

# CRYOTHERAPY

Cryotherapy is the therapeutic use of locally applied coolants to affect various physiological processes through the cooling of soft tissues. Cooling occurs when heat is removed or lost from an object through conduction of heat from one mass to another, or through evaporation. Conduction occurs when heat is transferred from a warm body to a colder body by direct contact between their surface molecules. The slow moving molecules of the cold body speed up by absorbing energy from the faster moving molecules of the warm body, thereby becoming warmer, while, conversely, the faster moving molecules of the warm body slow down as they lose energy and become cooler. Conduction occurs when a cool mass (like ice) is applied continuously to the skin, or when a body part is immersed in cold water. As the body or body part cools, the ice or cold water heats up.

Cryotherapy has historically been used to provide pain relief, reduce fever, slow the damage of thermal burns, control bleeding, and prevent or reduce edema caused by soft tissue trauma. Cryotherapy has also been shown to be useful for the reduction of extrafusal and intrafusal muscle spasm, neuromuscular hypertonicity, and spasticity. Cryotherapy may additionally be used to elevate the pain threshold and slow destructive enzyme action that occurs in some joint diseases.

The cooling of bodily tissue is governed by **two** basic physiological principles:

- 1) The cooling effect on the soft tissue by an ice massage or ice pack will decrease as the depth of the tissue increases.
- 2) The time required for cooling to be effective will vary according to the type of tissue being cooled (the speed of cooling underlying tissues will decrease as the amount of insulating fat increases).

As cooling decreases tissue temperatures, the sensory nerves in the skin are provoked to fire continuously until physiologically exhausted. Usually this causes the subject to predictably experience a sequence of sensations including aching, burning, and finally numbness (though exceptions will be found). Numbness or **temporary local anesthesia** occurs as the sensory nerves are exhausted and,

coincidentally, when the normal erythema of the skin reaches its zenith.

Deeper nerves (below the epidermis) may also be affected by cooling. Muscle cooling has been shown to affect the afferent nerves arising from the muscle spindle flower-spray and annulospiral sensory nerve endings. Their rate of discharge decreases as the temperature of muscle tissue decreases. As the temperature drops, the sensitivity of the muscle spindle initially increases (a minimal stretch is required for a spindle response at 30°C), but as the temperature decreases further, the spindle's sensitivity decreases (requiring a bigger stretch to elicit a muscle spindle response). Some evidence has suggested that cooling may affect a decrease in the rate of muscle spindle discharge by causing membrane hyper polarization with a lowering of potassium concentration. Cooling may also affect the speed of impulse of the gamma efferents to the muscle spindle by decreasing gamma biasing of the muscle spindle intrafusal muscle fiber, thereby depressing membrane activity and the stretch reflex. This occurs in the muscle after 10 minutes of cooling with an ice pack (if the muscle isn't too deep).

Cooling of the exteroceptors of the skin has been shown to increase the amplitude of the H response (a phasic stretch reflex induced by electrical stimulation), largely by-passing the muscle spindle by increasing or facilitating alpha motor neuron excitability. As the temperature drops toward 5°C, there are decreases in the amplitude and frequencies of the motor endplate potentials combined with increases in their duration. If cooling is sufficient to drive the muscle tissue temperature at the neuromuscular junction down to 5°C, blockage of the junction has been shown to occur.

The effects of cooling on peripheral nerves are primarily dependent on myelination and fiber diameter. All nerve fibers are generally affected by cooling. The smaller medullated fibers are affected first, then large medullated, and finally non-medullated. The smaller gamma efferent fibers are more sensitive to cold (their frequency slowing more quickly and to a greater extent) than are the alpha efferents. Motor nerve conduction velocity linearly

decreases at a rate of between 1.84 and 2.4 meters per second per degree (centigrade), as the temperature drops from 36 to 23°C. Proprioceptive sensory fibers (and others important for motor learning) are relatively insensitive to cooling since they are large diameter myelinated fibers.

Additionally, cooling has been shown to affect the various vascular structures at all levels to the extent of causing an initial reflex vasoconstriction to occur. It is unclear what specifically causes vasoconstriction, but various reasons have been suggested. One theory is that vasoconstriction occurs in tissues in which the cold induces an increase in the firing of sympathetic nerve fibers within the tissues cooled. Another theory postulates that vasoconstriction occurs from the cooling of tissues by directly affecting the blood vessels themselves.

Whatever the specific mechanism may be, vasoconstriction has been shown to reduce blood flow in tissues cooled to 18°C. As cooling continues, however, and the tissue temperature reaches 2°C, vasodilation occurs in a physiological attempt to increase blood flow and thereby prevent tissue damage. This phenomenon is called the **Hunting Reaction**.

Cryotherapy is most commonly applied as ice packs or ice bags (frozen hydrocollators or commercial ice packs).

An ice bag may be created by putting ice in a plastic bag or by freezing a moistened hydro collator. Commercially prepared chemical-ice packs or bags are also available. A damp towel should be wrapped around the ice bag to prevent any part of it from directly touching the unprotected skin. The towel-covered bag or commercial pack is then placed over the treatment site. Ice bags or commercial packs are not as cold as the crushed-ice pack, and should remain in place for 30 minutes or until sensory analgesia (temporary local anesthesia) of the skin is produced.

#### **Application:**

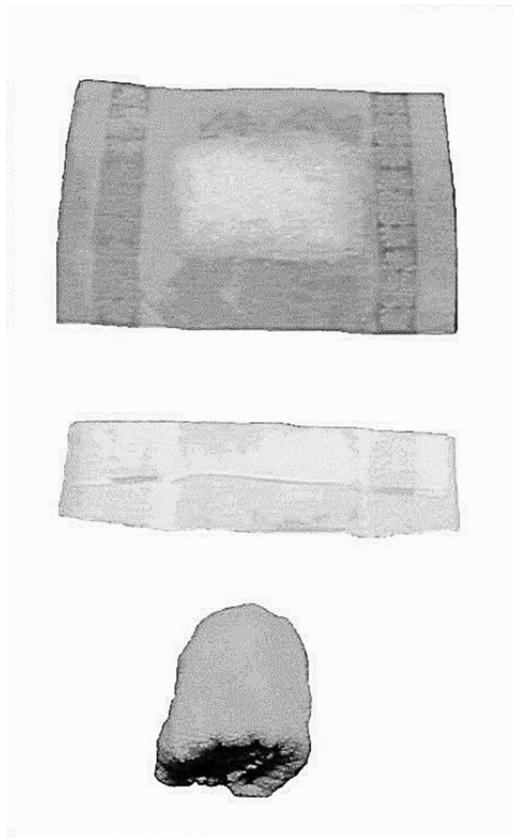
- Spread out a towel on a flat surface.
- Arrange a one-inch thick layer of crushed-ice (enough to cover the treatment site) in the middle of the towel.

- Fold the long edges of the towel to overlap one another and the ice.
- Roll up the ends of the towel toward one another to make handling easy.
- Before applying to the treatment site, moisten the side of the ice pack that will touch the skin with water.
- Unroll the ice pack in place over the treatment site.
- In common use (for the normal patient who is not allergic to cold), the crushed-ice pack should **not** be left in place longer than **10 to 12 minutes** or long enough to cause local anesthesia.

Cryotherapy has been shown to be extremely valuable when applied in combination with other modalities. Ice packing, for example, may be used together with heat in the form of **contrast packs** to increase capillary bed circulation and to reduce joint stiffness. The hot pack should last for 10 minutes followed by a three-minute ice pack. The heat should then be reapplied for four minutes followed by another three-minute ice pack; this process should be repeated for a total treatment time of 30 minutes.

Research has demonstrated that the cooling of a joint results in vasoconstriction and a decrease in interarticular temperature. This has the effect of slowing enzyme action and its destructive action. It has also been demonstrated that cryotherapy applied over the area of an over-stretched ligament may increase edematous swelling in the general area but decreases the edema around the injured ligament.

Cryotherapy has been shown to have a rather dramatic effect on soft tissues because of the physiological responses it provokes. As a result, it has become a valuable tool for the treatment of various physical dysfunctions, as illustrated by the following discussion of the various uses of cryotherapy.



**Making an ice pack**

**Precautions:**

Adverse effects of ice packing are rare, but some of the symptoms that may be associated with abnormal histamine production triggered by cooling include cold urticaria, erythema, itching, sweating, and shortness of breath. More severe symptoms may develop including syncope, tachycardia, extra systoles, dysphagia, abdominal cramping or diarrhea. These symptoms may occur during therapy or from several minutes to even several hours following treatment.

Cold hemolysins and agglutinins produced in abnormal amounts in response to tissue cooling may produce significant anemia, malaise, chills, fever, paroxysmal cold hemoglobinuria of the kidney, or the dermal symptoms of cold urticaria or ulcerations.

Abnormally high cryoglobulin production in response to cooling may produce chills and fever and may adversely affect vision and hearing (blindness or deafness in the extreme). It may cause conjunctival

hemorrhages and epistaxis, anemia with fibrinogenopenia, elevated sedimentation rates, and abnormal numbers of cryoglobulin inclusion cells. Other symptoms include itching, purpura, cold urticaria, ulcerations and necrosis, dyspnea, stomatitis, melena, and bleeding of the gums.

Cryotherapy may be contraindicated for open wounds. The use of a cryotherapeutic application should be based on the extent, nature, depth of the wound, and the chances of contamination. Advantages must be weighed against the risks. For example, there is little risk and a great deal of benefit to be gained by cooling a freshly contused area, in spite of the presence of a shallow wound. It may be helpful in slowing or stopping bleeding if a dry sterilized ice bag is used or if the treatment site is protected from the touch of any water (a plastic bag may be helpful). However, cryotherapeutic applications may further damage involved tissues if the wound is deep or the vasocirculation in the area is impaired through application.

## ANALGESIA/ANESTHESIA

Cryotherapy may be used to provide relief of localized pain arising from the musculoskeletal system, as well as providing local anesthesia of dermal layers. Pain relief or analgesia may result from cryotherapy in three ways:

- 1) Elevation of the pain threshold as cooling affects pain receptors and sensory fibers in the involved tissues.
- 2) Slowing of the inflammatory process.
- 3) Reducing muscle spasm.

Local anesthesia results from unrelieved cooling, through the general hyperstimulation and eventual overwhelming of the sensory nerves and sensory nerve endings in the skin and muscles below. Each class of sensory receptor will fire, in turn, as they are cooled and their individual resistance to the cooling is exceeded. They will continue to fire as cooling continues until fully exhausted and anesthesia occurs.

The most commonly used mode of cryotherapy is the *ice pack*. It is easy to apply to most treatment sites, requires little time or equipment to make, and places a minimal demand on the practitioner's time during treatment. Local anesthesia is usually produced by a crushed-ice pack in 10 to 12 minutes.

It should be noted that an ice bag is a poor substitute for a *crushed-ice pack*, if anesthesia is desired. It generally does not get the skin cold enough.

The use of cryotherapy to produce analgesia or anesthesia is most remarkable when used in the acute phases following traumatic injury. It can provide almost immediate relief from the pain of joint sprain or strain, muscle spasm, contusion and/or muscle strain. The relief of pain, while comforting to the patient, may also allow the practitioner the opportunity to use treatment techniques that might otherwise be painful (soft tissue manipulation and taping are examples). Additionally, cryotherapy may have the effect of slowing down or inhibiting the pathological processes of injury, including inflammation.

## HYPERTONICITY CONTROL

Hypertonicity control is defined here as the reduction of neuromuscular hypertonicity associated with extrafusal muscle spasm, or habitually *short* or *tight* muscles. Hyper-tonicity that results from upper motor neuron lesion or from peripheral nerve injury is not included in this discussion.

As mentioned earlier, cryotherapy may be used to reduce extrafusal muscle spasm or abnormal muscle tension by cooling exteroceptors and inhibiting flower spray and annulospiral afferent nervous activity in the skin. Essentially it can desensitize the muscle spindle to mechanical stretch and effectively suppress the phasic stretch reflex. Continued cooling with ice packs suppresses both the phasic stretch reflex and tonic stretch reflex by decreasing the frequency and transmission speed of efferent gamma nerve impulses. After the stretch reflexes have been sufficiently suppressed, the cooled musculature becomes insensitive to passive stretch and the entire muscle may be manually lengthened. This effectively relieves muscle tension or spasm by causing the involved muscle spindles to be reset at greater lengths. As the direct effects of the cooling are lost with warming, the entire muscle may remain lengthened (if the pack was applied while the muscle was on stretch). The direct effects of intense cooling of the muscle may last for several hours following treatment. The indirect effects may be more permanent if they are not superseded by central nervous system intervention (the patient should be kept relatively inactive for some time after

application). In short, crushed-ice packing may be used to successfully relieve both muscle spasms and to relax abnormally tight muscles. This is because of its ability to effectively cool deeper tissues and slow the nerve impulses responsible for the tonic and phasic stretch reflexes from the muscle spindles. Such slowing allows a muscle on stretch to lengthen without the interference of the stretch reflexes (i.e., allowing shortened muscle fibers to assume new lengths). Ideally, to relieve a muscle spasm, the muscle housing the spasm should be put on stretch, and the entire muscle should be packed for 10 to 12 minutes.

Cryotherapy most often facilitates a return to normal neuromuscular function by reducing the pain and intensity of muscle spasm. It accomplishes this without promoting increased muscle metabolism or metabolic by-product build up (which is a normal consequence of the use of local heat applications like diathermy, heat lamps or hot packing). Ice pack treatment is extremely valuable for the treatment of general neuromuscular hypertonus or muscle spasm accompanying acute muscle strain, especially when used in conjunction with ***low frequency electrical stimulation***.

*Ice bags* are not particularly useful for the treatment of hypertonically shortened muscles since their cooling ability is generally insufficient to affect muscle spindle stretch receptors.

## INFLAMMATION CONTROL

As previously discussed, inflammation is a physiological response to tissue stress or trauma. When traumatized (excessively stressed or irritated) the involved soft tissues produce inflammatory mediators that are designed to promote the healing process. These inflammatory mediators include histamine, bradykinin, and prostaglandins. The sources of soft tissue stress or trauma include external blows, puncture, tearing, burns, metabolite accumulation, bacterial toxins, viral toxins, enzyme irritations and others. Cryotherapy has proven to be useful in the treatment of soft tissue inflammation because of its ability to affect various physiological processes. These include: (1) slowing the action of destructive enzymes and toxins, (2) decreasing local metabolism, (3) desensitizing sensory nerves (those previously sensitized by histamine and bradykinin), and (4) retarding the production of prostaglandins by slowing the release of histamine from affected sensory nerves.

Crushed-ice packing best performs cryotherapy treatment of soft tissue inflammation. The treatment should continue until an erythemic reaction and local anesthesia of the skin has occurred. If a crushed ice pack is used, the entire inflamed area should be packed for 10 to 12 minutes or until local anesthesia takes place.

Blood vessel permeability caused by prolonged cooling is particularly useful when used in conjunction with and as a precursor to phonophoresis of anti-inflammatories into inflamed soft tissues. An ice pack is generally applied for 10 to 12 minutes to help increase capillary permeability before being followed by phonophoresis, insuring a greater and deeper penetration of anti-inflammatories.

*Ice bags* are not particularly effective for the treatment of soft tissue inflammation, since their cooling is generally superficial and they have little or no effect on deeper tissues.



**Ice pack applied to the extensor surface of the forearm for the treatment of Tennis Elbow**

## SWELLING CONTROL

The primary therapeutic effect of cryotherapy on soft tissue swelling is preventive by nature. Soft tissue cooling produces a sympathetic nervous reflex that initially produces vasoconstriction in the blood vessels (including capillary beds) under the site of application, which initially prevents soft tissue swelling by suppressing fluid flow into the area.

Historically, various authorities have suggested that intermittent cold applications exclusively used to induce vasoconstriction may have the beneficial effect of inhibiting swelling for as long as 48-hours after the initial trauma. However, continuous cooling eventually causes increased vascular wall permeability, promoting soft tissue swelling by allowing plasma to seep into adjacent tissues. Therefore, the most appropriate use of long duration cooling (15 to 20 minutes) is in the acute phase

following trauma. According to these authorities, soft tissue cooling becomes increasingly less beneficial after the first 24 hours. After 48 hours, it is of no benefit at all, and may then be contraindicated. To refute these authorities, more recent research has demonstrated that ice packing actually *increases* swelling if applied 30 minutes after injury, but has the saving grace of producing less swelling than would either contrast packing or heat applications (hot packing) alone.

In practice, the most effective use of ice packing is within the first 30 minutes following injury, when applied to reduce any initial swelling, in preparation for immediate skillful taping or other means of compression (inflatable casts or sleeves are examples) to prevent excessive swelling.

## References

- A.E. Grant, "Massage with Ice (Cryokinetics) in the Treatment of Painful Conditions of the Musculoskeletal System," *Arch Phys Med & Reh*, vol. 45, May 1964. Pp. 233-238
- L.R. Haldovich, W.J. Personius, H.P. Clamann, R.A. Newton, "Effect of Fluori-Methane Spray on Passive Hip Flexion," *Physical Therapy*, 61:2, February 1981. Pp. 185-190
- D.J. Johnson, S. Moore, J. Moore, R.A. Oliver, "Effect of Cold Submersion on Intramuscular Temperature of the Gastrocnemius Muscle," *Physical Therapy*, 59:10, October 1979. Pp. 1238-1242
- M.A. Kowal, "Review of Physiological Effects of Cryotherapy," *JOSPT*, 5:2, September/October, 1983. Pp. 66-73
- J.F. Lehmann, *Therapeutic Heat and Cold*, Williams and Wilkins, Baltimore, Md., 1982. Pp. 563-602
- S. Michlovitz, S.L. Wolf (Ed.), *Thermal Agents in Rehabilitation*, F.A. Davis, Philadelphia, Pa., 1986. Pp. 73-97, 263-275, 277-294
- F.B. Moor, S.C. Peterson, E.M. Manwell, M.F. Noble and G. Muench, *Manual of Hydrotherapy and Massage*, Pacific Press Publishing Association, Mountain View, Ca., 1964.
- A.J. Murphy, "The Physiological Effects of Cold Application," *Physical Therapy Review*, 40:2, 1960. Pp. 112-115
- R.A. Newton, "Effects of Vapocoolants on Passive Hip Flexion in Healthy Subjects," *Physical Therapy*, 65:7, July 1985. Pp. 1034-1036
- C.F. Simpson, "Heat, Cold, or Both," *American J Nursing*, February 1983. Pp. 270-272

### Analgesia/Anesthesia

- A.E. Grant, "Massage with Ice (Cryokinetics) in the Treatment of Painful Conditions of the Musculoskeletal System," *Arch Phys Med & Reh*, vol. 45, May 1964. Pp. 233-238
- L.R. Haldovich, W.J. Personius, H.P. Clamann, R.A. Newton, "Effect of Fluori-Methane Spray on Passive Hip Flexion," *Physical Therapy*, 61:2, February 1981. Pp. 185-190
- J.F. Lehmann, *Therapeutic Heat and Cold*, Williams and Wilkins, Baltimore, Md., 1982. Pp. 563-602
- S. Michlovitz, S.L. Wolf (Ed.), *Thermal Agents in Rehabilitation*, F.A. Davis, Philadelphia, Pa., 1986. Pp. 73-97, 263-275, 277-294
- R.A. Newton, "Effects of Vapocoolants on Passive Hip Flexion in Healthy Subjects," *Physical Therapy*, 65:7, July 1985. Pp. 1034-1036

### Hypertonicity Control

- A.E. Grant, "Massage with Ice (Cryokinetics) in the Treatment of Painful Conditions of the Musculoskeletal System," *Arch Phys Med & Reh*, vol. 45, May 1964. Pp. 233-238
- L.R. Halkovich, W.J. Personius, H.P. Clamann and R.A. Newton, "Effect of Fluori--Methane Spray on Passive Hip Flexion," *Physical Therapy*, 61:2, February 1981. Pp. 185-189
- D.J. Johnson, S. Moore, J. Moore, R.A. Oliver, "Effect of Cold Submersion on Intramuscular Temperature of the Gastrocnemius Muscle," *Physical Therapy*, 59:10, October 1979. Pp. 1238-1242
- J.F. Lehmann, *Therapeutic Heat and Cold*, Williams and Wilkins, Baltimore, Md., 1982. Pp. 563-602
- A.J. Murphy, "The Physiological Effects of Cold Application," *Physical Therapy Review*, 40:2, 1960. Pp. 112-115
- R.A. Newton, "Effects of Vapocoolants on Passive Hip Flexion in Healthy Subjects," *Physical Therapy*, 65:7, July 1985. Pp. 1034-1036

### **Inflammation Control**

M.A. Kowal, "Review of Physiological Effects of Cryotherapy," *JOSPT*, 5:2, September/October, 1983. Pp. 66-73

J.F. Lehmann, *Therapeutic Heat and Cold*, Williams & Wilkins, Baltimore, Md., 1982. Pp. 576-579, 585-590

K. McKean, "Pain," *Discover*, October 1986. Pp. 82-92

S.L. Michlovitz and S.L. Wolfe, *Thermal Agents in Rehabilitation*, F.A. Davis Co., Philadelphia, Pa., 1986. Pp. 73-97, 263-275, 277-294.

A.J. Murphy, "The Physiological Effects of Cold Application," *Physical Therapy Review*, 40:2, 1960. Pp. 112-115

M. Shodell, "The Prostaglandin Connection," *Science* 83, March 1983. Pp. 78-82

### **Swelling Control**

J.F. Lehmann, *Therapeutic Heat and Cold*, Williams & Wilkins, Baltimore, Md., 1982. Pp. 576-579

A.C. Guyton, *Textbook of Medical Physiology*, W.B. Saunders Co., Philadelphia, Pa., 1971. Pp. 241-251

M.A. Kowal, "Review of Physiological Effects of Cryotherapy," *JOSPT*, 5:2, September/October, 1983. Pp. 66-73

K. McKean, "Pain," *Discover*, October 1986. Pp. 82-92

S.L. Michlovitz and S.L. Wolfe, *Thermal Agents in Rehabilitation*, F.A. Davis Co., Philadelphia, Pa., 1986. Pp. 79-81

A.J. Murphy, "The Physiological Effects of Cold Application," *Physical Therapy Review*, 40:2, 1960. Pp. 112-115

M. Shodell, "The Prostaglandin Connection," *Science* 83, March 1983. Pp. 78-82