Cryotherapy for Treatment of Delayed Onset Muscle Soreness

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Cryotherapy is the application of cold as a therapeutic intervention,[1-5] which has been used to facilitate recovery from an acute injury since the 1800s.[6] Although cold can be applied to the body surface in a variety of ways, ice has been traditionally used to promote healing from injuries.[1] Cryotherapy modalities are also used to promote recovery between exercise training sessions and competitive events when some athletes experience delayed-onset muscle soreness (DOMS).[2] Despite the widespread use of cryotherapy, the findings of research on differing cryotherapy modes, temperatures, and treatment times are inconsistent. The purpose of this report is to review evidence pertaining to the effectiveness of cryotherapy for treatment of DOMS. Specifically, we review what is known about (a) systemic responses to cold application, (b) the possible benefits of cryotherapy for exercise recovery, (c) performance decrements associated with DOMS, and (d) methods used to measure recovery from DOMS.

Key Points

- Cryotherapy is an accepted modality for acute injury management.
- Cryotherapy may facilitate recovery from Delayed Onset Muscle Soreness (DOMS), but limited research evidence is available to guide management of the condition.
- The negative effects of DOMS include pain, diminished strength, and functional performance decrements for 24-72 hours postexercise.

Common modes of cryotherapy administration include cold water immersion (CWI; Table 1), ice massage (Table 2), ice pack application (Table 3), or the use of a cold sprays or gels. The use of cryotherapy as part of the widely-accepted Rest, Ice, Compression, Elevation (RICE) approach to sports injury management is often the first response to a musculoskeletal injury,[2,3] but the optimal temperature and duration of treatment are not well-established. Various types of cold packs and cold sprays, which produce different levels of subcutaneous tissue cooling, are readily available, but confusion exists about the best practice for realization of optimal therapeutic benefit. CWI temperature and treatment duration are not universally accepted; researchers have reported CWI temperatures range from 50–60 °F and reported treatment times range from 5–20 minutes.[5-7] A possible explanation for this inconsistency may be lack of a clear understanding of the physiologic effects of cryotherapy. The research evidence pertaining to the use cryotherapy as an injury recovery modality is mixed; some evidence supports its use,[8-10] but other evidence fails to support the practice.[11-13] A lack of evidence-based recommendations for the use cryotherapy in treatment of DOMS presents clinicians with a decision-making dilemma that results in wide variation in practices.

Table 1. Efficacy of Cold Water Immersion for Treatment of DOMS

Author, year	Variable Used to Induce DOMS	Time Frame for Treatment	Method	Measurements	Result for Cryo Group
Howatson et al., 2008[11]	drop jumps (5 × 20 with 2 min)	After exercise, 24, 48, and 72 hours post exercise	12 min CWI at 15 °C	(repeated bout effort) 14-21 days	no effect
Peiffer et al., 2008[5]	90-min cycling (216 ± 12W), then 16.1km TT	1 treatment	20 min CWI at 14 °C	MVIC (knee extensors), (SMVIC), femoral venous diameter, (measured prior, 0, 45, and 90 min after TT). Rectal and skin temperatures measured continuously from the start of the 90 min CS throughout duration.	Decreases skin and rectal temps. Femoral vein diameters, and results in greater decreases in MVIC and SMVIC compared with the control.
Goodall & Howatson, 2008[12]	100 drop jumps	Post, 24, 48, 72 h post exercise	12 min CWI at 15 °C	MVC, CK, soreness, ROM, girth (every 24 hours for 96 hours)	no effect
Ingram et al., 2008[8]	80 min team sport, 20 m shuttle run test to exhaustion	Post, 24 hours post	2 × 5 min CWI (2.5 min out) at 10 °C	ck, soreness (Likert scale), sprints	Quicker recovery in sprint performance, less soreness rating, reduced decrements to isometric leg extension and flexion.
Peiffer et al., 2008[5]	1-km cycling TT	Immediately post	5 min CWI at 5°C	TT immediately after treatment (cycling power) rectal and muscle temp	Lowered muscle temp, but did not affect strength or 1-km cycling performance.
Bailey et al., 2007[9]	90 minute intermittent shuttle run	1 treatment	10 min CWI at 10° C	Perceived soreness, muscle function, intracellular proteins (before, after, 1, 24, 48, 162 h after) (MVC, vertical jump, sprint time)	Less soreness, more strength, no change in vertical jump, sprint performance, or CK levels.
Sellwood et al., 2007[13]	Eccentric loading with non-dominant leg	Immediately post	5 °C CWI	Pain (VAS), swelling, hopping for distance (function), CK	No changes, increased pain.
Skurvydas et al., 2006[35]	100 drop jumps (20 s between jumps)	After exercise, 4, 8, 24 hours post exercise	2 × 15 min CWI (10 min rest) at 15 °C	CK levels, subjective soreness, MVCF	Significant recovery of muscular force, less CK activity.
Eston & Peters, 1999[7]	8 × 5 contractions of elbow flexors	After exercise, 6 more times spaced 12 hrs apart	15 min CWI at 15 °C	Elbow angle, CK activity, muscle tenderness, edema, isometric strength	Relaxed elbow angle and CK activity were lower 2-3 days post. Muscle tenderness, edema, and isometric strength were not different.
Kimura et al., 1997[36]	No DOMS	Immediately post	30 min CWI at 10 °C	Endurance and peak torque of plantar flexors (isokinetic dynamometer) after icing	No effect on peak torque, improved endurance.

Table 2. Efficacy of Ice Massage for Treatment of DOMS

Author, Year	Variable Used to Induce DOMS	Time Frame for Treatment	Method	Measurements	Result for Cryo Group
Howatson &Van Someron, 2008[11]	3 × 10 bicep curls with extended eccentric phase (twice)	After exercise	Ice ball, 15 minutes	DOMS (Talag Scale), limb girth, ROM, MVC, CK, Myoglobin (measured post, 24, 48, 72, and 96 h post)	Ineffective in reducing the indirect markers associated with EIMD and enhancing recovery of muscle function.
Howatson & Van Someron, 2003[37]	3 × 10 bicep curls with extended eccentric phase	1 treatment	Circular strokes with ice cup for 15 minutes	1RM, plasma CK, soreness, girth, ROM (pre, post, 24, 48, 72 hours)	Reduced CK, no other effect.
Gulick et al, 1996[25]	15 × 15 on forearm extensors	Post exercise	Ice massage	Pre, post, 20 min after, 24, 48, 72h after (soreness, strength, forearm girth)	No change
Isabell et al., 1992[27]	Up to 300 contractions of elbow flexors	Immediately post	Circular strokes with ice cup for 15 min	ROM, strength, soreness, CK	No change

Table 3. Efficacy of Ice Pack Application forTreatment of DOMS

Author, Year	Variable Used to Induce DOMS	Time Frame for Treatment	Method	Measurements	Result for Cryo Group
Verducci, 2000[10]	1 set of 22 reps at 75% 1RM arm pulls, sets continue until failure	After each set	10 min ice bag application	Number of sets completed before fatigue.	Completed more sets of arm pulls.

Systemic Responses to Cold Exposure

Exposure to cold elicits multiple systemic responses, which relate to the potential benefits of cryotherapy treatment. Until the 1970s, the theorized positive effect of cold application was attributed to a decrease in blood flow that suppressed hemorrhage and edema formation.[4] Subsequently, Knight[14] introduced the secondary hypoxic injury theory, which suggested that a lack of oxygen at the injury site induces damage to the surrounding cells.[14,15] The positive effects of cryotherapy were related to a decrease in metabolism of the tissues in the vicinity of the injured tissues.[4] By lowering the tissue temperature, the cells' demand for oxygen is also lowered, which makes them less likely to be damaged by oxygen deprivation.

Research has demonstrated that intramuscular temperature drops when cold is applied to the body surface, and it continues to drop after the cold modality has been removed.[16-18] Whole-body cold exposure increases levels of circulating thyroid hormones, which increases the basal metabolic rate. CWI sometimes involves submersion of a large portion of the body, which will elicit a systemic response.

Cryotherapy Use in Acute Injury Management and Exercise Recovery

Cryotherapy is often administered during the acute inflammation phase for reduction of pain and swelling.[4] Although pain and swelling are symptoms of inflammation, research findings suggest that suppression of other aspects of the inflammatory response may be detrimental to the healing process.[19] According to Knight,[14] decrease in secondary hypoxic injury, which may prevent subsequent swelling, is the primary benefit derived from cryotherapy.

Research has demonstrated that skin temperature remains lower than normal for several hours after prolonged cryotherapy, even after removal of the cold modality.[18-20] The cold skin stimulus generates afferent neural impulses that are conveyed by large, myelinated nerve fibers at a much faster velocity than that of pain impulses conveyed by smaller unmyelinated nerve fibers, which inhibits transmission of pain impulses within the spinal cord[18-20] and which suppresses the stretch reflex.[21] The subjective nature of pain sensations has made the analgesic effect of cryotherapy difficult to study.

Although cryotherapy use for acute injury treatment is strongly supported by research evidence, its effect on recovery from DOMS remains controversial.[1-5] DOMS is typically associated with high-intensity eccentric muscle actions.[2] Symptoms may include tenderness to touch and debilitating pain that may last up to 72 hours after exercise.[22-24] Some researchers have suggested that CWI is more effective than hot/cold contrast baths or no treatment for reduction of pain and restoration of normal functon,[25] whereas others have reported that CWI increased muscle pain in the days following treatment.[13]

Performance Decrements in DOMS

Substantial reduction in muscular strength and power has been documented after the onset of DOMS induced by eccentric muscle actions.[26-28] The greatest reduction in strength and power occurs during the period from 24 to 48 hours postexercise.[29-30] Treatment during this postexercise period may be crucial for athletes who compete in sports that involve competition over a period of several days or on consecutive days.[31] If cryotherapy can mitigate DOMS, it could optimize performance during multiday sporting events.[28-31] Whether or not cryotherapy actually has a physiologic effect on DOMS remains unclear.

Measurement of Recovery From DOMS

Pain

Although pain is a subjective sensation, its perception can inhibit performance. Pain related to DOMS may result from disruption of the contractile component of muscle tissue, especially at the Z-line of the sarcomere.[32] A visual analog scale (VAS) quantifies pain perception by having the patient make a mark on a line that represents a continuum from no pain to excruciating pain.[33] Athletes and nonathletes may differ in terms of tolerance for pain, which may be an important consideration for interpretation of data derived from a VAS.[34] Researchers who have quantified pain perception associated with DOMS have reported that cryotherapy was effective for decreasing pain perception,[8,9] which may result from a reduction in nerve conduction velocity.[22]

Muscle Activity

Research evidence clearly indicates that strength decreases after DOMS has been induced.[2,28-31] Comparison of strength before and after activity that induces DOMS may provide evidence of the effectiveness of cryotherapy for facilitation of recovery from DOMS. The unique physiologic demands imposed by different sports may influence the specific parameters for cryotherapy that best facilitate recovery from DOMS. Until further research is conducted, clinicians will not have evidence to rely upon for guidance of practice.

Functional Testing

The adverse effects of DOMS on athletic performance can be examined using sport-specific functional tests, which may include running, jumping, throwing, and landing. Much of the previous research has analyzed single-joint movements, which may not provide an adequate representation of the effect of DOMS on sport performance capabilities.[23]

Summary

Even though cryotherapy is the most common treatment for sport-related injuries, universally-accepted treatment parameters have not been established for different conditions. The effectiveness of cryotherapy for facilitation of recovery from DOMS remains unclear. Because athletes with DOMS experience negative effects for up to 72 hours postexercise, further research is needed to establish evidence-based guidelines for DOMS management. ▮

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