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Medicine

PHYSIOLOGICAL EFFECTS OF CRYOTHERAPY : A SYSTEMIC REVIEW

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KEYWORDS :

Cryotherapy is a pain treatment that uses a method of localized freezing temperatures to deaden an irritated nerve. Cryotherapy is the local or general use of low temperatures in medical therapy. Cryotherapy is used to treat a variety of benign and malignant tissue damage, medically called lesions.

The therapeutic use of cold , has clinical applications in rehabilitation and in other areas of medicine.Cryotherapy is used primarily outside of rehabilitation for the destruction of malignanat and non – malignant tissues growths;very low temperature are used , and cooling is generally applied directly to the tissue being treated . In rehabilitation , mild cooling is used to control inflammation , pain and edema ;to reduce spasticity ; to control symp[toms of multiple scelorsis ; and to facilitate movement . This type of cryotherapy is applied to the skin but can decrease tissue temperature deep to the area of application , including tne intra – articular area .

Physiologic Effects of Cryotherapy

Cryotherapy is broad term that covers a number of specific techniques, including ice packs, cold gel packs, ice massage, ice immersion, cold whirlpool, and vapocoolant spray.

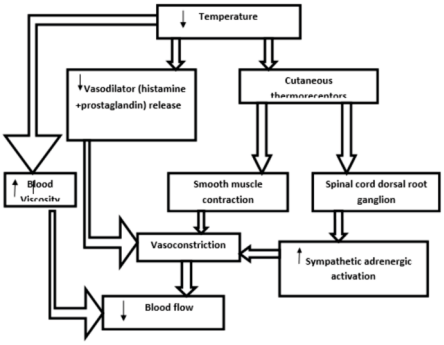
Initially, after application of ice pack, patient feels cold, which progresses to burning, warming sensation. Aching, tingling, and finally numbness follow.First response is constriction of arterioles and venules (within 15 minutes or less). Blood flow to area decreases, and body attempts to conserve heat. Vasodilation can be cold-induced after initial period of vasoconstriction when cold is maintained for longer than approximately 15 minutes or when temperature is reduced below 10^0 C.Period of alternating vasodilation and vasoconstriction also may occur, known as "hunting response." This response is most predominant in apical areas where arteriovenous anastomoses are located in skin and has been shown to be absent in deeper tissues. After cold is removed, temperature rises in adjacent body parts.

HEMODYNAMIC EFFECTS-

Initail decrease in blood flow

Generally , cold applied to the skin caused immediate constriction of the cutaneous vessels and reduction in blood flw. This vasoconstriction persists as long as the duration of cold application is limited to less than 15 to 20 minutes .[3]Studies show that repeating ice application after an initial 20 minutes application for two repetitions of 10 minutes off and 10 minutes on lowers blood flow significantly more than a single 20 min ice application.[4]

The vasoconstriction and reduction in blood flow produced by cryotherapy are most pronounced in the area where the cold is applied because this is where the tissue temperature decrease is greatest .



Cryotherapy decrease blood flow

Cold cause cutaneous vasoconstriction both directly and indirectly . Activation of cutaneous cold receptors by cold directly stimulates the smooth muscles of blood vessel wall to contract . Cooling of tissue decreases the production and release of vasolator mediators such as histamine and prostaglandins , resulting in reduced vasodiation . Decreasing the tissue temperature also causes a reflex activation of sympathetic adrenergic neurons , resulting in cutaneous vasoconstriction in the area that is cooled and , to a lesser extent , in the area distant from the site of cold application .[5]It is thought that the body reduces blood flow in response to decreased tissue temperature to protect other area from excessive decrease in temperature and to stabilize the core body temperature.[6]

Later increase in blood flow

The immediate vasoconstriction response to cold is a consistent and well documented phenomenon however when cold is applied for longer periods of time or when the tissue temperature reaches less than 10 degreeC(50^0 f), vasodilation may occur this phenomenon is known as cold induced vasodilation(cvid) [3,11]

NEUROMUSCULAR EFFECTS

Decrease nerve conduction velocity

When nerve temperature is decreased nerve conduction velocity decreases in proportion to the degree and duration of the temperature changes .[14] Reversible total nerve conduction block can occur with the application of ice over superficially located major nerve branchesw such as the peroneal nerve at the lateral aspect of knee.[17]

Increase pain threshold

Applying cryotherapy can increase the pain threshold and decrease the sensation of pain proposed mechanisms tfor these effects include ciunterirritation via the gate control mechanisms and reduction of muscle spasm , sensory nerve conduction velocity or post injury edema.[18]

Altered muscle strength

Proposed mechanisms for this response to brief cooling include facilitation of motor nerve excitability and increased psychological motivation to perform in contrast after cooling for 30 minutes or longer isometric muscle strength has been found to decrese initially and the to insease an hour later to reach greater than precooling strength for the following 3 hours or longer [21-23] because muscle strength can be temporarily influenced by cryotherapy strength testing should be performed before rather than after cryotherapy application.

Decreased spasticity

After more prolonged cooling lasting 10 to 30 minutes a temporary decrease in or elimination of spasticity and clonus, depression o f the Achilles tendon reflex and a reduction in resistance to passive motion have been observed in some patients with spasticity .[25,29]

USES OF CRYOTHEAPY

Inflammation control

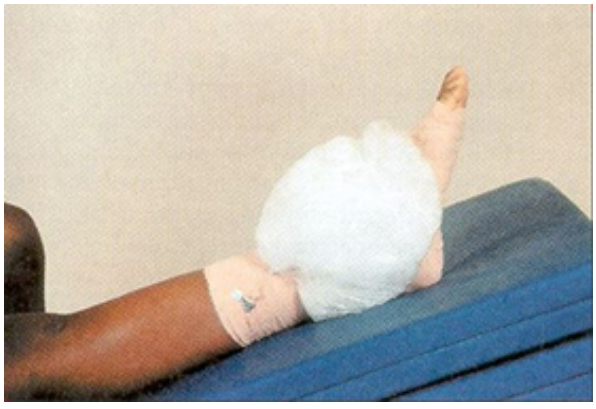
Cryotherapy can be used to control acute inflammation there by acceleratingrecovery from injury or trauma .[33] A recent critical review of studies on various treatment modalities for soft tissue injuries of the ankle concluded that cryotherapy reduced pain and edema and shortened recovery time if it was applied within the first 2 days after an injury.[34]

Aaply cryotherapy immediate after injury and during the acute

inflammatory phase of healing to help control bleeding edema and pain and to accelerate recovery cryotherapy is often recommended for the treatment of acute inflammation and may be helpful in patient with chronic inflammatory condition such as osteoarthritis and reheumatiod arthritis .[44-46]

Edema control

Cryotherapy can be used to control the formation of edema particularly when edema is associated with acute inflammation [44,47] to minimize the edema formation cryotherapy should be applied soon as the possible after an acute trauma the formation of edema associated with inflammation will be controlled most effectively of cryotherapy is applied in conjunction with compression and elevation of the affected area [48,49] cryotherapy along with compression and elevation reduces post injury edema.



Cryotherapy with compression and elevation Pain control

The decrease in tissue temperature produced by cryotherapy may directly or indirectly reduce the sensation of pain cryotherapy directly and rapidly modifies the sensation of pain by gating pain transmission through the activity of cutaenous thermal receptor this immediate analgesic effect of cold is exploited when vapocoolant sprays or ice massage is used to cool the skin before stretching of the muscle below the reduced sensation of pain allows the stretch to be more forceful and thus potentially more effective

Applying cryotherapy for 10 to 15 min or longer can control pain for 1 hour or longer this prolonged effect is thught to be the result of blocking conduction by deep pain transmittion by cutaneous thermal receptors.[16]

Cryokinetics and cryostretch

Cryokinetics is a technique that combines the use of cold and exercise in the treatment of pathology or disease [59] this technique involves applying a cooling agent to the point of numbness shortly after any injury to reduce the sensation of pain thus allowing patient to exercise and work toward regaining range of motion as early as possible in recovery process [60]

CRYOSTRETCH

is the application of a cooling agent before stretching the purpose of this sequence of treatment is to reduce muscle spam thus allowing greater ROM increase with stretching [62] it has been found that application of a cold pack after a hot pack is more effective than a hot pack alone in improving passive ROM (PROM) in people with restricted knee ROM [65]

Indications of Cryotherapy

a. Michlovitz notes rationale for application of cold 24-48 hours after acute injury.
I. Decreases fluid filtration into interstitium by vasoconstriction.
ii. Decreases inflammation.
iii. Decreases pain and muscle spasm.
iv. Decreases metabolic rate.
b. In acute injury cold is used most often in conjunction with compression and elevation.
c. Cryotherapy is also indicated for treating acute burn. Bloch's extensive review led to conclusion that cooling burns can decrease magnitude of injury by reduction in edema, pain, local fluid loss, tissue injury, and blood volume during the first 48 hours after injury.
d. Patients with acute spinal cord injury (SCI) also improve with local hypothermia treatments. Bricolo et al. reviewed SCI cases from the literature and noted that complete destruction of spinal cord often may not occur at initial moment of impact but relates to self-destructive process in cord and hypoxic neurologic changes secondary to vascular alterations.

e. Decreasing spasticity.
f. Reduction of fever.
g. Facilitation of muscle contractions by increasing motor neuron excitability.
h. Especially effective for bursitis and tendinitis.
Knight K: Cryotherapy Theory: Technique and Physiology. Chattanooga, TN, Chattanooga Corporation. 1985

Contraindications-

a. Impaired sensation. Patients cannot report when they become anesthetic from cold. Tissue damage occurs slightly below temperatures that produce numbness.
b. Impaired circulation: tissue damage may result from vasoconstriction.
c. Open wounds after 48 hours.
d. Hypersensitivity to cold, such as Raynaud's phenomenon, cold urticaria, cryoglobulinemia, and paroxysmal cold hemoglobinuria.
e. Angina pectoris or other severe cardiac disease.
f. Regenerating peripheral nerves.

Knight K: Cryotherapy Theory: Technique and Physiology. Chattanooga, TN, Chattanooga Corporation. 1985

Precautions

a. Hypertension
I. Careful monitoring is needed because of transient increases that can occur in systolic and diastolic blood pressure.
ii. Treatment should be discontinued if increase in blood pressure is seen.
b. **Elderly patients**
I. Decreased efficiency with vasoconstriction.
ii. Therefore, they have decreased ability to conserve heat.
c. Length of treatment
I. Do not use cold gel packs longer than 15-20 minutes directly on skin, and do not apply any cryotherapy directly to skin for > 1 hour continuously.
ii. Extended treatment may lead to neurapraxia or axonotmesis of superficial peripheral nerves.

Knight K: Cryotherapy Theory: Technique and Physiology. Chattanooga, TN, Chattanooga Corporation. 1985

Adverse effects

A variety of adverse effects have been reported when cold is applied incorrectly when contraindicated the most severe adverse effect resulting from improper application of cryotherapy is tissue death caused by prolonged vasoconstriction ischemia and thromboses in the smaller vessels tissue death may also result from freezing of the tissue tissue damage can occur when the tissue temperatuere reaches 15degree c (59 degree F)

However freezing (frostbite) does not occur until the skin temperature drops to between 4 degree c and 10 degree c (39 degree f to 50 degree f) or lower excessive exposure to cold may cause temporary or permanent nerve damage resulting in pain numbness tingling hyperhidrosis or nerve damage the duration of copld application should be limited to less than 45 min and the tissue temperature should be maintained above 15 degreeC (59 degree f)

Because prolonged application of cryotherapy to the distal extremities may cause reflex vasodilatation and increase blood flow cryotherapy should be applied for only 10 to 20 min when the goal of the intervention is vasoconstriction.

Application Techniques

It may be applied using a variety of materials including cold or ice packs ice cups controlled cold compression units vapocoolant sprays frozen towels ice water cold whirpools and contrast baths cool cold packs for at least 2 hours before initial use and for 30 minutes between uses the typical sequence of sensation in response to cryoptheray is as follows :

1 intesive cold ,2 burning ,3 aching , 4 analgesia, and 5 numbness these sensation are thought to correspond to increasing stimulation of thermal receptors and pain receptors followed by blocking of sensory nerve conduction as tissue temperature decreases

Cold packs or ice packs

Cold pack are usually filled with gel composed of silica or mixture ofd saline and gelatin and are usually covered withvinyl the gel is formulated to be semisolid at between 0 degree c and 5 degree c (between 32 degree f and 41 degree f) so the pack conforms to body contourswhen it is within this temperature range the temperatureof the cold pack is maintained by storing it in specialized cooling units or in a freezer at -5 degree c (23 degree f) cold packs should be cooled for atleast 30 minutes between use and foe 2 hours or longer before initial use.

Cold packs

Cooling unit for cold packs

ICE MASSAGE

Ice massage acts as an analgesic or pain-reliever by numbing tissues, reducing muscle spasms and slowing tissue metabolism. Because ice massage helps reduce swelling, inflammation and pain, it's the preferred modality for acute musculoskeletal injuries, such as ligament sprains, muscle strains, joint subluxations and dislocations, bruises and fractures. Ice cups or or frozen water popsicles [80]can be used to apply ice massage. Frozen cups are made by freezing small paper or Styrofoam cups of water.To use , these , the therapist holds on the bottom of the cup and gradually peels back the edge to expose the surface of ice and put it in direct contact with the patient's skin .

Ice Cup

Application of ice massage

Lowers Metabolic Rate & Promotes Healing

According to a 1999 study published in the journal "**Medicine and Science in Sports and Exercise,"** cryotherapy, or ice massage, also reduces the metabolic rate of injured tissues, allowing injured cells to survive the acute phase of injury, as well as reducing the area of secondary injury. Secondary injury is caused by post-trauma hypoxia or tissue oxygen deficiency, and is due to the following factors: bleeding of injured blood vessels, hemostasis or the stoppage of bleeding and reduced blood flow due to increased blood viscosity or thickness.

CONTROLLED COMPRESSIO N THERAPY

Cold Compression Therapy accelerates the body's natural healing process by increasing blood flow while reducing both pain and swelling. The compression wrap is snugly positioned around the injured area, then the pump is activated. Intermittent pneumatic compression is initiated, and the process of swelling and pain reduction begins. It is recommended that a patient continue to use a cold compression wrap until a significant reduction in swelling is evident.

Cold compression unit and its application

Cold compression units alternately pump cold water and air into a sleeve that is wrapped around a patient's limb . The temperature of water can be set at between 10^0C and 25^0C (between 50^0F and 77^0F) to provide cooling .A small study found that cold compression decreased capillary blood flow , preserved deep tendon oxygen saturation , and facilitated venous capillary outflow in the Achilles tendon when applied to this region. [81]

The goal of a cold compression wrap for a shoulder injury is to optimize and ultimately decrease recovery time. Dislocated shoulder recovery typically takes 3-4 months to complete. This process can be reduced 7-14 days by using a cold compression wrap and engaging in a intermittent pneumatic compression process.

Cold compression therapy goes a step beyond an ice pack. With a compression wrap, the shoulder is fully enclosed and every part of the shoulder joint is being affected. Active compression helps to diminish pain by dulling nerve endings and reaching areas that an ice pack doesn't reach. Cold compression therapy works to assist the body in it's natural healing process.

Application of cold compression therapy

VAPOCOOLANT SPRAY(e.g., fluoromethane, ethyl chloride) Vaporized liquid nitrogen.When sprayed on skin, it produces significant cooling through evaporation.Container should be held about 2 feet from body part and sprayed in one direction only at rate of 4 inches/second, using 1-2 sweeps while maintaining passive stretch. Ethyl chloride is flammable and may freeze skin on contact; therefore, fluoromethane is preferre Effective in reducing painful muscle guarding and desensitizing trigger point areas.

VAPOCOOLANT SPRAY

Application of vapocoolant spray

General principles and practical application of cryotherapy

Cryotherapy increases the threshold of pain and induces physiological changes. It influences hemodynamics (reduction of skin- and muscle temperature through vasoconstriction), metabolism (reduction of ischemia due to hypoxia), and neural control (reduction of nerve conduction velocity and muscle tone).Cryotherapy is indicated mainly in locomotor system related pain. Such pain can be induced by degenerative changes, postoperatively, and during mobilisation of contracted joints.

Cryotherapy may be used as short term therapy (less than 15 min) as well as long term therapy (more than 20 min).For maximal efficacy the intensity of application as well as the application medium must be considered.Due to biorhythm, cold application seems to be more effective in the afternoon.

Conclusion

The conclusions are that the results of the studies reviewed were consistent in describing reductions in musculoskeletal pain, spasm, connective tissue distensibility, intramuscular temperature, nerve conduction velocity, and spasticity (except the initial seconds of application). Other conclusions are that the results of the studies reviewed were inconsistent in describing the changes in swelling, blood flow, heart rate, blood pressure, intraarticular temperature, rheumatoid arthritis, monosynaptic reflex, and the muscle spindle.

Discussion

An extensive review of cold study results was made and a summary of these results was provided. The consistent findings were reductions in musculoskeletal pain, spasm, connective tissue distensibility, intramuscular temperature, nerve conduction velocity, and spasticity (except upon initial cold contact). The inconsistent findings were effects on swelling, blood flow, heart rate, blood pressure, intraarticular temperature, rheumatoid arthritis, the monosynaptic reflex, and the muscle spindle. The physical therapist should be aware of what has been documented and whether or not he has a valid reason for using cold therapy in the manner in which he uses it.

REFERENCE

1. Weston M, Taber C, Casagranda L, et al: Changes in local blood volume during cold gel .J Orthop Sports Phys Ther 19:197–199, 1994. 5.
2. Karunakara RG, Lephart SM, Pincivero DM. Changes in forearm blood flow during single andintermittent cold application. J Orthop Sports Phys Ther. 1999 ...
3. Wolf SL: Contralateral upper extremity cooling from a specific cold stimulus, Phys Ther 51:158-165,1971.
4. Palmieri RM , Garrison JC , Leonard JL,et al:Peripheral ankle cooling and core body temperature, J Athl Train 41:185-188,2006.
5. Taber C , Countaryman K , Fahernbruch J , et al ; Measurement of reactive vasodilation during cold gel pack application to nontraumatized ankles , Phy Ther 72:294-299 ,1992.
6. Lee JM , Warren MP ,Mason SM :Effects of ice on nerve conduction velocity , Physiotherapy 64:2-6 ,1978.
7. Douglas WW , Malcom JL:The effect of localized cooling on cat nerves , J Physio130:53-54 ,1955.
8. Bassett FH , Kirkpatrick JS , Engelhardt DL , et al :Cryotherapy induced nerve injury , AmJ Sport Med 22:516-528 , 1992.
9. Ernst E , Fialka V :Ice freezes pain? A review of the clinical effectiveness of analgesic cold therapy ,JPain Symptom Mgmt 9:56-59 , 1994.
10. Oliver RA , Johnson DJ , Wheelhouse WW, et :Isometric muscle contraction response during recovery from reduced intramuscular temperature , Arch Phys Med Rehabil 60:126-129,1979.
11. Jhonson J , Leider FE: Influence of cold bath on maximum handgrip strength ,
12. Percept Mot Skills 44:323-325.1977.
13. Davies CTM , Young K : Effect on the contractile properties and muscle power of triceps surae in humans , J Appl Physiol 55:191-195,1983.
14. Knuttsson E: Topical cryotherapy in spasticity , Scand J Rehabil Med 2:159-162, 1970.
15. Price R , Lehmann JE , Boswell –Bassette S , et al : Influence of cryotherapy on spasticity at the human ankle , Arch Phys Med Rehabil 74:300-304 , 1993.
16. Hocutt JE , Jaffe R , Ryplander CR , et al: Cryotherapy in ankle sprains , Am J Sports Med 10:316-319 , 1982.
17. Ogilive – Harris DJ , Gilbart M : Treatment modalities for soft tissue injuries of the ankle : a critical review , Clin J Sport Med 5:175-186,1995. Retrived from Database of Abstracts of Reviews of Effectiveness [Dare] on November 13 , 2006 .
18. Brosseau L ,Yonge KA , Robinson V , et al:Thermotherapy for treatment of osteoarthiritis , Cochrane Database Syst Rev(4):CD004522 , 2003.
19. Robinson V , Brosseau L , Casimiro L ,et al: Thermotherapy for treating rheumatoid arthiritis , Cochrane Database Syst Rev(2): CD002826 ,2002.
20. Hirvonen HE , Mikkelsson MK , Kautiainen M,et al: Effectiveness of different cryotherapies on pain and disease activity in active rheumatoid arthiritis : a randomized single blinded controlled trial , Clin Exp Rheumatol 24:295-301, 2006.
21. Cote DJ , Prentice WE , Hoojer DN , et al: Comparison of three treatment procedures for minimizing ankle sprain swelling , Phys Ther 68:1072-1076 , 1988.
22. Wilkerson GB: Treatment of inversion ankle sprain through syn-chronous application of focal compression and cold , Athl Train 26:220-225 , 1991.
23. Quillen WS , Roullier LH : Initial management of acute ankle sprains with rapid pulsed pneumatic compression and cold , J Orthop Sports Phys Ther 4:39-43,1982.
24. Douglas WW , Malcom JL: The effect of localized cool, 1955.ng on cat nerves , J Physiol 130:53-54 .
25. Knight KL : Cryotherapy : teory : technique , physiology , Chattanooga , TN , 1985 Chattanooga Corp.
26. Hayden CA: Cryokinetics in an early treatment program , J Am Phys Ther Assoc 44:990 ,1964.
27. Prentice WE : An electromyographic analysis of the effectiveness of heat or cold and stretching for including relaxation in injured muscle , J Orthop Sports Phys Ther 3:133-137 , 1982.
28. Day MJ: Hyperseneitive response to ice massage : report of a case , Phys Ther 54:592-593 , 1974.
29. Krumhansi BR : Ice Iollies for ice massage , Phys Ther 49:1098 . 1969.
30. Knobloch K , Grasemann R , Jagodzinski N , et al: Changes of Achilles midportion tendon microcirculation after repetitive simultaneous cryotherapy and compression using a Cryo/Cuff, Am J Sports Med 34:1953 - 1959 , 2006.