

Is ice right? Does cryotherapy improve outcome for acute soft tissue injury?

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ABSTRACT

Aims: The use of ice or cryotherapy in the management of acute soft tissue injuries is widely accepted and widely practised. This review was conducted to examine the medical literature to investigate if there is evidence to support an improvement in clinical outcome following the use of ice or cryotherapy.

Methods: A comprehensive literature search was performed and all human and animal trials or systematic reviews pertaining to soft tissue trauma, ice or cryotherapy were assessed. The clinically relevant outcome measures were (1) a reduction in pain; (2) a reduction in swelling or oedema; (3) improved function; or (4) return to participation in normal activity.

Results: Six relevant trials in humans were identified, four of which lacked randomisation and blinding. There were two well conducted randomised controlled trials, one showing supportive evidence for the use of a cooling gel and the other not reaching statistical significance. Four animal studies showed that modest cooling reduced oedema but excessive or prolonged cooling is damaging. There were two systematic reviews, one of which was inconclusive and the other suggested that ice may hasten return to participation.

Conclusion: There is insufficient evidence to suggest that cryotherapy improves clinical outcome in the management of soft tissue injuries.

Ice is routinely used in the management of soft tissue injuries, from sprains to strains and contusions. A recent personal survey of Irish emergency physician practice indicated that 73% of consultants "always or frequently" advocate the use of ice while only 7% "never" use cryotherapy; 30% were "unsure" if ice therapy is beneficial. Experience (47%) and common sense (27%) were the reasons most frequently cited for using ice, while 17% used scientific reasoning. Two-thirds (66%) of the consultants surveyed occasionally questioned the medical evidence for ice, 17% never questioned it and 17% frequently questioned the evidence. Almost a quarter (23%) had read literature supporting an improved clinical outcome following ice, 17% had not read supporting literature and 60% were unsure. The frequency with which Irish physicians advocate the use of ice echoes the findings of a UK study stating that 80% of emergency department consultants recommend ice in the management of ankle sprains.¹ The use of ice in the management of acute soft tissue injuries is firmly established, but is there evidence to support this practice?

A comprehensive review of published scientific literature was undertaken to investigate if ice improves outcome when used in the management

of acute soft tissue injuries. Outcome was defined as (1) a reduction in pain, (2) a reduction in swelling/oedema, (3) improved function and (4) reduced time to return to participation in normal activity.

METHODS

A thorough review of the published literature was performed by a single investigator. Search terms for ice included: ice, cryotherapy, thermal treatment, cold and freezing. A second set of search terms for soft tissue injury included: sprain, strain, contusion, bruise, minor injury, ligament, tendon and haematoma. Lastly, for outcome, there were four specific parameters: (1) reduction in pain; (2) reduction in swelling or oedema; (3) improved function; and (4) time taken to return to participation.

Specific exclusion criteria were exercise-induced injury, acute bone injury and the postoperative use of ice. Unlike published systematic reviews,^{2,3} this comprehensive review was not confined to human studies and animal trials were also considered.

A comprehensive literature search was performed using Medline 1966–2006 (using the MeSH system), EMBASE 1988–2006, the Cochrane Library, Google Scholar and citation tracking. The search sought to identify papers that examined the therapeutic effect of cryotherapy on soft tissue injuries using the search terms above. After a generalised search, limits for "trials" were applied. Exclusion criteria included the terms "exercise-induced injury", "bone injury", "post-operative", "ice hockey" and "ice cream". No limits were applied to the year of the study or population (animal or human). Non-randomised trials were included in the search. The references of identified articles were examined to identify additional articles that may have been missed during the original search. In several cases direct correspondence with the publisher was required to obtain these articles.

Human trials were then assessed using Jadad⁴ and PEDro⁵ scoring systems to assess the internal validity (effect of bias) of the research methods. These scoring systems, while somewhat flawed, do facilitate comparison between clinical trials and allow a crude assessment of quality.

RESULTS

The various search methods yielded 66 potential papers of interest of which either the abstract or complete article was obtained. Several of the older papers^{6–8} required direct communication with the journal publishers as they were not available electronically or in otherwise accessible journals. The studies were then subdivided into clinical trials, animal trials and systematic reviews.

Review

Table 1 Jadad and PEDro scores for clinical trials

Reference	Jadad (maximum 5)	PEDro (maximum 10)
Airaksinen <i>et al</i> , 2003, Finland ^a	5	10
Basur <i>et al</i> , 1976, UK ¹⁰	0	2
Cote <i>et al</i> , 1988, USA ^a	2	4
Laba, 1989, New Zealand ⁶	3	3
Hocutt <i>et al</i> , 1982, USA ¹¹	1	2
Sloan <i>et al</i> , 1989, UK ¹²	5	8

Selected older reviews were also considered, although they were not strictly systematic.

Human trials

There was significant variation in the quality of the clinical trials with Jadad⁴ and PEDro⁵ scores ranging from 0–5 and 2–10, respectively (table 1). A summary of the key papers is given in table 2.

Clinical outcome measures focused primarily on function and, to a lesser extent, on pain and oedema. In general the study methods used were poor. Basur *et al*¹⁰ used neither randomisation nor blinding and Hocutt *et al*¹¹ lost almost 40% of patients to follow-up. Two papers describe well conducted studies; the most recent was published in 2003 by Airaksinen *et al*^a and clearly demonstrates in 74 patients the benefits of a cold gel versus placebo in reducing pain at rest, pain with movement and functional disability. These results were statistically significant with p values <0.001. The principal author works in the Physical and Rehabilitation Centre of a university hospital and it is not stated if the patients presented here

directly or through an emergency department. A disclosure statement acknowledges that neither the author nor institution benefited financially from the study.

The well-designed study by Sloan *et al*¹² was conducted in a UK emergency department (1989). One hundred and forty-three patients had a single 30 min cryotherapy session using a cooling anklet applied by a physiotherapist. The results for 116 patients showed reduced soft tissue swelling (p = 0.07), reduced injury severity scores (p = 0.15) and a minimal improvement in weight bearing (p = 0.64) in the cold therapy group. Cryotherapy had no impact on range of movement or analgesia needs and, while these results are not statistically significant, the author comments that a study of more prolonged cooling warrants investigation.

The interpretation of the results by Coté *et al*⁸ and Laba and Roestenburg⁶ show inconsistencies with the conclusions drawn in table 2. Coté *et al*⁸ examined the absolute (rather than the percentage) change in ankle volume between their three study groups. This may be acceptable if the baseline volumes of each group are similar. However, no randomisation occurred and significant intragroup differences exist. If they had considered percentage change, then the results would favour heat therapy instead of cooling.⁸ Laba and Roestenburg⁶ surmise that there is no difference between the groups but later state that the rate of recovery is faster in the ice group (grade 4 sprains recover 2.9 days more quickly with ice). No statistical calculations were made. The study is fundamentally flawed as 13 of the 30 patients used ice at home before enrolment in the study.

Animal trials

There were four relevant animal studies (table 3). The primary outcome measure was oedema (volume,¹³ microcirculatory¹⁴ and

Table 2 Summary of cryotherapy trials in human subjects

Author	Population	Exposure	Outcome	Limitations
Airaksinen <i>et al</i> ^a	74 patients with sports-related soft tissue injuries <48 h old	Prospective randomised double-blind study. Application of cold gel vs placebo gel 4 times/day for 14 days	In cold gel group, measurements at days 7, 14, 28 showed: reduced pain at rest (p<0.001); reduced pain on movement (p<0.001); reduced functional disability (p<0.001)	Does not state which medical service the patients attended
Basur <i>et al</i> ¹⁰	60 patients with ankle sprains	Non-randomised allocation to either cryogel every 4 h for 48 h then crepe bandage or crepe bandage alone. Followed for 14 days.	Mean period of disability 9.7 days with cooling vs 14.8 days in control. Combined score for pain, oedema and function – separate analysis not possible but trend in favour of cryotherapy	No randomisation, no blinding. Conflict of interest not stated. Limited statistical analysis
Cote <i>et al</i> ⁸	30 students with grade 1–2 ankle sprains attending university doctor. Treated day 3 after injury	Randomised to one of three groups: cold treatment, heat treatment or contrast bath on day 3–5 after injury	Oedema: ankle volumes measured before and after treatment on days 3, 4 and 5. Author states all treatments increased ankle oedema with a smaller increase in oedema in cold treatment group	Randomisation not described. Baseline group differences and no control. No blinding
Hocutt <i>et al</i> ¹¹	53 patients aged 8–46 with grade 3–4 ankle sprains enrolled. Results available for 37 patients	Two therapeutic regimes: cooling (whirlpool or ice) or heat (water or heat pad) for 20 min 1–3 times daily for 3 days. Treatment started at day 0 (within 1 h), day 1 (1–36 h) or day 2 (>36 h)	Function: run/jump without pain. Grade 3 sprain: 6 days for day 0/1 cold group, 11 days for day 2 cold group, 14.8 days for heat groups. Grade 4 sprain: 13.2 days for day 0/1 cold group, 30.4 days for day 2 cold group, 33 days for heat groups (p<0.05)	No blinding or randomisation. Subjective scoring by participants. Small numbers involved
Laba ⁶	30 patients with grade 3–4 ankle sprains referred from ED to physiotherapy within 48 h	Toss coin randomisation. Ice applied once for 20 min in ice group. Ultrasound, exercise and support to both groups. No blinding	No statistical difference in pain, swelling or function between groups (however patients with grade 4 functional sprain recovered in 7.3 days with ice and 10.2 days without)	Authors and patients not blinded. 13/30 patients had already used ice prior to study and were included in control and treatment groups
Sloan <i>et al</i> ¹²	143 patients age 16–50 attending ED with acute ankle sprains. 116 patients followed	Prospective randomised trial. “Cooling anklet” with elevation for 30 min in test group and dummy anklet with no elevation in control. Standard therapy for both groups: bandage, NSAIDs, rest, elevation	Cold therapy group showed trend for improvement but did not reach statistical significance. Reduced soft tissue oedema (p = 0.07), improvement on injury severity score (p = 0.15), increased weight bearing or function (p = 0.64)	Single application of ice therapy in otherwise well designed study

ED, emergency department; NSAID, non-steroidal anti-inflammatory drug.

Table 3 Summary of cryotherapy trials in animals

Study	Population	Exposure	Outcome	Conclusion	Limitations
Deal <i>et al</i> , 2002, USA ¹⁴	60 rats with a dorsal microvascular chamber	4 groups of rats: (1) 5 contusion, no ice; (2) 15 contusion and ice; (3) 15 sham contusion and ice; (4) 15 sham contusion, no ice. Ice applied for 20 min	Oedema: group 1 had maximum oedema; group 2 oedema less than group 1 ($p < 0.001$) but more than group 4 ($p = 0.012$)	Microvascular permeability is increased 300 min after contusion but this response can be reduced with ice	Size of group 1 is small. No observer blinding stated
Dolan <i>et al</i> , 1997, USA ¹³	16 rats	Both hind limbs traumatised. One limb: cold water to 12.8–15.6°C. Control limb: water at 22–25.5°C. 4 cycles of immersion for 30 min, rest for 30 min	Oedema: limb volume of cold group significantly smaller than control ($p = 0.03$). Volume assessed by water displacement	Exposure to cold water at 12.8–15.6°C curbed oedema formation after blunt trauma in rats	Absolute volume difference 0.05 ml
Farry <i>et al</i> , 1980, New Zealand ⁷	16 piglets	Groups of piglets: (A) $n = 2$: no injury, no ice; (B) $n = 4$: no injury, one limb iced; (C) $n = 10$: both limbs injured, ice applied to one limb. Radiocarpal ligament crushed and stretched. Ice 20 min, rest 1 h, ice 20 min	Oedema: volume/ histological. Swelling greatest in ice-treated groups (with or without injury) but histological inflammation at 48 h less in injured limbs treated with ice	Superficial tissues of injured/ uninjured limbs are damaged by cold-induced ischaemia but ice reduces the microscopic evidence of oedema	No blinding, no p values or confidence intervals given
McMaster <i>et al</i> , 1979, USA ¹⁵	30 white rabbits	Groups of rabbits: (1) 10 controls: left leg crushed, kept at room temperature; (2) 10 rabbits: left legs crushed, 5 legs cooled to 30°C, 5 legs to 20°C for 1 h. (3) 10 rabbits: both legs crushed, 3 1-hour cycles of cooling, 10 legs to 30°C, 10 legs to 20°C	Oedema: at 24 h, 1 h of cooling at 30°C had less swelling than 20°C group or controls. Prolonged cooling at 20°C and 30°C resulted in residual swelling at 24 h	Benefit from modest cooling for a short period. Too much cold or prolonged application may be deleterious	No blinding stated

histological changes⁷). Each study showed a reduction in soft tissue swelling with modest cooling (ice for 20 min,¹⁴ cold water 12.8–15.6°C,¹³ cooling to 30°C for 1 h¹⁵). McMaster¹⁵ shows that prolonged cooling and cooling to very low temperatures increases tissue damage.

This suggestion is supported in a study of cryotherapy and bony injury by Matsen *et al*¹⁶ (not included in this systematic review as inclusion criteria were soft tissue injuries only). The tibial fractures induced by Matsen *et al* in rabbits were cooled for either 6 or 24 h with bags of water at 5–25°C. Prolonged subcutaneous swelling occurred in limbs cooled to 5–15°C for 24 h but significant swelling did not occur in limbs cooled to 10°C for 6 h or cooled to 20–25°C for 24 h. An inverse linear relationship exists between temperature and soft tissue oedema.

The major limitation of these animal studies is lack of observer blinding.

Systematic reviews

Two true systematic reviews were included (table 4). The 2004 study by Bleakley *et al*² conducts a very broad and thorough review of the literature. Five clinical questions are posed and an attempt is made to draw a meaningful conclusion. Their efforts

are limited by the broad inclusion criteria and this hampers any direct comparisons. Hubbard *et al*³ pose a very focused clinical question as to whether ice therapy hastens return to participation in normal activity. The conclusion drawn is that cryotherapy instituted soon after injury may be effective. The major limitation is that the search was limited to randomised controlled trials in humans and only four papers with weak methodologies were obtained.

DISCUSSION

Soft tissue injuries form a significant proportion of the work load in the emergency department. Ankle sprains alone are estimated to comprise 3–5% of emergency department attendances or 5600 injuries per day in the UK.¹ Ice therapy or cryotherapy is an accepted practice that is perceived by physicians to be cheap, safe and tolerable with only moderate inconvenience to patients. However, the animal studies above show a potential for cold-induced tissue damage with prolonged exposure and very cold temperatures, and there are occasional case reports of burns, nerve injury and frost bite.^{17 18} The evidence base for cryotherapy, like many other established therapies, is largely unquestioned.

Table 4 Systematic reviews

Study	Clinical question	Inclusion/exclusion criteria	Literature search methods	Appraisal of literature	Conclusions drawn	Limitations
Bleakley <i>et al</i> , 2004, Ireland ²	To explore the clinical evidence base for cryotherapy. Five sub-questions posed.	Human studies up to 2002. Broad inclusion criteria – trauma and postoperative RCTs. 4 outcome measures: pain, swelling, ROM and function	Multiple databases, hand searches and citation tracking. 22 studies found (5 relating to soft tissue injury, 17 relating to surgery).	Used PEDro scoring, range 2–5/10. Appraisal inconclusive	Many more high quality studies are needed to ensure adequate evidence-based practice	Clinical question was not focused, hence reducing study validity and applicability. Mixed population –trauma and surgery. Non-specific conclusion due to breadth of clinical question
Hubbard <i>et al</i> , 2004, USA ³	Does cryotherapy hasten return to participation?	Clear and relevant. Focused clinical question	English language journals 1976–2003. Limits included RCTs only. 4 trials found	Used PEDro scoring, range 2–4/10. Good appraisal	Cryotherapy instituted soon after injury may be effective in speeding return to work or sports	Well designed systematic review with focused clinical question. Major limitation is paucity of papers obtained

Review

While numerous papers on ice therapy exist, many are set in artificial scenarios (such as exercise-induced injury) which may not represent the cohort of trauma patients presenting to an emergency department. Other studies use surrogate outcome measures (commonly skin or muscle temperature) which do not necessarily correlate with patient-orientated outcomes that matter. This systematic review was designed to be relevant and applicable to patients presenting with acute trauma and to investigate patient-orientated outcomes.

Despite thorough searching, there is a paucity of evidence for such a well-accepted practice, and the evidence available is based on small patient numbers and some inherently weak trials. Only one clinical trial, involving 74 patients, showed a definite benefit of cold therapy in reducing pain and disability. The animal studies do show reduced oedema, but it is not yet known if that corresponds to faster clinical recovery.

Other systematic reviews on ice therapy have been performed. The review by MacAuley¹⁹ in 2001 examines the literature for the most effect icing method. That study, however, used skin temperature as a measure of effect and not any of the outcome measures defined by this study.

Two other thorough but not truly systematic reviews are notable. Meeusen and Lievens²⁰ provide a comprehensive review of many animal and human trials and conclude that the effect of cryotherapy, while useful, is probably confounded by other co-existing first aid measures. Cold therapy may reduce pain and can both increase and decrease inflammation. An interesting older study by Olson and Stravino²¹ in 1972 predates the concept of systematic reviews. Only papers where "systematic study has been pursued" were reviewed. The appraisal had four aims, the second of which was to review the literature and the third to examine the benefits and limitations of cold therapy. Several studies from the 1950s and 1960s are quoted, and the authors conclude that the numbers involved in the studies are too low to allow meaningful analysis and that comparison of techniques is difficult. They conclude that physiological and clinical studies suggest that cold therapy can be valuable in decreasing haemorrhage and oedema in acute injuries and providing analgesia for acute muscle spasm.

Now, over 30 years later, many of these same issues exist in assessing this clinical question; well conducted trials are few, patient numbers are low and direct comparison between studies is not without difficulty.

CONCLUSIONS

This systematic review concludes that cryotherapy may have a possible benefit in the treatment of acute soft tissue injury if it

is instituted soon after the injury and care is taken to limit exposure time and to induce only modest cooling, otherwise harm may ensue. The volume and quality of data available for such a prevalent clinical condition, however, are inadequate, and it begets the question "If cryotherapy was a pharmacological therapy, is there an evidence base to support its use?"

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