Cryotherapy: Evidence Based Practice Summary - Physiotherapy

"Icing is a major industry in musculoskeletal medicine yet it rests on a precarious foundation.(Backletter, 2001)

"Strength of evidence supporting the use of cryotherapy in the management of acute soft tissue injury is generally poor" (Bleakley et al, 2006, p.700).

The following is the summary of a review of the literature of the physiological basis for and clinical effectiveness of cold therapy in the management of musculoskeletal injury/surgery.

1. PHYSIOLOGICAL BASIS

Cooling can be defined as the transfer of energy away from a body region (Robertson et al, 2006 p. 387). Cooling may be accomplished by evaporating liquids off the skin, blowing cold air over the skin, or the conduction of cold from a cooler to warmer surface. The extent of cooling is dependent on the following factors:

- The rate and amount of heat energy removed
- The difference in temperature between the skin and cooling source
- Whether the cooling source has a constant temperature or it gradually warms
- Whether there are barriers .e.g. oils, towels, plastic bag
- The size of area cooled (larger the area the greater the heat loss)
- The thermal conductivity of substance used e.g. ice vs gel packs, muscle vs fat
- The rate of flow of blood through the tissue
- Method of cooling e.g. icing with a damp or a dry towel placed between the ice and skin
- Duration of exposure

a) Local Effects (Robertson et al, 2006)

1. Immediate perception of cold and pain:
    - Cold receptors are stimulated
    - Pain receptors responding to cold may be stimulated
2. Immediate vasoconstriction of cutaneous vessels followed by vasodilation in some areas i.e. Lewis' hunting response of about 15 minutes – occurs most easily if the rest of body is relatively warm; confined to face, nose & ears, hands, feet, patella, olecranon, buttocks and some parts of the chest wall (Fox & Wyatt, 1962).
3. Reduced local deep blood volume and flow rate

a. Depending on area cooled & depth of tissue. Can cool deep (intra-articular [Oosterveld et al, 1992) and bone [Ho et al, 1995]).

b. Skin temp can decrease rapidly, cooling of deeper tissue is slower
    - 30 min to decrease muscle temp at 4 cm depth by 3.5 deg C

- 20 min to decrease muscle temp at 2.5 cm by 5 deg C
- 3 kg ice chips in bag for 30 min on front of knee caused the intra-articular temp of the knee joint to fall by an average of 9.4 deg C (Oosterveld et al, 1992) with 16.4 deg C fall in knee skin temp in normal subjects!

c. Deeper tissues re-warm more slowly.
d. Thickness of adipose layer affects cooling (Myrer et al, 2001) difference in temp change is approx three times less at depths of both 1 and 3 cm if skinfold thickness is 20 mm vs 8 mm or less
e. To ensure and maintain deep cooling the application should be repeated within another 40 to 60 min

4. Reduced local metabolic rate
    - Reduced oxygen requirement
    - Decrease metabolism of cells which survived the initial injury as they can be deprived of their usual rate of oxygen supply and suffer hypoxic death; reduced metabolic demand and rate of necrotic enzyme release and activity enhances survival of vulnerable cells; also reduces edema (less tissue damage); swelling increased distance of cells from their usual supply vessels and possibly occludes smaller vessels
    - Reduced cellular activity
5. Effects on peripheral nervous system
    - Initial strong sensory stimulus
    - Initially stimulate cold receptors.
    - Eventual suppression or reduction of pain
    - Delayed onset deep aching produced by activation of nociceptors of C fibers; in acute injury ice is of value because A-gamma is reduced but of little value for chronic pain where C fibers are dominant: pain relief is not due to reduced transmission nor due to gating
6. Variable effect on motor system
    - Can increase muscle strength and endurance if lesser cooling
    - Can reduce motor activity and fine skill performance if greater cooling (Richendollar et al, 2006)

Other (Morsi et al, 2002):

- May reduce nerve conduction (Knight KL et al, 2000)
- May reduce mm spasm
- May inhibit stretch reflex
- Short term 15-30 min relief (Ernst & Fralka, 1994)
- Vasoconstriction results in decreased permeability of blood vessels and thus decreased hemorrhage (Karunakara, 1999).

2. General effects

Local sensation of cooling, then adaptation and stimulation of hypothalamus resulting in generalized vasoconstriction.

2. CLINICAL EFFECTIVENESS

There is wide variation in the use of timing of cold therapy (Bleakley et al, 2004) with different methods of application, local cooling temperature and time of application (Morsi, 2002). In a systematic review of animal and healthy human models MacAuley (2001) stated that "A clinician searching this [*literature*] would have difficulty identifying a specific treatment plan" and indeed there was"… no evidence to suggest an optimal mode, duration or frequency of ice application". Moreover, there is a need identified for evidence for the risks (eg. local tissue damage, impairment of proprioceptive abilities, and the increased potential for further injury), as well as the benefits, for cold therapy.

In the absence of high quality evidence, best practice should be focused on the interpretation and application of the best evidence available. Key points for clinical practice include:

- *Immediate* management of acute injury:
  - Ice application is critical to reduce degree of secondary cell injury thereby minimizing the extent of the inflammatory response (MacAuley, 2001; Merrick, 2002).
  - Although the immediate vasoconstriction results in greater viscosity of blood and thus diminished flow, if the degree of cooling is too intense, clotting time is lengthened (Robertson et al, 2006).
- Post-immediate management
  - Intermittent applications may enhance the therapeutic effect of ice in pain relief after acute soft tissue injury (Bleakley et al, 2006). Eg. two applications of 10 minutes versus 1 application of 20 minutes. Superficial tissues reach their peak temperature reduction at ~ 10 minutes of cooling (MacAuley, 2001).
  - Cold packs, ice packs (towel or bag); immediate cooling but after ~ 1 minute a layer of water develops in contact with the skin thus warming up a little so tolerable for ~ 20 min (*if move the pack, the surface temperature will be reduced again to be more effective, however, this can be potentially dangerous for eliciting ice burn in vulnerable patients). Should use a damp towel if using ice in bag. Cooling with ice bag is greater than that with gel pack.
  - Commercial cold packs – reusable or single use; gel packs are more flexible and can be molded to the body part; best to place over a towel; chemical packs are single use- if they rupture clean the skin immediately due to corrosive nature of materials. Frozen peas cool more than a gel pack over a layer of damp towel (Chesterton et al, 2002).
  - Cryotherapy flow units - maintain temp close to 0 deg C; general more effective than other methods.
  - Local immersion – if really cold only tolerable for a few minutes thus intermittent best; post treatment cooling continues longer than with local application.
  - Ice towels – flaked ice and water then wrung out; can exercise with it but messy
  - Ice massage - local cooling greater than if ice pack is used
  - Evaporating sprays - rapid but brief cooling
  - Ice wrap - crepe bandage soaked and applied *caution re use with compression
  - Use caution if using strap or body weight. Compression increases extent of temperature drop (Barlas et al, 1996).

- Always explain to patient the expected response and what to do if there is an unexpected response.
- Use toweling or paper towel on areas that need to be protected (Tsang, et al, 1997).
- Inspect skin at 1 minute and at 5 minutes and if response is abnormal the pack should not be placed back onto the patient.

3. RISKS

- Ice burn – erythema and tenderness within a few hrs of application, subsiding in 1-2 days; if with fatty necrosis can last up to 3 weeks; more risky over local nerve or if large piece of ice held against skin for a long time
- Cold sensitivity (a) vasospasm eg. Raynauds; cryoglobinaemia – abnormal protein; cold urticaria causes release of histamine from mast cells to cause general slowing of BP and raised HR; cooling large areas can cause temp increase in BP
- Caution with reduced sensation.

4. CONCLUSIONS

The literature does not provide strong evidence to support specific prescription parameters for cryotherapy at various stages of injury. However, the existing evidence can be summarized by the following likely progression of increasing intensity (from least to greatest effect) of cooling response:

1. Gel pack
2. Ice bag
3. Ice massage
4. Wet towel with ice bag
5. Wet towel
6. Immersion in bucket of water & ice

One key advantage of cryotherapy flow units: maintain constant temp eg. do not have a layer of warming water.

Consequently, clinicians could use the above progression, together with the additional concepts of addition of protective layers (oil, paper towel, towels) and compression to 'titrate' their prescription of cryotherapy according to the location, stage of injury (level of acuity and whether there is primarily inflammation, edema or swelling) and the relative 'vulnerability' of the patient to risk of ice burn. In addition, shorter, intermittent sessions of cryotherapy (e.g. 10 min duration every 1 to 2 hours for acute injury) would appear to be preferable for less intense cooling without sacrificing effectiveness.

References

Backletter, 2001. Oct: 16(10): 110.
Barlas, D. et al (1996). In ivo tissue temperature comparison of cryotherapy with and without external compression. Ann Emerg Med, 28, 436-439.
Bleakley CM et al. (2006). Icing protocols for acute ankle sprain. Br. J Sports Med, 40:700-705.

Bleakley CM. et al.(2006). Cryotherapy for acute ankle sprains: a randomized controlled study of two different icing protocols. Br. J. Sports Med. 40, 700-705.
Bleakley, C et al. (2004). The use of ice in the treatment of acute soft tissue injury: a systematic review of RCTs. Am J Sports Med, 32:251-61.
Chesterton, L et al. (2002). Skin temperature response to cryotherapy. Arch Phys Med Rehavil, 83, 543-549.
Ernst, E. & Fralka, V. (1994). Ice freezes pain? A review of the clinical effectiveness of analgesic cold therapy. J Pain Symptom Manage, 9: 56-9.
Healy, W et t al. (194). Cold compressive dressings after total nee arthroplasty. Clin Orthop, 299, 174-178.
Ho, S. et al. (1995). Comparison of various icing times in decreasing bone metabolism and blood flow in the knee. Am J Aports Med, 23, 74-76.
Ivans, D. (2006). Acute ankle sprain: An update. Am Fam Physician, 74: 1714-20, 1723-4, 1725-6.
Karonkkara RG. et al (1999) Changes in forearm blood flow during single and intermittent cold application. J Orthop Sports Phys Ther, 29: 177-80
Knight, KL et al, (2000). Muscle injury management with cryotherapy. Thletic Therapy Today, 5:26-30.
Levy, A. & Marmar, E. (1993)). The role of cold compression inte post operative treatment of total knee replacement. Clin Orthop, 297, 174-178.
MacAuley, D. (2001). Ice therapy: How good is the evidence? Int J Sports Med, 22: 379-84.
MacAuley, D. (2001). Textbooks agree on their advice on ice? Clin J Sports Med, 11:67-72.
Matsen, PA et al. (1975). The effect of cooling on post fracture swelling: a controlled study. Clin Orthop, 109: 201.
Meeusen, R. & Lievens, P. (1986). The use of cryotherapy in sports injuries. Sports Med, 3: 398-414.
Merrick, M. et al. (1999) . A preliminary examination of cryotherapy and secondary injury in skeletal muscle. Med Sci Sports Exerc, 31, 1516-1521.
Merrick, MA (2002). Secondary injury after musculoskeletal trauma: a review and update. J Athl Train, 37:209-17.
Morsi, E (2002). Continuous –flow cold therapy after total knee arthroplasty. J of Arthroplasty, 17(6), 718-722.
Oosterveld, F et al, (1992). The effect of local heat and cold therapy on the intraarticular and skin surgace temp of the knee. Arth Rheum, 35, 146-151.
Richendollar, ML et al, (2006). Ice bag application, active warm-up, and 3 measures of maximal functional performance. J Athl Training, 41(4), 364-370.
Robertson, V. et al. (2006). Cold Therapy. In Electrotherapy Explained. Principles and Practice. Butterworth Heinmann.
Schroder, D & Passler, H. (1994). Combination of cold and compression after knee surgery. A prospective randomized study, Knee surgery, Sports Traumatology, Arthroscopy, 2(3), 158-165.
Smith. J et al. (2002). A Randomized, controlled trial comparing compression bandaging and cold therapy in postoperative Total Knee Replacement surgery. Orthop Nursing, 21(2).
Tsang, K et al (19970. The effect of cryotherapy applied through various barriers. J. Sports Rehabil, 6, 343-354.
Webb J et al. (1998). The use of cold compression dressings after total knee replacement: A randomized controlled trial, Orthopedics, 21(1), 59-61.

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