatoid arthritis)
 - g) Paroxysmal cold hemoglobinuria
- E. Application of cryotherapy^{7,9}
1. Cold packs/Ice packs (Fig. 5)
 - a) Cold packs stored in freezer at about 20-25°F

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- b) Apply a single layer of moist towel between skin and cold pack (can instead use a dry towel for slower conduction)
 - c) Apply cold pack over towel, for 20-30 minutes, with elevation and compression
 - d) Check skin intermittently; remove if skin turns white or if rash or wheals develop
 - e) Can treat every 1-2 hours for an acute injury
 - f) If using cold pack over cast, treat longer (40 minutes or more)
 - g) Advantages:
 - (1) Easy to use
 - (2) Does not need constant attendance
 - (3) Can cover a large area
 - h) Disadvantages:
 - (1) Cold pack may not conform to contoured areas
 - (2) Need to remove cold pack to check skin periodically
 - (3) Longer duration of treatment than ice massage
2. Ice Massage (Fig. 6)
- a) Use ice cup (e.g., small paper cup filled with water and frozen)
 - b) For small areas only
 - c) Rub over skin in small overlapping circles
 - d) Will initially burn, ache, then go numb
 - e) If burning and aching sensations do not go away within a few minutes, you are covering too large an area.
 - f) Stop and remove if skin turns white or if rash or wheals develop
 - g) Advantages:
 - (1) Cools the tissue quickly
 - (2) Can see area being treated
 - (3) Inexpensive equipment
 - (4) Can be used easily by clients at home
 - h) Disadvantage: can cover only a small area
3. Vapocoolant spray
- a) Vapocoolant spray is used for “spray and stretch” technique
 - b) Place muscle on stretch
 - c) Spray vapocoolant over muscle, trigger point, or area of referred pain in one direction, proximal to distal, repeating spray 2-5 times, ½ to 1 inch apart
 - d) Gently take up any slack in the muscle as the skin cools
 - e) Re-warm before performing occupation or exercise, or before repeating spray and stretch
 - f) Cover face if used near the head
 - g) Can also use ice cup stroking for a similar effect
 - h) Advantages: applied quickly
 - i) Disadvantages: limited coverage area, cools skin only
4. Cold compression unit
- a) Cold water is circulated through a cuff that is wrapped around the extremity
 - b) Variety of makes and models with varying instructions
 - c) Often used post-operatively
 - d) Advantages:
 - (1) Cools better than ice/cold packs
 - (2) Can be used to apply compression as well

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- e) Disadvantages:
 - (1) Units can be expensive
 - (2) Some units have been reported to cause injury when used improperly⁹
 - (3) Need to remove cuff to check skin periodically
- 5. Cold bath/whirlpool^{9,11,12}
 - a) Use water temperature of 50-60°F for an extremity (colder temperatures can cool quicker, but will be more painful)
 - b) Whirlpool convection will provide quicker cooling than a still bath
 - c) Treatment time 5-15 minutes for whirlpool¹¹
 - d) Check client intermittently; stop when numb, if painful, or if rash or wheals develop
 - e) Advantages:
 - (1) Good contact with body part to be cooled
 - (2) Most intense, longest lasting cooling agent¹¹
 - f) Disadvantages:
 - (1) Dependant position may be undesirable if edema is present
 - (2) Need to disinfect whirlpool between uses
 - (3) Time required to set up and clean up.

VIII. Deep thermal physical agent modalities

A. Ultrasound

1. Basic principles¹³

- a) Ultrasound is a mechanical pressure (sound) wave
 - (1) Sound waves with a frequency between 20 Hz (cycles per second) and 20,000 Hz (20 KHz) are considered audible
 - (2) Ultrasound (US) is defined as sound above 20 KHz
 - (a) Therapeutic US is typically 1 to 3 MHz
 - (b) Diagnostic (imaging) US ranges from 2 to 18 MHz, but uses a much lower intensity (typically 0.0005 to 0.05 W/cm²)¹⁴
 - (3) Sound waves are generated by a piezoelectric crystal in the sound head
 - (4) Standing waves (which have significantly greater intensity than the source wave) can occur when the US waves reflected by bone interact with the source US wave from the sound head. Standing waves can be minimized by keeping the sound head moving.
- b) Collimation
 - (1) US beam consists of longitudinal waves which project from the US head in a more or less straight cylinder with a uniform diameter
 - (2) The US beam tends not to spread out or narrow on its own
- c) Attenuation
 - (1) Is the loss of energy in the US beam due to scattering (from reflection and refraction) and absorption
 - (2) Absorption causes the thermal effects of US as US is converted to heat in the tissues
 - (3) Different tissues absorb US energy (and therefore heat up) at different rates^{10,13,15,16}; Patellar tendon heats about 3.5 times faster than calf (triceps surae) muscle using identical parameters¹⁶

Chapter 32 Figures



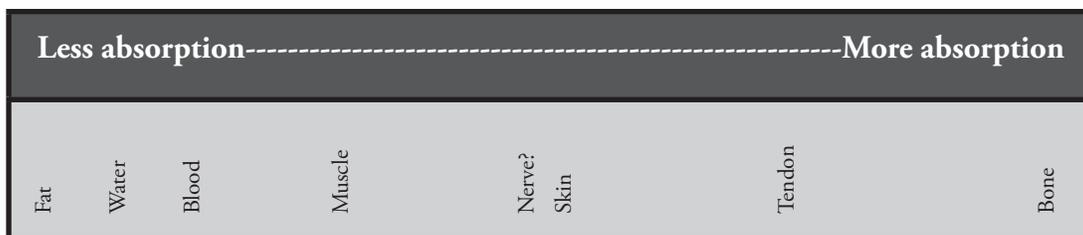
Figure 5: Gel Cold Pack



Figure 6: Ice Cup

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- (4) Higher US frequencies are absorbed more quickly: 3 MHz US heats 3-4 times faster than 1 MHz US¹⁷
- d) Beam Non-uniformity Ratio (BNR)
 - (1) An US beam is not uniform in the energy it emits – may have “hot spots”
 - (2) BNR is the ratio of the highest intensity found in the US beam (spatial peak intensity) to the spatial average intensity
 - (a) E.g., if the machine is set at 1 W/cm² and the machine has a BNR of 6:1, there will be areas in the beam as intense as 6 W/cm²
 - (3) The lower the BNR, the more comfortable the US treatment will be¹⁸
- e) Coupling
 - (1) US attenuates quickly in air, and is reflected at the air-tissue interface
 - (2) To get the US energy to the tissue where you want it, you need a coupling agent
 - (3) Water & US gel transmit US well (with relatively low attenuation)
 - (4) Hydrocortisone cream, Eucerin cream, & Vaseline transmit no US energy¹⁹
2. Ultrasound Parameters (document all of these each treatment)
 - a) Frequency
 - (1) Typically 1 MHz or 3 MHz – frequency determines depth of penetration and rate of heating
 - (2) Depth of penetration:
 - (a) 1 MHz effectively heats human tissue to a depth of about 5 cm (theoretically/traditionally)
 - (b) 3 MHz effectively heats human tissue to a depth of at least 2.5 cm²⁰
 - (3) Rate of heating:
 - (a) 3 MHz US heats tissue about 3-4 times faster than 1 MHz US does¹⁷
 - b) Effective radiating area (ERA)
 - (1) The cross-sectional area of the US beam
 - (2) Should be only slightly smaller than the physical size of the sound head
 - (3) Some units have a large difference between the ERA and physical size of the sound head as shown in image (Fig. 7) and graph (Fig. 8)²¹
 - (4) Usually labeled on the sound head itself
 - (5) Common sizes include 10 cm², 5 cm², 2 cm², 1 cm², & 0.5 cm² (see Fig. 9)
 - c) Intensity
 - (1) Spatial Average (SA) intensity: watts per square centimeter (W/cm²)
 - (2) Power: watts (W) – (divide by ERA to get SA intensity: W/cm²)

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- (3) SA intensity influences rate of heating, in conjunction with other parameters (duty cycle, frequency)
 - (4) Intensity does not influence depth of penetration¹³
 - d) Duty cycle
 - (1) Continuous: US on all the time
 - (2) Pulsed: US cycles on and off
 - (a) Often 20% (written p20%)
 - (b) Intensity that you set on the machine is the intensity while the US is on
 - (3) Temporal Average (TA) Intensity: Is the average intensity over time
 - (4) Spatial Average, Temporal Average (SATA) intensity is the product of the SA intensity and the duty cycle
 - (a) Examples:
 - (i) 1 W/cm^2 (SA intensity) \times 0.2 (20% duty cycle) = 0.2 W/cm^2 SATA intensity
 - (ii) 0.5 W/cm^2 (SA intensity) \times 1 (continuous 100% duty cycle) = 0.5 W/cm^2 SATA intensity
 - e) Duration: How long US is applied (usually documented in minutes)
 - f) Site of application: Describe site and specify treatment area in relation to ERA (e.g., “Dorsal wrist capsule, 2x ERA”)
 - g) Also document patient positioning and sequence of US in treatment session
 3. Ultrasound application technique – direct coupling
 - a) Given the potential for body lotions to block US, it might be beneficial to clean the skin before doing US.
 - b) Apply US gel – avoid bubbles in gel
 - c) Movement of sound head
 - (1) Should always be kept moving, for both continuous and pulsed duty cycles^{13,15,22}
 - (a) To avoid overheating hot spots caused by beam non-uniformity
 - (b) To avoid standing waves
 - (c) A stationary sound head could result in pain and/or tissue damage
 - (2) Movement can be either longitudinal (side to side) or overlapping circles²²
 - (3) Speed of the sound head movement
 - (a) Speed of the sound head movement does not influence the dosage or the heating effect²³
 - (b) Generally a speed of 4 cm/second is recommended
 - d) Orientation of the sound head²⁴
 - (1) Sound head should be kept in a consistent flat plane while moving
 - (2) Visualize the target tissue and keep it inside the collimated US beam
 - e) Choice of sound head ERA
 - (1) Physical size of sound head should match body part to be treated
 - (a) Need to be able to couple entire sound head to body part
 - (b) If two sizes will work equally well, tend to choose the larger
 - f) Coverage area
 - (1) Two to three times the ERA of the sound head is generally recommended¹³

Chapter 32 Figures



Figure 7: Large difference between the ERA and the physical size of the sound head

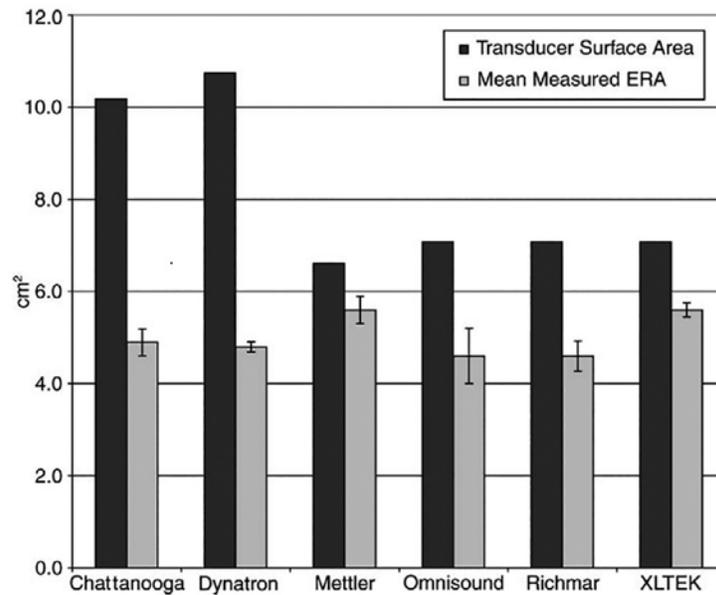
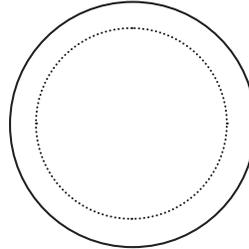


Figure 8: Comparison between sound head surface area and mean measured ERA. Reprinted with permission from Johns LD, Straub SJ, Howard SM. Variability in effective radiating area and output power of new ultrasound transducers at 3 MHz. *Journal of Athletic Training*. Jan-Mar 2007;42(1):22-28.

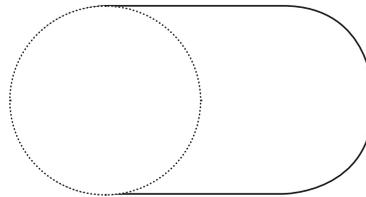
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- (2) Others recommend covering only 1.5 to 2 times the ERA²²
- (3) A coverage area of two times the ERA has been used in most of the recent research.
 - (a) Example coverage areas
 - (i) Circular motion: A 5 cm² ERA is shown with a dotted line and the 10 cm² recommended coverage area is shown with a solid line.



- (ii) Side to side motion: A 5 cm² ERA is shown with a dotted line and the 10 cm² recommended coverage area is shown with a solid line.



- (4) Covering an area four times the ERA of the sound head results in less rapid heating and more rapid cooling¹⁶
 - (5) A coverage area of two times the ERA of the sound head is **not** two times the diameter of the sound head.
 - (6) A coverage area of 40 times the ERA of the sound head (e.g. covering a 10 x 20 cm area with a 5 cm² ERA sound head) results in essentially no heating²⁵
4. Precautions & Contraindications^{10,15,22,26}
- a) Precautions for US (*use caution* in these situations)
 - (1) Cognitive/communicative impairment
 - (2) Impaired pain or temperature sensation (patient cannot tell if overheating)
 - (3) Reduced circulation (leads to a reduced homeostatic effect and might lead to overheating); others call this a contraindication²⁶
 - (4) Acute inflammation
 - (5) Avoid “high dose” ultrasound over healing fractures (but low dose ultrasound can facilitate fracture healing)
 - (6) No “high dose” ultrasound over breast implants (could cause excessive heating and rupture)
 - (7) Back area in radiculopathy
 - (8) Joint implants/hardware—see below

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- (9) Dose conservatively if using after another thermal modality due to cumulative heating effect
 - (10) Main peripheral nerve branches (author's opinion); could result in axonotmesis if incorrect dosage causes a burn
 - b) Contraindications for US (*do not use* therapeutic US under these conditions)
 - (1) Do not apply after cold pack/ice (due to altered sensation)
 - (2) Do not apply over stellate or cervical ganglia
 - (3) Do not apply over area of active bleeding or infection
 - (4) Do not apply over malignancy
 - (5) Do not apply over area of DVT or thrombophlebitis
 - (6) Do not apply over pacemaker or other implanted electrical device
 - (7) Do not apply over CNS tissue (possible after laminectomy)
 - (8) Do not apply over eye
 - (9) Do not apply over heart
 - (10) Do not apply over pregnant uterus or potentially pregnant uterus (low back, pelvis, abdomen)
 - (11) Do not apply over testes or over female reproductive organs
 - (12) Epiphyseal area (growth plates) in children—see below
 - c) Controversial areas:
 - (1) US over joint implants/hardware: varying opinions exist in the literature, as follows:
 - (a) US over plastic implants and joint cement:
 - (i) Is ok, as long as the sound head is kept moving¹⁰
 - (ii) Is a precaution²²
 - (iii) Is contraindicated^{15,26}
 - (iv) Is contraindicated only for joint cement¹³
 - (b) US over metal implants:
 - (i) Is ok or a precaution, as long as appropriate technique is used and pain or discomfort is avoided^{10,15,22,26}
 - (2) US over epiphyseal area (growth plates) in children: varying opinions exist in the literature
 - (a) Avoid higher intensities if possible¹⁰
 - (b) Avoid “high dose”^{15,26}
 - (c) US contraindicated over growth plates^{13,22}
5. Thermal Effects & Dosage of Ultrasound
- a) Both continuous and pulsed US generate a thermal effect.
 - (1) The thermal effect is determined by the SATA intensity together with other parameters, not by the duty cycle alone.²⁷
 - (2) Some suggest that a SATA intensity ≤ 0.2 W/cm² will minimize thermal effects,^{13,28} though that hypothesis ignores the influence of US frequency, duration, and tissue type on the thermal effect
 - b) Baseline temperature
 - (1) Normal human core temperature is 37 to 38°C²⁹
 - (2) Extremity temperatures can be somewhat cooler
 - (a) Achilles tendon baseline reported at 28-30°C³⁰
 - (b) Triceps surae muscle baseline reported at 34-35°C^{31,32}

Chapter 32 Figures



Figure 9: Ultrasound heads with a 10, 5, & 1 cm² ERA

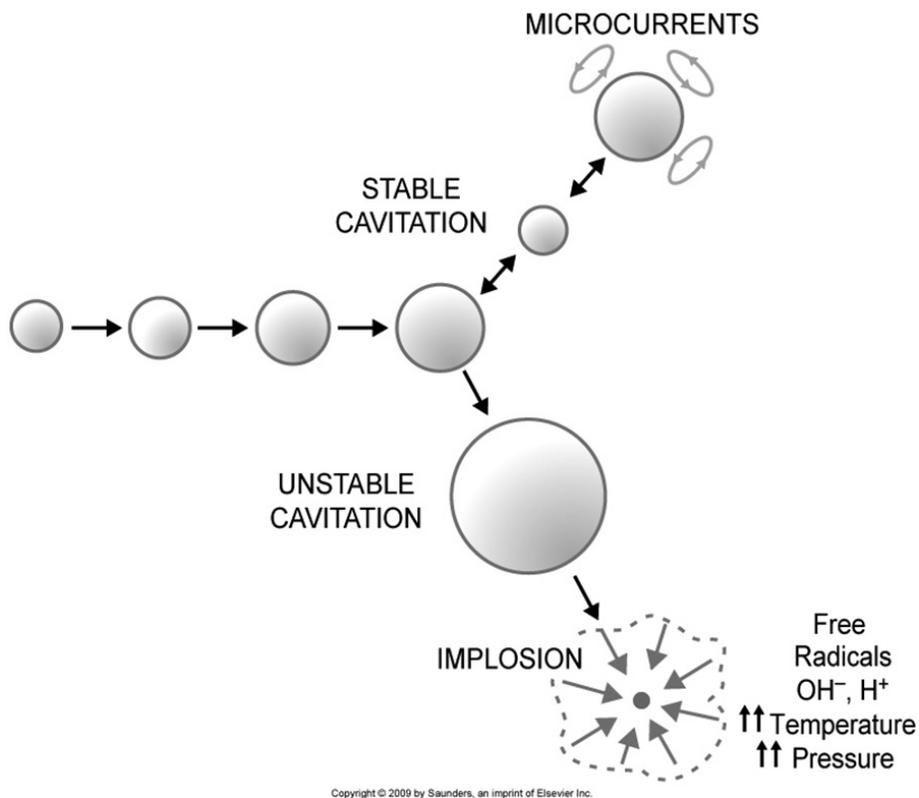


Figure 10: Cavitation and Microstreaming. Reprinted with permission from Cameron MH. Ultrasound. In: Cameron MH, ed. *Physical Agents in Rehabilitation: From Research to Practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009:177-206.

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- c) Increased extensibility
 - (1) In order to achieve increased tissue extensibility, some suggest that tissue temperature must be raised to 40°C for 5 minutes²⁸
 - (2) Others suggest that a temperature increase of 4°C above baseline is adequate for increased collagen extensibility¹³
 - (3) After the US treatment, the duration of temperature increase for stretching is very short: 3-4 minutes in superficial structures and only slightly longer in deeper structures¹³
- d) Decreased pain, muscle spasm: requires a temperature increase of 2-3°C above baseline¹³
- e) Increased metabolism/cellular activity/ “healing”:
 - (1) Requires a temperature increase of 1°C above baseline¹³
 - (2) High frequency US is generally not accepted as a treatment for chronic venous or pressure ulcers,²² but low frequency MIST US may be effective^{33,34}
- f) Increased circulation
 - (1) But any appreciable immediate increase in circulation occurs in skin, not muscle, and a greater increase in skin circulation can be achieved with moderate exercise³⁵
- g) *Heating tissue above 45°C can cause tissue damage and should be avoided.*
- 6. Non-thermal mechanisms and effects
 - a) Non-thermal effects are effects not attributable to the thermal effects of US. They are also termed “mechanical” effects.
 - b) Proposed mechanisms:
 - (1) Stable Cavitation: expansion and contraction of tiny bubbles as a result of the US wave (compression and rarefaction), causing microcurrents around the bubbles^{13,15} (Fig. 10).
 - (2) Frequency Resonance: the frequency of US may alter an enzyme’s shape or structure and therefore its function³⁶
 - c) The parameters required to create specific non-thermal effects are largely unknown, with a few exceptions
 - (1) Good evidence for fracture healing with specific non-thermal dose parameters²²
 - (2) Both thermal and non-thermal dosages of US will have non-thermal effects^{13,15}
 - (3) Pulsed and continuous US may each have different non-thermal effects³⁷
 - d) Reported non-thermal effects¹⁵; the clinical significance of these effects is largely unknown
 - (1) Increased mast cell degranulation and histamine release
 - (2) Increased intracellular calcium
 - (3) Increased fibroblast activity
 - (4) Increased protein synthesis
 - (5) Increased blood flow in ischemic tissue
 - (6) Increased bone healing
 - (7) Increased proteoglycan synthesis in cartilage
- 7. Advantages and disadvantages of ultrasound²⁴
 - a) Advantages:

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- (1) Heats deeply, and fairly quickly at 3 MHz
 - (2) Can target specific area without heating a large area
 - (3) Selectively heats tissue with high collagen content (i.e., scar, adhesion, contracture) more than other tissues such as skin and fat
 - b) Disadvantages:
 - (1) Limited coverage area
 - (2) Heat dissipates more quickly with US vs. a modality with a larger coverage area
 - (3) Unit can be expensive, cannot be used at home
 8. Phonophoresis
 - a) Transdermal delivery of medication facilitated by US
 - b) Need to be sure that the medication preparation transmits US²²
 - c) Evidence supports transdermal delivery of dexamethasone to subcutaneous tissue, but not submuscular or subtendinous tissue³⁸
 - d) Low frequency US (e.g., 20-100 KHz) may be more effective for phonophoresis³⁹
 - e) Phonophoresis is an area of emerging research in terms of both efficacy and parameters
- B. Diathermy
1. Basic principles⁴⁰
 - a) Is the use of electromagnetic waves to create heat in the tissues
 - b) Wavelength used varies: shortwave (radio) diathermy or microwave diathermy
 - c) Can be continuous or pulsed
 - d) Pulsed radio frequency waves that are of such a low intensity that they do not create heat are termed *pulsed electromagnetic fields* (though this term is used inconsistently) or *pulsed radio frequency energy* instead of diathermy
 2. Methods of application⁴⁰
 - a) Capacitive method (shortwave diathermy)
 - (1) Also known as the electric field method
 - (2) Place body part between 2 electrodes (contraplanar method, used more for extremities) or place the electrodes next to each other on a body part (coplanar method, used more for back muscles)
 - (3) Remove all metal and clothing from area to be treated (use non-metal chair or mat table)
 - (4) Place single layer of dry toweling between skin and electrodes
 - (5) Adjust electrode plates within plate guards for desired effect (closer to skin = more heat perceived; further from skin = deeper heating)
 - (6) Be sure distance between electrode plates is at least as much as the diameter of the plates when using the contraplanar method
 - (7) Fat is heated more than muscle (particularly with contraplanar method), so this may not work as well in areas of thick (> 1 cm) adipose tissue.
 - b) Inductive method (shortwave diathermy)
 - (1) Also known as the magnetic field method
 - (2) Uses a coil contained in either a drum which is placed on the body part, or a sleeve to fit an extremity
 - (3) Remove all metal and clothing from area to be treated (use non-metal chair or mat table)

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- (4) Place single layer of dry toweling between skin and monode if using a single drum model, 1 cm of toweling between skin and diplode if dual hinged drum is used
 - (5) Heats blood and skeletal muscle the most
 - c) Microwave diathermy
 - (1) Not commonly used in therapy
3. Effect of shortwave diathermy⁴⁰
 - a) Primarily heating, as the oscillating electrical field creates movement of ions, water molecules, and electrons, resulting in friction that produces heat
 - b) As a result of the heat, increased tissue extensibility and decreased pain
 - c) Tissue healing may occur as a result of both the heating and the electrical fields generated
4. Parameters⁴⁰
 - a) Dosage and intensity are based on the patient's subjective response
 - b) Duration is 15-30 minutes, depending on intensity and treatment goals
5. Precautions & contraindications⁴⁰
 - a) Refer to precautions and contraindications for heat as well as those below
 - b) Precautions for diathermy (*use caution* in these situations)
 - (1) Impaired sensation
 - (2) Impaired circulation
 - (3) Over epiphyseal areas (growth plates) in children
 - (4) Low back or pelvis in menstruating women
 - (5) Mildly damaged skin
 - (6) Intrauterine contraceptive device containing copper
 - (7) Obesity (inductive diathermy)
 - c) Contraindications for diathermy (*do not use* under these conditions)
 - (1) Metal on the patient or within the electromagnetic field
 - (2) Malignancy
 - (3) Any implanted electrical devices
 - (4) In an area where external electrical medical devices are being used – keep all electronic equipment 9-15 feet from diathermy when in use⁴¹
 - (5) Hemorrhage, acute injury, or inflammation
 - (6) Pregnant or potentially pregnant
 - (7) Eyes, testes
 - (8) Synthetic clothing, pillows, mat table coverings (nylon, plastic, foam rubber)
 - (9) Contact lenses (for diathermy on the head)
 - (10) Impaired mentation or communication (intensity and dosage are adjusted according to patient report)
 - (11) Obesity (capacitive diathermy)
 - (12) Moist clothing, dressings, etc.
 - (13) Infection, severely damaged or atrophic skin
 - d) Metals in the body:
 - (1) contraindication for shortwave and microwave diathermy
 - (2) precaution for pulsed shortwave diathermy, if metal is small and does not form circles or loops (avoid with wire fracture fixation)
 - e) Pregnant therapists should avoid exposure to diathermy; non-pregnant therapists should limit exposure⁴¹

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IX. Electrical physical agent modalities

A. Nomenclature

1. Neuromuscular Electrical Stimulation (NMES)
2. Functional Electrical Stimulation (FES) is the use of switch-controlled NMES during functional activity
3. Transcutaneous Electrical Nerve Stimulation (TENS)
4. Iontophoresis

B. Types of Current and Waveforms

1. Metric refresher
 - a) Milli = 1/1000
 - b) Micro = 1/1,000,000
 - c) i.e., there are 1000 microseconds in a millisecond and 1000 microamperes (μA) in a milliampere (mA)
2. Microcurrent⁴²
 - a) Current that is less than 1 milliamp in amplitude (max output will be less than 1000 μA [microamperes])
 - b) Microcurrent cannot depolarize afferent or efferent axons, therefore is sub-sensory.
 - c) Sometimes termed MENS (“microcurrent electrical nerve stimulation”)—this is a misnomer as these devices cannot elicit an axon depolarization⁴³
 - d) Insufficient evidence for the efficacy of microcurrent stimulation for pain management^{42(p161)}
 - e) Low intensity direct current (LIDC) can be effective for ulcer healing⁴⁴
3. Direct current (DC)
 - a) Monophasic current is termed “direct current” if the unidirectional flow of electrons or ions lasts for at least 1 second^{43,45}
 - b) Direct current can be interrupted or reversing⁴³
 - c) AKA “galvanic current”
 - d) Direct current produces pH changes under the electrodes, with an alkaline response under the cathode (negative electrode) and an acidic response under the anode (positive electrode). These pH changes can damage skin and otherwise limit the efficacy of a treatment. Therefore the utility of DC is limited.
 - e) Used for iontophoresis, direct stimulation of denervated muscle, wound healing
4. Alternating current (AC)⁴³
 - a) Consists of biphasic current with a number of waves in a row
 - b) Modulation
 - (1) Time modulated or Burst AC (also known as Russian Stimulation)
 - (a) An interrupted series of waves, always less than 1 second in duration
 - (b) Typically used to stimulate a motor nerve
 - (2) Amplitude modulated AC (also known as interferential stimulation)
 - (a) Achieved with 4 electrodes using two channels at slightly different frequencies of AC
 - (b) Typically used for pain control
 - (c) Some units create amplitude modulated AC with 2 electrodes, but this is not “true” interferential stimulation, and may have different effects

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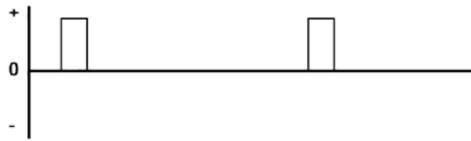
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5. Pulsed Current

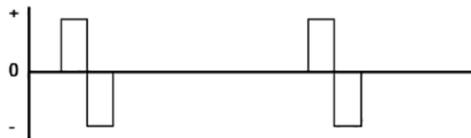
a) Description⁴⁵

- (1) Most commonly used current for TENS, NMES, FES
- (2) In pulsed current, the current starts and stops
- (3) The pulse duration is very brief (microseconds to milliseconds), with a short interpulse interval between pulses (a fraction of a second)
- (4) The pulsed current wave form may be monophasic (current moves in one direction only) or biphasic (current reverses direction during the pulse)

Monophasic pulsed current

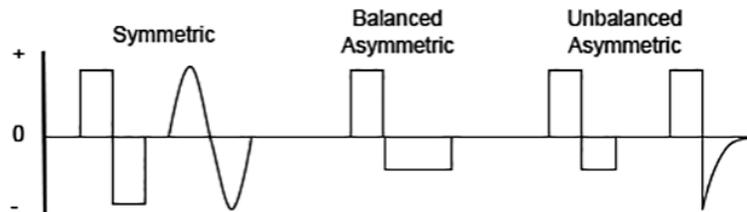


Biphasic pulsed current



b) Pulsed Biphasic Waveforms⁴⁵

- (1) Symmetric waveforms will look the same above and below the isoelectric line
- (2) Asymmetric waveforms will look different above and below the isoelectric line
- (3) Balanced asymmetric waveforms will have the same amount of current going in each direction, just in a different waveform
- (4) Unbalanced asymmetric waveforms will have more current flowing in one direction than another



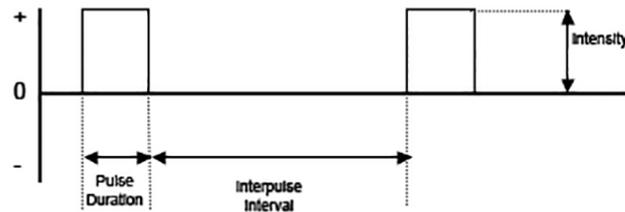
c) Waveform Parameters of Pulsed Current⁴⁵

- (1) Pulse Duration – the duration in milliseconds (msec) or microseconds (μ sec) that the pulse is on. Also known as pulse width.
- (2) Interpulse interval – time between pulses

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- (3) Pulse Frequency – number of pulses per second (Hz). Also known as pulse rate.
- (4) Intensity – amount of current flow. Also known as amplitude or strength.



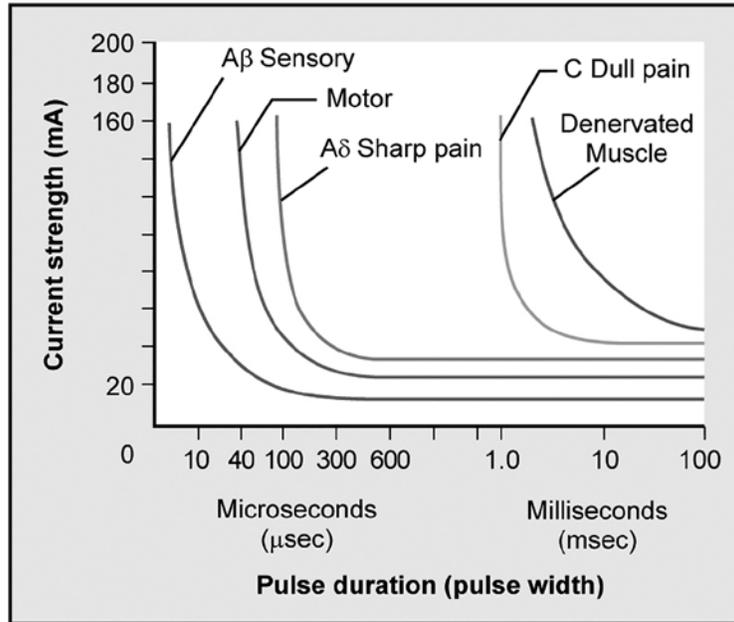
- C. Electrical stimulation of a nerve using an electrical agent⁴⁶
1. Neuron resting membrane potential and polarization
 - a) At rest (when not transmitting an impulse) the neuron is more negative internally than externally (it is polarized).
 - b) The sodium (Na^+) Potassium (K^+) pump maintains this state
 2. Action potential: when a neuron becomes less polarized to a certain threshold level, depolarization of the neuron occurs. An action potential or nerve impulse is then propagated down the nerve axon.
 3. Effect of external electrical stimulation of nerve fibers
 - a) By repelling negative ions, the cathode (the negative electrode) pushes extracellular negative ions towards the neuron cell membrane and pushes negative ions within the neuron away from the cell membrane, causing depolarization, and propagating an action potential.
 - b) The cathode is thus called the “active” electrode.
 4. Strength-Duration Curve
 - a) An external electrical stimulus may generate an action potential in nerve or muscle tissue, depending on two things:
 - (1) the strength (intensity) of the stimulus and
 - (2) the duration of the electrical pulse.
 - b) The relationship between these two parameters is demonstrated in the strength-duration curve
 - c) The curved line is the point at which the combination of strength and duration causes depolarization of the various types of nerve or muscle tissue. (Fig. 11)
- D. Precautions and Contraindications for electrical stimulation^{46,47}
1. Precautions for electrical stimulation (*use caution* in these situations)
 - a) Other implanted electrical devices: consult with physician prior to using e-stim
 - b) Hypertension/hypotension: monitor blood pressure during treatment
 - c) Avoid stimulation that could increase blood flow in areas of peripheral vascular disease
 - d) Impaired Sensation
 - e) Cardiac Disease (i.e., old MI)
 - f) Impaired Mentation
 - g) Irritated Skin
 - h) Acute inflammation for NMES

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- i) Seizures
 - j) Obesity (increased resistance from adipose tissue increases risk of burns and decreases effect)
 - k) Osteoporosis for NMES (a strong contraction with severe osteoporosis could cause a fx. Avoid if pt. has a history of pathologic fxs)
2. Contraindications to Electrical Stimulation (*do not use* under these conditions)
- a) Demand type Cardiac Pacemaker or defibrillator (or obtain cardiologist written consent after patient has been evaluated with cardiac monitoring during e-stim use)
 - b) Placement that applies current to carotid sinus region
 - c) Placement over area of blood clot
 - d) Transcerebral placement
 - e) Stimulation that draws current through the chest
 - f) Placement over pelvis, trunk, or low back of possibly pregnant woman
 - g) In the vicinity of diathermy devices (within 15 feet)
 - h) Over the pharynx
 - i) In areas of cancer (unless specifically directed by physician for pain control in a hospice setting)
- E. Transcutaneous Electrical Nerve Stimulation (TENS) (Fig. 12)
- 1. Terminology
 - a) Taken literally, TENS refers to any stimulation of nerves using surface electrodes
 - b) In practice and in the literature, the term TENS is generally used to mean the use of a pulsed biphasic waveform for pain control
 - 2. Mechanisms of pain control and related TENS applications:
 - a) Gate theory of pain: “conventional” or “high rate” TENS^{46,47}
 - (1) Electrical stimulation of large non-nociceptive sensory fibers “close the gate” on signals from nociceptive fibers
 - (2) Parameters used:
 - (a) Pulsed biphasic waveform
 - (b) Pulse frequency 100-150 Hz
 - (c) Pulse duration 50-100 μ sec
 - (d) Intensity set to sensory level stimulation
 - (e) Duration of treatment can be as long as needed
 - (i) Biphasic waveform reduces concern about pH changes
 - (ii) With no motor response, you don’t need to worry about muscle fatigue
 - (f) The waveform is often modulated to prevent adaptation
 - (3) Effect: Blocks pain signals *while the modality is on*
 - b) Endogenous opiate theory of pain control: “Low rate” TENS^{46,47}
 - (1) Also known as “acupuncture like” TENS, though there is no use of acupuncture theory in the application
 - (2) Electrical stimulation of motor fibers causes the release of endogenous opiates in the CNS that naturally block pain signal transmission
 - (3) Parameters used:
 - (a) Pulsed biphasic waveform
 - (b) Pulse frequency 2-10 Hz
 - (c) Pulse duration 150-300 μ sec
 - (d) Intensity set to motor level stimulation (should see a twitch)

Chapter 32 Figures



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Figure 11: Strength Duration Curve. Reprinted with permission from Shapiro, S. (2009). Chapter 8: Electrical currents. In: Cameron MH, ed. *Physical Agents in Rehabilitation: From Research to Practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009: 207-244.



Figure 12: TENS Unit

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- (e) Duration of treatment 20-45 minutes (longer sessions could cause muscle fatigue, resulting in Delayed Onset Muscle Soreness)
 - (f) No modulation needed
 - (4) Effect: Pain relief for 4-5 hours.⁴⁶ Pain relief onset is not immediate.
 - (5) Other endorphin-release parameters include burst,⁴⁶ brief-intense,⁴⁷ and noxious⁴⁷ (Fig. 13)
 - 3. TENS electrode placement⁴⁶
 - a) Electrodes should always be placed at least 1 inch apart to prevent conduction across the surface of the skin
 - b) Can use one channel (2 electrodes) or 2 channels (4 electrodes)
 - c) Generally the electrodes are placed so that the current goes through the area of pain
 - d) Can also place electrodes proximal to the painful area so that they stimulate the sensory nerve branch that innervates the painful area.
 - e) For “low rate” TENS, the electrode placement may be less critical, since the mechanism is in the CNS
 - 4. For TENS, document the following:
 - a) Pulse duration (AKA width)
 - b) Amplitude/strength
 - c) Pulse Rate/frequency
 - d) Modulation type
 - e) Total treatment time
 - f) Electrode placement/size/shape
 - g) Patient’s response to treatment
- F. Interferential current⁴³
 - 1. Used for pain control
 - 2. Consists of two channels (four electrodes), with each channel providing high frequency AC current at slightly different frequencies (e.g., 4000 Hz and 4100 Hz)
 - 3. The difference in the two frequencies creates interference and a resultant “beat frequency” (100 Hz in the above example), which provides the therapeutic effect.
 - 4. Some think that the high frequency AC may penetrate better than other waveforms
 - 5. “Sweep” and “swing” refer to frequency modulation to prevent accommodation
 - 6. “Scan” is amplitude modulation to cover a larger area
- G. Neuromuscular Electrical Stimulation (NMES)
 - 1. Refers to the electrical stimulation of an efferent (motor) nerve
 - 2. Parameters used (Fig. 14)
 - a) Symmetrical vs. asymmetrical waveforms^{10,48}
 - (1) With a symmetrical biphasic waveform, both electrodes spend an equal amount of time being the cathode and anode, thus both are equally active in causing nerve depolarization.
 - (2) With an asymmetrical biphasic waveform, one electrode spends more time as the cathode than the other. This “primary cathode” is more active in causing nerve depolarization than is the primary anode.
 - (3) Use a symmetrical biphasic waveform if the muscle is large enough to have 2 electrodes over the muscle with electrodes at least 1 inch apart. In the UE, this limits a symmetrical wave form to upper arm and shoulder muscles.

Chapter 32 Figures

Parameters for Pain Modulation (TENS)*

Indication	Type	Wave-form	Pulse Frequency	Pulse Duration	Amplitude	Duration
Acute pain: for relief during stimulation	Sensory-level stimulation	Mono- or bi-phasic pulsed current	High: approximately 100 pps	Short: 50-100 μ sec	mA to comfortable sensory perception	20-30 min (longer if used during activity)
Acupuncture stimulation	Motor-level stimulation	Mono- or bi-phasic pulsed current	Low: less than 10 pps	Long: greater than 150 μ sec	mA to visible muscle twitches	20-45 min
Brief-intense stimulation	Motor-level stimulation	Mono- or bi-phasic pulsed current	High: approximately 100 pps	Long: greater than 150 μ sec	mA to visible strong muscle twitches	Less than 15 min
Noxious-level stimulation	Hyperstimulation (point stimulation)	DC or mono-phasic	High: 100 pps Low: 1-5 pps	Long: greater than 250 μ sec, up to 1 sec	mA to highest tolerated painful stimulus	30-60 sec to each area

**These parameters are not specific to traditional TENS units and can be repeated on many line-powered clinical stimulators.*

Figure 13: Parameters for Pain Modulation (TENS). Reprinted with permission from Bellew JW. Clinical electrical stimulation: Application and techniques. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:241-277.

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- (4) Use an asymmetrical waveform for the forearm and hand, where the muscles are too small to accommodate two electrodes. The primary cathode (the negative electrode) will then be placed over the belly or motor point of the target muscle.
 - b) Pulse frequency⁴⁶
 - (1) To get a smooth (tetanic) contraction, use at least 35 Hz. More than 50 Hz will cause quicker muscle fatigue. Do not use a pulse frequency above 80 Hz.
 - c) Pulse Duration⁴⁶
 - (1) 150-200 μ sec for small muscles and 200-300 μ sec for large muscles
 - (2) Shorter pulse durations are more comfortable
 - d) Intensity⁴⁶
 - (1) Strengthening after injury or surgery: 10% of max voluntary contraction is adequate
 - (2) Muscle re-education: Use lowest amplitude needed to produce the desired motion
 - e) Duration of treatment
 - (1) Up to 30 minutes, depending on goals; stop when fatigue is noted.
 - f) On/off time⁴⁶
 - (1) With NMES, the stimulation is on for a period of time, then off for a period of time to allow muscle recovery.
 - (2) For strengthening, start with on-off ratio of 1:5 (e.g., 10 seconds on, 50 seconds off).
 - g) Ramp time
 - (1) For NMES, the intensity is ramped up gradually at the start of each “on time” for comfort and then ramped down gradually at the end of each on time.
 - (2) Generally want 1-2 seconds of ramp time, depending on goals.
 3. NMES electrode placement
 - a) Primary cathode
 - (1) When using an asymmetric biphasic waveform, place the primary cathode (the lead wire marked with a “-” sign) over the muscle belly of the muscle you want to stimulate^{10,48}
 - (2) The primary anode (positive lead wire) can go:⁴⁸
 - (a) On a second muscle you want to stimulate, but with less intensity
 - (b) Distal or proximal to the muscle being stimulated (distal forearm is often used)
 - b) Motor point
 - (1) Is where the efferent nerve enters the muscle
 - (2) Stimulation at this point will produce the most contraction with the least amplitude (and therefore the least discomfort)
 - (3) Generally motor points are near the middle of the muscle belly; motor point charts are also available
 - c) Distance between electrodes and depth of penetration
 - (1) The farther apart your electrodes are placed, the deeper the current will penetrate into the tissues⁴⁷

Chapter 32 Figures

Recommended Parameter Settings for Electrically Stimulated Muscle Contractions

Parameter Settings/ Treatment Goal	Pulse Frequency	Pulse Duration	Amplitude	On:Off Times and Ratio	Ramp Time	Treatment Time	Times per Day
Muscle strengthening	35-80 pps	150-200 μ s for small muscles, 200-350 μ s for large muscles	To >10% of MVIC in injured, >50% MVIC in uninjured	6-10 sec on: 50-120 sec off, ratio of 1:5, initially. May reduce the off time with repeated treatments	At least 2 sec	10-20 min to produce 10-20 repetitions	Every 2-3 hours when awake
Muscle reeducation	35-50 pps	150-200 μ s for small muscles, 200-350 μ s for large muscles	Sufficient for functional activity	Depends on functional activity	At least 2 sec	Depends on functional activity	NA
Muscle spasm reduction	35-50 pps	150-200 μ s for small muscles, 200-350 μ s for large muscles	To visible contraction	2-5 sec on: 2-5 sec off. Equal on:off times	At least 1 sec	10-30 min	Every 2-3 hours until spasm relieved
Edema reduction using muscle pump	35-50 pps	150-200 μ s for small muscles, 200-350 μ s for large muscles	To visible contraction	2-5 sec on: 2-5 sec off. Equal on:off times	At least 1 sec	30 min	Twice a day

MVIC, Maximum voluntary isometric contraction; *NA*, Not applicable

Figure 14: Recommended parameter settings for electrically stimulated muscle contractions. Reprinted with permission from Shapiro, S. (2009). Chapter 8: Electrical currents. In: Cameron MH, ed. *Physical Agents in Rehabilitation: From Research to Practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009: 207-244.

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- (2) In the upper extremity, it is possible to stimulate the antagonist of the muscle you are trying to stimulate if your electrodes are placed too far apart, especially with a symmetric biphasic waveform⁴⁸
 - (3) Electrodes should be at least 1 inch apart; may need to place electrodes more than 1 inch apart if the muscle contraction would draw them closer to each other⁴⁶
 4. For NMES, you should document the following:
 - a) Stimulation on/off time
 - b) Waveform
 - c) Pulse duration (also known as width)
 - d) Amplitude/strength
 - e) Pulse Rate/frequency
 - f) Total treatment time
 - g) Electrode placement/size/shape (and which one is the primary cathode if an asymmetric waveform is used)
 - h) Patient's response to treatment
- H. Iontophoresis
 1. Consists of the use of DC to facilitate transdermal delivery of a medication that has an electrical charge
 - a) Medication penetrates only 1-2 mm deep in an in-vitro model. Further penetration occurs by diffusion and local circulation.⁴⁹
 - b) Need an order that specifies both the modality *and* the medication.
 2. Additional considerations specific to iontophoresis: In addition to the electrical stimulation precautions and contraindications, one must consider the precautions and contraindications of the medication being delivered.
 3. Parameters used⁴⁷
 - a) Intensity
 - (1) Measured in milliamperes (mA); generally set between 1 and 4 mA on clinic units
 - b) Duration
 - (1) Measured in minutes
 - c) Dosage of the medication is thus measured in milliamp minutes (mA·min)
 - (1) Calculated by multiplying the intensity by the duration
 - (2) Generally a dose of 40 to 80 mA·min is used
 - (3) In the author's experience, the slower the dose is delivered (i.e., with a longer duration and lower intensity), the less skin irritation occurs. Intensities over 2 mA seem to cause more skin irritation.
 4. Electrodes⁴⁷
 - a) A treatment electrode is saturated with the medication ion to be delivered. This electrode is connected to the lead wire that has the SAME charge as the drug ion. The electrode with the medication on it is paced directly over the target tissue.
 - b) The other electrode is placed somewhere else on the extremity
 5. Iontophoresis systems
 - a) Traditional in-clinic unit (Fig. 15A)
 - b) Patch (disposable, battery operated, lower intensity, worn for several hours)
 - c) Hybresis (hybrid of in-clinic and patch systems) (Fig. 15B)

Chapter 32 Figures



**Figure 15: A, Clinic iontophoresis unit;
B, Hybrid iontophoresis unit**

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6. Iontophoresis procedure:
 - a) Do not shave area (clipping hair is ok)
 - b) Use an alcohol prep to clean the target area and an area for the “dispersive” electrode
 - c) Saturate the medication electrode with the medication to be used (the electrode is labeled with the amount of medication needed to saturate)
 - d) Further set-up and dosage vary depending on type of iontophoresis (traditional, patch, or Hybresis)
 - e) Avoid interventions that would disperse the medication after iontophoresis (heat, manual edema mobilization, kinesiotape)
7. Common medications; indications; polarity:⁴⁷
 - a) Dexamethasone; inflammation; negative
 - b) Lidocaine; pain; positive
 - c) Acetic acid; calcific tendinitis; negative
 - d) Iodine; soft tissue adhesions; negative
8. Document the following:
 - a) Number of treatments delivered to date
 - b) Intensity (mA)
 - c) Treatment time (minutes)
 - d) Dosage (intensity x duration)
 - e) Medication used
 - f) Electrode placement and size
 - g) Patient’s response to treatment
 - (1) Any immediate adverse effects (skin blistering, etc.)
 - (2) Any treatment effects
9. Number and frequency of treatments
 - a) Generally expect to see initial improvement within 3-5 treatments.
 - b) Know the half-life of the medication to effectively space treatments to maintain consistent medication levels
 - (1) Generally you want to have the next treatment about one half-life after the previous in order to maintain a therapeutic level in the tissues
 - (2) E.g., dexamethasone has a biologic half-life of about 50 hours, thus you would want to treat with this medication every other day.
10. Advantage of iontophoresis: provides a therapeutic alternative to an injection performed by the physician
11. Limitations of iontophoresis
 - a) May only target superficial structures
 - b) Can be costly compared with injection
 - c) Appropriate for small target only
- I. High volt pulsed current (HVPC)
 1. Uses:⁴⁷
 - a) Prevention of edema in the acute inflammatory phase
 - (1) Use the cathode as the active electrode, and the anode as the dispersive
 - (2) Intensity slightly below motor threshold (comfortable sensory stimulation)
 - b) Tissue healing
 - (1) Cathode or anode is the active electrode placed at the wound, depending on goals
 - (2) Intensity set at comfortable sensory stimulation

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2. Parameters:⁴³
 - a) Consists of a pair of pulses of monophasic high amplitude (150-500V), short duration (50-100 µsec) current, with a long interpulse interval between pairs
 - b) Frequency of the twin pulses is 1 to 120 Hz
 - c) The active electrode is typically smaller than the dispersive
 - d) Sometimes called high volt pulsed galvanic stimulation, but the term galvanic is no longer preferred for this waveform
- X. Mechanical physical agent modalities
- A. Intermittent pneumatic compression pump⁵⁰
 1. Indications: edema reduction for subacute and chronic edema (not acute edema)
 2. Precautions and contraindications:^{50,51}
 - a) Precautions for compression pump (*use caution* in these situations):
 - (1) Impaired sensation
 - (2) Impaired communication or cognition
 - (3) Controlled hypertension
 - (4) Cancer in the area
 - (5) Stroke or transient ischemic attacks
 - (6) Areas of superficial peripheral nerves
 - b) Contraindications for compression pump (*do not use* in these situations):
 - (1) Pulmonary edema
 - (2) Congestive heart failure
 - (3) Deep vein thrombosis, thrombophlebitis, pulmonary embolism (acute or recent)
 - (4) Uncontrolled hypertension
 - (5) Obstructed venous or lymphatic return
 - (6) Arterial insufficiency/peripheral arterial disease
 - (7) After arterial re-vascularization or repair
 - (8) Unhealed fracture
 - (9) Severe hypoproteinemia (serum protein < 2.0 gm/dl)
 - (10) Skin infection in the area
 3. Device
 - a) Consists of a pump, hoses, and a sleeve with one or more chambers
 - b) Sequential pumps typically use a sleeve with 3 to 12 chambers that are sequentially compressed in a distal-to-proximal fashion
 4. Parameters
 - a) Pressure:
 - (1) Never set pressure greater than 10 mmHg below the client's diastolic blood pressure
 - (2) Generally 30-50 mmHg in the upper extremity, depending on diagnosis and goals
 - b) Inflation and deflation cycle
 - (1) Varies; on time to off time ratio is generally 3 or 4 to 1
 - c) Treatment duration
 - (1) Varies, usually 45-60 minutes
 - B. Hydrotherapy for wound care
 1. Whirlpool⁵²
 - a) See superficial thermal section for temperature recommendations

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- b) Advantages:
 - (1) Moisturizes, debrides, and cleans wound
 - (2) May promote circulation
 - c) Disadvantages:
 - (1) Easy to mechanically damage healing tissue
 - (2) May cause maceration
 - (3) May spread infection
 - (4) May promote edema
 - (5) Disinfectant additives may be cytotoxic
 - (6) Expense of unit
 - (7) Time required for clean-up and set-up.
 - d) Many precautions and contraindications
 - e) Due to the disadvantages of whirlpool for wound care, pulsed lavage with suction is often preferred
2. Pulsed lavage with suction (PLWS)⁵²
- a) Irrigates with sterile water or saline under controlled pressure while simultaneously suctioning solution and debris
 - b) Pressure adjustable from 4 to 15 PSI
 - c) Treatment time 15-30 minutes, 3-7 days a week, depending on wound status
 - d) Set up:
 - (1) Perform in a private room
 - (2) Cover patient, medical equipment and supplies to prevent contamination
 - (3) Remove dressings
 - (4) Use towel or other drape to absorb run-off
 - (5) Don PPE (mask, face shield, gloves, gown, shoe cover, and head covering that covers ears)
 - e) Advantages:
 - (1) Portable
 - (2) Faster than whirlpool
 - (3) Disposable sterile attachments decrease risk of cross-contamination
 - (4) Can treat a small area without putting entire extremity in whirlpool
 - f) Disadvantages:
 - (1) Difficult to treat very large areas
 - (2) Cost of disposable parts
- C. Continuous passive motion (CPM)²⁶
- 1. Electrically powered mobilizing orthotic device that provides passive range of motion to one or more joints for prolonged periods of time
 - 2. Moderate and inconsistent evidence that it may prevent post-operative joint stiffness
 - 3. No evidence supporting use in later stages of healing
 - 4. Parameters:
 - a) Arc of motion
 - b) Force or torque
 - c) Speed of motion
 - d) Duration of treatment session
 - e) Frequency of treatment
 - f) Progression of the above parameters
 - 5. Precautions and contraindications:

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- a) Precaution for CPM (*use caution* in this situation)
 - (1) Patient receiving anticoagulants
- b) Contraindications for CPM (*do not use* in these situations)
 - (1) Unstable fracture
 - (2) Infection near/in the joint
 - (3) Muscle spasm or spasticity

References

1. American Occupational Therapy Association. Physical Agent Modalities. *The American Journal of Occupational Therapy*. 2012;66(6 Supplement):S78-S80.
2. Bellew JW, Michlovitz SL. Therapeutic Modalities. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:3-17.
3. American Physical Therapy Association. Exclusive use or use of multiple physical agents/modalities, HOD P06-10-08-05. 2010. <http://www.apta.org/Policies/Practice/>. Accessed 2013.
4. American Occupational Therapy Association. Guidelines for Supervision, Roles, and Responsibilities During the Delivery of Occupational Therapy Services. *The American Journal of Occupational Therapy*. November 1, 2009 2009;63(6):797-803.
5. Accreditation Council for Occupational Therapy Education. 2011 Accreditation Council for Occupational Therapy Education (ACOTE®) Standards and Interpretive Guide. 2012; <http://www.aota.org/Educate/Accredit/Draft-Standards.aspx>.
6. Commission on Accreditation in Physical Therapy Education (CAPTE). CAPTE Accreditation Handbook. 2013; <http://www.capteonline.org/AccreditationHandbook/>.
7. Cameron MH. Thermal agents: Cold and heat. In: Cameron MH, ed. *Physical Agents in Rehabilitation: From Research to Practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009:131-176.
8. Rennie S, Michlovitz SL. Therapeutic heat. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:59-83.
9. Fruth SJ, Michlovitz SL. Cold Therapy. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:21-58.
10. Bracciano AG. *Physical Agent Modalities: Theory and application for the Occupational Therapist*. 2nd ed. Thorofare, NJ: SLACK; 2008.
11. Prentice WE. Cryotherapy and Thermotherapy. In: Prentice WE, ed. *Therapeutic Modalities in Rehabilitation*. 4th ed. New York: McGraw Hill Medical; 2011:285-359.
12. Cameron MH. Hydrotherapy. In: Cameron MH, ed. *Physical Agents in Rehabilitation: From Research to Practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009:245-286.
13. Draper DO, Prentice WE. Therapeutic Ultrasound. In: Prentice WE, ed. *Therapeutic Modalities in Rehabilitation*. 4th ed. New York: McGraw Hill Medical; 2011:363-416.
14. Kristiansen TK, Ryaby JP, McCabe J, Frey JJ, Roe LR. Accelerated healing of distal radial fractures with the use of specific, low-intensity ultrasound. A multicenter, prospective, randomized, double-blind, placebo-controlled study. *The Journal of bone and joint surgery. American volume*. Jul 1997;79(7):961-973.
15. Cameron MH. Ultrasound. In: Cameron MH, ed. *Physical agents in rehabilitation: From research to practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009:177-206.
16. Chan AK, Myrer JW, Measom GJ, Draper DO. Temperature changes in human patellar tendon in response to therapeutic ultrasound. *Journal of athletic training*. Apr 1998;33(2):130-135.
17. Draper DO, Castel JC, Castel D. Rate of temperature increase in human muscle during 1 MHz and 3 MHz continuous ultrasound. *Journal of Orthopaedic & Sports Physical Therapy*. Oct 1995;22(4):142-150.
18. Draper DO. Ten mistakes commonly made with ultrasound use: current research sheds light on myths. *Athletic training: Sports Health Care Perspectives*. 1996;2(2):95-107.

References

19. Cameron MH, Monroe LG. Relative Transmission of Ultrasound by Media Customarily Used for Phonophoresis. *Physical Therapy*. February 1, 1992;72(2):142-148.
20. Hayes BT, Merrick MA, Sandrey MA, Cordova ML. Three-MHz Ultrasound Heats Deeper Into the Tissues Than Originally Theorized. *Journal of athletic training*. Sep 2004;39(3):230-234.
21. Johns LD, Straub SJ, Howard SM. Variability in effective radiating area and output power of new ultrasound transducers at 3 MHz. *Journal of athletic training*. Jan-Mar 2007;42(1):22-28.
22. Michlovitz SL, Sparrow KJ. Therapeutic Ultrasound. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:85-108.
23. Weaver SL, Demchak TJ, Stone MB, Brucker JB, Burr PO. Effect of transducer velocity on intramuscular temperature during a 1-MHz ultrasound treatment. *Journal of Orthopaedic & Sports Physical Therapy*. May 2006;36(5):320-325.
24. Borst MJ. Therapeutic ultrasound: Evidence-based practice for occupational therapists. *American Occupational Therapy Association 91st Annual Conference & Expo*. Philadelphia 2011.
25. Garrett CL, Draper DO, Knight KL. Heat distribution in the lower leg from pulsed short-wave diathermy and ultrasound treatments. *Journal of athletic training*. Jan 2000;35(1):50-55.
26. Belanger A. *Therapeutic electrophysical agents: Evidence behind practice* 2nd ed. Philadelphia: Wolters Kluwer Lippincott Williams & Wilkins; 2010.
27. Gallo JA, Draper DO, Brody LT, Fellingham GW. A comparison of human muscle temperature increases during 3-MHz continuous and pulsed ultrasound with equivalent temporal average intensities. *Journal of Orthopaedic and Sports Physical Therapy*. Jul 2004;34(7):395-401.
28. Dyson M. Mechanisms involved in therapeutic ultrasound. *Physiotherapy*. 1987;73:116-120.
29. Tunkel AR. Biology of infectious disease. In: Porter RS, Kaplan JL, eds. *The Merck manual of diagnosis and therapy*. 19th ed. Whitehouse Station, NJ: Merck Sharp & Dohme; 2011:1148-1164.
30. Draper DO, Edvalson CG, Knight KL, Eggett D, Shurtz J. Temperature increases in the human achilles tendon during ultrasound treatments with commercial ultrasound gel and full-thickness and half-thickness gel pads. *Journal of athletic training*. Jul-Aug 2010;45(4):333-337.
31. Draper DO, Ricard MD. Rate of temperature decay in human muscle following 3 MHz ultrasound: The stretching window revealed. *Journal of athletic training*. Oct 1995;30(4):304-307.
32. Rose S, Draper DO, Schulthies SS, Durrant E. The stretching window part two: Rate of thermal decay in deep muscle following 1-MHz ultrasound. *Journal of athletic training*. Apr 1996;31(2):139-143.
33. Ennis WJ, Foremann P, Mozen N, Massey J, Conner-Kerr T, Meneses P. Ultrasound therapy for recalcitrant diabetic foot ulcers: results of a randomized, double-blind, controlled, multicenter study. *Ostomy Wound Management*. Aug 2005;51(8):24-39.
34. Kavros SJ, Liedl DA, Boon AJ, Miller JL, Hobbs JA, Andrews KL. Expedited wound healing with noncontact, low-frequency ultrasound therapy in chronic wounds: a retrospective analysis. *Advances in Wound and Skin Care*. Sep 2008;21(9):416-423.
35. Baker KG, Robertson VJ, Duck FA. A review of therapeutic ultrasound: biophysical effects. *Physical Therapy*. Jul 2001;81(7):1351-1358.
36. Johns LD. Nonthermal effects of therapeutic ultrasound: the frequency resonance hypothesis. *Journal of athletic training*. Jul 2002;37(3):293-299.

References

37. da Cunha A, Parizotto NA, Vidal Bde C. The effect of therapeutic ultrasound on repair of the achilles tendon (tendo calcaneus) of the rat. *Ultrasound in Medicine and Biology*. Dec 2001;27(12):1691-1696.
38. Byl NN, McKenzie A, Halliday B, Wong T, O'Connell J. The effects of phonophoresis with corticosteroids: a controlled pilot study. *Journal of Orthopaedic and Sports Physical Therapy*. Nov 1993;18(5):590-600.
39. Merino G, Kalia YN, Guy RH. Ultrasound-enhanced transdermal transport. *Journal of pharmaceutical sciences*. Jun 2003;92(6):1125-1137.
40. Dellagatta EM, Nolan TP. Electromagnetic waves: Laser, diathermy, and pulsed electromagnetic fields. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:135-171.
41. Cameron MH. Diathermy. In: Cameron MH, ed. *Physical agents in rehabilitation: From research to practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009:385-404.
42. Manal TJ, Snyder-Mackler L. Electrical stimulation for pain modulation. In: Robinson AJ, Snyder-Mackler L, eds. *Clinical electrophysiology: Electrotherapy and electrophysiologic testing*. 3rd ed. Philadelphia: Wolters Kluwer Lippincott Williams & Wilkins; 2008:151-196.
43. Bellew JW. Foundations of Electrotherapy. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:209-239.
44. Mahoney E. Therapeutic modalities for tissue healing. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:361-385.
45. Robinson AJ. Basic concepts in electricity and contemporary terminology in electrotherapy. In: Robinson AJ, Snyder-Mackler L, eds. *Clinical electrophysiology: Electrotherapy and electrophysiologic testing*. 3rd ed. Philadelphia: Wolters Kluwer Lippincott Williams & Wilkins; 2008:1-26.
46. Shapiro S. Electrical currents. In: Cameron MH, ed. *Physical agents in rehabilitation: From research to practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009:207-244.
47. Bellew JW. Clinical electrical stimulation: Application and techniques. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:241-277.
48. Baker LL, Wederich CL, McNeal DR, Newsam CJ, Waters RL. Neuromuscular electrical stimulation: A practical guide. 4th ed. Downey, CA: Los Amigos Research & Education Institute; 2000.
49. Anderson CR, Morris RL, Boeh SD, Panus PC, Sembrowich WL. Effects of iontophoresis current magnitude and duration on dexamethasone deposition and localized drug retention. *Physical Therapy*. Feb 2003;83(2):161-170.
50. Lowe E, Bellew JW. Intermittent pneumatic compression. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:199-207.
51. Cameron MH. Compression. In: Cameron MH, ed. *Physical agents in rehabilitation: From research to practice*. 3rd ed. St. Louis: Saunders Elsevier; 2009:317-345.
52. Bukowski EL, Nolan TP. Hydrotherapy: The use of water as a therapeutic agent. In: Michlovitz SL, Bellew JW, Nolan TP, eds. *Modalities for Therapeutic Intervention*. 5th ed. Philadelphia: F.A. Davis; 2012:109-134.

Multiple Choice Questions

- 1) A construction worker had a crush injury to his hand. No bones were broken and the skin was left intact, but there was extensive soft tissue trauma that has now resulted in a stiff hand 4 weeks later. Your goal is to improve AROM. Which of the following modalities would be the best choice for improving AROM?
 - a. Ultrasound, 3 MHz, 1 cm² ERA, 0.8 w/cm², 8 minutes, p50% duty cycle with direct coupling
 - b. Paraffin dip and wrap with 8 dips, removing the paraffin after 10 minutes
 - c. Fluidotherapy with temperature set at 113°F with AROM for 20 minutes
 - d. Continuous passive motion, 30 minutes daily

- 2) Which of the following is a contraindication for cryotherapy?
 - a. Over an area of vascular repair
 - b. Hypertension
 - c. Age > 72 years
 - d. Impaired sensation

- 3) Which of the following types of heat transfer raise tissue temperature to a certain pre-set target level and no higher?
 - a. Conduction
 - b. Convection
 - c. Conversion
 - d. Radiation

- 4) What kind of heat is fluidotherapy?
 - a. Conduction
 - b. Convection
 - c. Conversion
 - d. Radiation

- 5) You have a client with subacute edema s/p healed distal radius fracture. The edema is brawny, with pitting that rebounds slowly. Which of the following is the best choice for edema reduction?
 - a. Cold water whirlpool
 - b. High volt pulsed current
 - c. Sequential intermittent compression pump
 - d. Hot packs applied to the dorsum of the hand and wrist

- 6) Which of the following can be used to elicit a contraction in denervated muscle?
 - a. NMES
 - b. Direct current
 - c. Microcurrent
 - d. Russian Stimulation

Multiple Choice Questions

- 7) After a thermal ultrasound treatment, the vigorous heating (sufficient to facilitate stretching) lasts:
- 3-4 minutes after ultrasound application
 - 10-12 minutes after ultrasound application
 - 15-18 minutes after ultrasound application
 - Up to 25 minutes after ultrasound application
- 8) What is the spatial average, temporal average (SATA) intensity given the following parameters for an ultrasound treatment: 3 MHz, 0.5 cm² ERA, 1.5 W/cm², 8 min, 20% duty cycle
- 0.30 W/cm²
 - 0.50 W/cm²
 - 0.10 W/cm²
 - 0.20 W/cm²
- 9) Which TENS parameters would be best for continuous use and result in pain control that begins immediately and continues as long as the modality is on?
- Pulsed biphasic, 2 Hz pulse frequency, 150 μsec pulse duration, intensity set to a motor twitch
 - Pulsed biphasic, 120 Hz pulse frequency, 50 μsec pulse duration, intensity set to a tingling sensation
 - Asymmetric pulsed biphasic, 35 Hz pulse frequency, 175 μsec pulse duration, intensity set to a motor response of ½ the available AROM
 - Pulsed monophasic, 3 Hz pulse frequency, 200 μsec pulse duration, intensity 400 μamps
- 10) Which of the following is true regarding ultrasound?
- You should always keep the sound head moving for both continuous and pulsed US
 - Moving the sound head too quickly will prevent tissue heating
 - Pulsed ultrasound is non-thermal and will avoid any heating effect
 - 3 MHz US heats only 1.6 cm deep
- 11) What kind of current does TENS typically use?
- Microcurrent
 - AC
 - Interrupted DC
 - Pulsed biphasic
- 12) Which type of waveform should be used when performing NMES to the forearm or hand?
- Pulsed asymmetrical biphasic
 - Pulsed symmetrical biphasic
 - Interferential with 100 Hz beat frequency with modulation
 - Low intensity direct current

Multiple Choice Questions

- 13) Which of the following is used to promote wound healing?
- a. TENS
 - b. Iontophoresis
 - c. High volt pulsed current
 - d. NMES

**Multiple Choice Question Answer Key
Chapter 32**

1-C, 2-A, 3-B, 4-B, 5-C, 6-B, 7-A,
8-A, 9-B, 10-A, 11-D, 12-A, 13-C