PAIN TOPICS

The Use of Heat and Cold in Pain Modulation

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Introduction

Thermal modalities are passive modalities, whether they are applied by the patient or the nurse, physical therapist, athletic trainer, or parent. It is essential that each patient is evaluated for the cause of pain in order to make an appropriate clinical decision about the use of passive modalities. The passive role may be appropriate for patients in acute pain, for those with recurrent pain from reinjury or exacerbation of disease, or for palliative care. Some modalities may be appropriate for chronic pain, but only if their application is associated with a functional goal, and are best applied by the patient himself. Self-application of heat or ice can be used to provide symptomatic relief from pain which permits a more active treatment approach, and can be used as a reward for accomplishing a functional goal. These modalities are easy to apply, and can be used effectively in an overall plan of care for a variety of pain patients. They are most often effective in conjunction with techniques of soft tissue mobilization, exercise, stretching, and stabilization.

Heat

There are three theories of pain relief using heat. The vascular theory is based on the finding that heat application induces vasodilatation, which can increase tissue blood flow up to 30 ml per 100 g of tissue (Lehmann and DeLateur 1990). The increase in blood flow reduces pain by effectively supplying oxygenated blood and nutrients while washing out metabolites (including those that contribute to nociception, such as K^+) accumulated during muscular activity. Through this mechanism it is expected that there will be an increased potential for edema formation due to the increase in capillary permeability induced by heat.

The counterirritation theory is based on the gate control mechanism originally proposed by Melzack and Wall (1965). Pain may be modulated by thermoreceptor afferent input which can act as a gating mechanism in the dorsal horn of the spinal cord at the spinal level of the pain and thermal sensory input. The dual affective stimulation is said to block pain transmission to higher centers. Also, heating of a painful part can induce whole body relaxation, perhaps through a descending pain inhibitory pathway which influences the same gate in the dorsal horn, and helps to inhibit painful muscle spasm or muscle tension.

The third theory involves the direct influence of heat on neuromuscular tissue, including muscle spindles and on sensory nerve conduction. When animal muscle spindles and exposed nerve endings are directly heated, a significant decrease in neuronal activity of the secondary endings and an increase in activity of primary endings and Golgi tendon organs have been measured. This produces a net inhibitory influence of the motor neuron pool that breaks the vicious circle of pain-spasm-pain (Newton 1990). It presumably takes a very intense amount of heat to achieve direct heating of nerves in situ.

Many people associate better penetration with wet heat, rather than dry. Examples of wet heat include hot packs and whirlpool and dry heat include an infra-red heating lamp, and ultrasound. Dry heat actually elevates skin temperatures more than deeper structures, while wet heat elevates both skin and deeper tissues slightly more (Abramson 1967).

A variety of hot packs are commercially available for self-application of heat. Each type has advantages and disadvantages in terms of price, ease of reuse, temperature control, length of heating, and portability. Patients are instructed in the use of superficial heat to warm muscles before stretching and exercise, for relaxation, and for transient pain reduction when there is no edema present. Once patients are instructed in the safe use of superficial heat, including the appropriate use of a protective barrier such as toweling to prevent burns, patients may be invited to use heat independently before or after exercise or functional activities.

For acute injuries, heat is contraindicated.

Many physical therapists apply ultrasound as a heating modality. It has deeper heating effects, as well as nonthermal benefits, and penetrates to structures such as joints, muscle, and bone. It has been shown in experimental studies to stimulate tissue regeneration and bone growth (Dyson et al. 1968, Duarte 1983) and increase pain threshold and collagen extensibility (Alyea et al. 1956, Gersten 1955). In a meta-analysis of 22 studies on the effect of ultrasound application in the treatment of musculoskeletal disorders, however, no significant effect of ultrasound on pain reduction was found (Gam and Johannsen 1995).

Cold

Cold therapy can be delivered in three basic forms: cold packs, ice massage, or vapocoolant spray. Cold packs are commercially available or can be made at home with crushed ice, ice cubes, or bags of frozen vegetables (not to be eaten after use!). Cold packs are useful for postexercise soreness, acute inflammation, or inflammation associated with edema, and transient reduction of pain (symptomatic relief).

In ice massage, ice is rubbed directly over the skin until numbness is felt. Ice massage delivers cold to a more focal area with greater efficiency than a cold pack and may also provide more effective counterirritant therapy for pain relief. Patients are instructed in the safe use of ice massage, the warning signs of frostbite, and the four stages of sensation during ice massage (cold, burning, aching, and numbness). Ice massage is useful for relaxation, transient pain reduction, and treatment of local inflammation.

Cold application for pain relief can achieve peripheral or central responses. Brief, intense cold such as that delivered with a vapocoolant spray most likely produces peripheral receptor adaptation (Cattell and Hoagland 1931). The counterirritation discussed in the section on heat therapy also applies to cold therapy. Brief, intense cold can slow conduction velocity in C fibers carrying nociceptive input to the spinal cord. This action and receptor adaptation may be the mechanism of the trigger point therapy advocated by Travell and Simons (1983).

For every 1°C decrease in intramuscular temperature, a decrease of 1.2 m per second in motor nerve conduction velocity (Lehmann and DeLateur 1990) and a 2 m-per-second drop in sensory nerve conduction velocity has been recorded (Buchthal and Rosenfalck 1966). The "hunting response," characterized by cold-induced vasodilatation after an initial vasoconstriction, occurs in the ears, nose, fingers, and toes. This phenomenon is seen when tissue temperature is reduced by more than 10°C. Under conditions of continued intense cold, this reversal continues as a cycling of vasoconstriction-vasodilatation, permitting tissue temperature to be kept somewhat constant, although lower than precooled temperatures (Michlovitz 1990). Prolonged cold can also produce vasodilatation in deeper muscle tissues and stimulate profound hyperemia (increased blood flow to the effected area) after withdrawal of the cold (Clarke et al. 1958).

Which is best, heat or cold?

The choice between using heat or cold for pain should take into account several factors. Heat decreases pain and induces relaxation. Therefore, it may have a counterproductive sedative effect if used before exercise. It increases tissue extensibility (softer and easier to stretch—think of what happens when mozzarella cheese is warmed), which is advantageous when addressing stiff joints through self-mobilization and stretching. Heat decreases overall stiffness of musculoskeletal tissues. It may result in edema and should be used carefully if swelling is already a component of the patient's problem.

Cold decreases pain and swelling and is especially indicated in an acute injury; however, it increases overall stiffness and decreases tissue extensibility. Some patients have a profound aversion to cold and experience anxiety with its use. Many patients with neuropathic pain do not tolerate cold well.

The clinician should choose a modality based on the patient's preferences and, in the case of chronic pain, convenience for self-treatment. In pain that has persisted well beyond an expected healing time, the emphasis is not on pain relief, but on using the modality as a method of coping with pain. It should be possible for a patient to learn to safely apply a modality as a specific part of the total pain rehabilitation program.

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