Cryotherapy

**Indexing Metadata/Description**

- **Device/equipment:** Cryotherapy
- **Synonyms:** Cold therapy; ice pack therapy; ice therapy; cooling; cryokinetics
- **Area(s) of specialty:** Acute Care, Hand Therapy, Home Health, Neurological Rehabilitation, Orthopedic Rehabilitation, Pediatric Rehabilitation, Sports Rehabilitation
- **Description/use**
  - In a rehabilitation context cryotherapy is the withdrawal of heat from the body using various cooling agents to achieve a therapeutic effect\(^{(1)}\)
  - In a surgery/radiology context, cryotherapy is a minimally invasive treatment that uses extreme cold to freeze and destroy diseased tissue\(^{(2)}\)
  - This Clinical Review focuses on therapeutic use of cold
    - Whole body cryotherapy, the exposure of the body to very cold air in temperature-controlled cryochambers, is not included in this review. This treatment has recently gained popularity, particularly among athletes, but is under scrutiny for its safety.\(^{(71,72)}\) The United States Food and Drug Administration does not recognize any medical benefits from cryotherapy chambers, and does not regulate the devices\(^{(71)}\)
  - In physical therapy, cryotherapy refers to application of mild superficial cooling agents to an area of the body to lower tissue temperature
  - Heat energy is removed from the body via conduction (e.g., ice packs, ice massage), convection (e.g., cold-water immersion), or evaporation (e.g., vapocoolant sprays)\(^{(1)}\)
  - Therapeutic effects of cold result from its effects on hemodynamic, metabolic, and neuromuscular systems\(^{(1)}\)
    - Cooling can suppress nerve conduction by slowing conduction velocity and suppressing synaptic transmission, which can produce analgesia and reduce muscle spasm\(^{(3)}\)
    - Cooling can lower oxygen requirements in the tissue, cause vasoconstriction, and decrease vessel wall permeability\(^{(3)}\)
  - Commonly used in the acute phase after soft tissue injury in conjunction with rest, compression, and elevation (“RICE”)
  - The use of cold after the acute phase of a soft tissue injury, in conjunction with active exercises, is referred to as cryokinetics\(^{(3)}\)
- **CPT codes:** 97010 hot or cold packs (including ice massage)
- **Reimbursement**
  - Coverage varies with insurance plans, depending on diagnosis and reason specific treatment is required. There might be limitations, such as number of treatments per condition or per time period
  - Cold packs applied in the absence of associated procedures or modalities, or used alone to reduce discomfort, are considered not to require the unique skills of a therapist
  - Code 97010 is bundled. It can be bundled with any therapy code. Regardless of whether code 97010 is billed alone in conjunction with another therapy code, this code is never paid separately. If billed alone, this code will be denied. Reimbursement for code 97010 is included in the reimbursement for the comprehensive therapeutic code...
Indications for device/equipment

Cryotherapy is used in a wide variety of conditions to reduce pain, swelling, and edema; to prevent hematoma formation; to reduce inflammation and metabolic activity; and to decrease nerve conduction velocity and muscle spasm.\textsuperscript{(1-3)} Conditions might include:
- Acute soft tissue injury
- Subacute and repair phase of soft tissue injury
- Postsurgical swelling and pain
- Exercise-induced muscle damage
- Chronic pain
- Rheumatoid arthritis flares
- Muscle spasm and tightness
- Spasticity
- Decreased ROM
- Myofascial trigger points
- Recovery after endurance performance
- Precooling prior to physical activity in warm conditions

Guidelines for use of device/equipment

There are no clear evidence-based guidelines for the selection of methods or protocols for application of cryotherapy\textsuperscript{(4,5)}

- In general, greater temperature reduction is thought to cause better suppression of metabolism, suggesting that techniques that reduce temperature more are more effective\textsuperscript{(5)}

Temperature change and the effects of cooling are related to the time of exposure, the method used to cool the tissue, and the conductivity of the tissue\textsuperscript{(6)}

- 15- to 20-minute applications are commonly reported
- Deeper tissue will require longer exposure to get desired effects
- Because adipose tissue can act as an insulator, obese patients might require longer exposure\textsuperscript{(7)}
  - Adipose thickness is commonly measured by skinfold thickness
  - Authors of a study conducted in the United States of skinfold thickness at common cryotherapy treatment sites found that skinfold thickness varied by sex, activity level, and site\textsuperscript{(8)}
    - It is recommended that clinicians measure skinfold thickness to determine an appropriate cryotherapy duration\textsuperscript{(8)}
- Researchers who conducted a randomized controlled trial in Taiwan compared the effects of 3 different ice pack therapy durations on soft tissue injuries\textsuperscript{(57)}
  - Ninety-nine patients presenting to the emergency department with soft tissue injuries were randomly assigned to receive ice pack therapy for 10, 20, or 30 minutes
  - Anti-swelling and analgesic effects and patient discomfort were measured
  - All 3 ice pack therapy durations lowered skin temperature, reduced pain, and caused similar discomfort. There were no significant differences between groups
  - The authors concluded that 10 minutes is the optimal ice pack therapy duration for patients with soft tissue injuries
- Muscular tissue temperature decreases during cryotherapy and continues to decrease even when the modality is removed\textsuperscript{(2,9)}
  - Other factors that might affect the amount of intramuscular temperature change include temperature gradient between the cold agent and body surface, and surface area\textsuperscript{(9)}
- Although cryotherapy is commonly thought to decrease blood flow, authors of a study measuring the perfusion and intramuscular temperature of the calf during cooling found that cryotherapy did not decrease blood flow and blood volume from resting levels in healthy subjects, even though intramuscular temperature decreased\textsuperscript{(10)}
  - The study was a single-blind crossover study conducted in the United States
  - A crushed ice bag was placed over the medial gastrocnemius muscle for the amount of time required for the subcutaneous tissue temperature to reach a 7°C decrease from baseline
  - Ultrasound was used to image microvascular perfusion
  - Intramuscular temperature was measured 1 cm into the muscle belly using a thermocouple
The question of whether any intramuscular temperature change affects blood flow remains. Future research on the effect of cryotherapy on blood flow in conditions that increase blood flow (e.g., inflammation, exercise) is warranted.

The same research group in the United States reported that ice did not decrease muscle perfusion 48 hours after eccentric muscle-damaging exercise that increased blood flow.

Based on a controlled laboratory study involving 18 healthy participants who performed unilateral heel-lowering exercises off a step to induce eccentric muscle damage:

- A randomized intervention (cryotherapy, sham or control) was applied to the exercised leg immediately after exercise, and 10, 24, 34 and 48 hours later.
- Cryotherapy was applied with a 750 g bag of crushed ice. A 750 g bag of room temperature candy corn was applied for the sham treatment. For the control group, a towel was placed over the area.
- Perfusion measurements were made using contrast-enhanced ultrasound.
- Blood volume and blood flow increased in all conditions at 48 hours after exercise; however, there were no interactions among interventions for microvascular perfusion.
- VAS scores were lower for the cryotherapy group than for the control group.
- The researchers concluded that although cryotherapy helped to control pain, it did not decrease muscle blood flow 48 hours after eccentric exercise, and therefore the proposed benefits of the clinical application of ice may need re-examining.

There are several methods and techniques used in the application of cold. They vary in their uses and effectiveness:

- Ice packs, cold packs, gel packs
- Ice applied directly to the skin in stroking motion
- Cold-water immersion
- Might be intermittent or continuous
- Cryotherapy devices – e.g., circulating water
- Ice water is delivered through a hose from a cooler to a bladder
- Bladder is applied to area of interest
- Cold compression units
- Combined cryotherapy and pneumatic compression
- Vapocoolant sprays
- Applied topically to skin
- Their evaporation might cause decrease in skin temperature
- Hyperbaric gaseous cryotherapy
- Carbon dioxide microcrystals under high pressure and low temperature are applied to the skin
- Modality was developed to shorten cooling time
- Cold air

The amount of time required to induce numbness for 3 different modes of cryotherapy and the duration of the numbness were investigated in a repeated study conducted in the United States.

- Crushed ice bag, ice massage, and cold-water immersion were each applied to 30 healthy adults on separate occasions.
- Ice massage and cold-water immersion produced numbness significantly faster than the crushed ice. There were no significant differences in numbness duration.
- Changes in cutaneous sensation occurred within 6–12 minutes with ice massage and cold-water immersion.

A comparison of patient-reported sensations and skin temperatures achieved with different cryotherapy modes found ice massage to be the best mode for achieving anesthesia as quickly as possible, whereas cold-water immersion and ice bag application might be better for pain reduction associated with noxious stimulation of skin receptors.

- 30 healthy subjects in the United States participated.
- Ice massage reduced skin temperature to a greater extent with less altered sensations prior to numbness.
- Cold-water immersion and ice bag application first produced altered sensations described as tight, tingling, cold, and stinging for longer periods of time.
- Ice massage produced an average skin temperature of 6.3°C at the time numbness was reported, compared to 16.1°C for ice bag and 14.6°C for cold-water immersion.
Contraindications/Precautions to device/equipment

› Contraindications
  • Do not use cryotherapy in patients with:\(^{(25)}\)
    – Cold urticaria (also known as cold hypersensitivity or cold allergy)
    – Raynaud’s disease
    – Cryoglobulinemia
    – Hemoglobinemia
    – Impaired circulation
    – Untreated hemorrhagic disorders
    – Active deep vein thrombosis (DVT) or thrombophlebitis
    – History of frostbite
  • Do not apply cryotherapy over/near:\(^{(25)}\)
    – Chronic wounds
    – Regenerating nerves
    – Tissues affected by tuberculosis
    – Hemorrhaging tissue
    – Anterior neck and carotid sinus
  • Use of cryotherapy at home is contraindicated in patients with cognitive and/or communication impairments that might impact safety\(^{(25)}\)
  • Open sores in spray area contraindicate use of vapocoolant sprays\(^{(23)}\)

› Precautions
  • Precautions must be used in patients with:\(^{(25)}\)
    – Impaired sensation
    – Infected tissues
    – Hypertension
      - Reports of the effects on heart rate and blood pressure are variable\(^{(3)}\)
        - Vasoconstriction might cause angina pectoris or elevation of blood pressure in susceptible individuals and can exacerbate peripheral vascular disease\(^{(2)}\)
    – Cardiac failure
  • Precaution must be used when applying cryotherapy over/near:\(^{(25)}\)
    – Eyes
    – Damaged or at-risk skin
  • Prolonged application at very low temperatures can cause serious side effects such as frostbite and nerve injuries\(^{(3)}\)
    – Risk of frostbite is reduced by applying a wrap between the ice and skin and by limiting time of application to less than 30–45 minutes
    – Nerve palsy can occur in areas where large nerves are superficial; most frequently peroneal nerve at knee and ulnar nerve at elbow
  • Frost nip (chilblain or pernio) can occur after an unprotected area of skin is exposed to mild cold at temperatures of 0–15°C (32–60°F)\(^{(26)}\)
  • Cold can increase elasticity and decrease viscosity of connective tissue
    – An increase in stiffness of collagen fibers can cause a decrease in muscle flexibility\(^{(3)}\)
    – Vigorous exercise immediately following cryotherapy is therefore not recommended\(^{(3)}\)
  • In a study to quantify the magnitude and persistence of vasoconstriction associated with cryotherapy, researchers in the United States found that cold-induced vasoconstriction can persist long after the cooling ends\(^{(74)}\)
    – Four different FDA-approved ice water circulating cryotherapy devices were used. Blood perfusion and skin temperature were measured at multiple sites during baseline, cooling, and rewarming
    – Even while the tissue temperature was returning to baseline, there was a significant and persistent state of vasoconstriction of the local area of cryotherapy treatment
    – This has implications when considering risk of ischemic injury with cryotherapy
Authors of a 2014 systematic review addressing the effect of local cooling on immediate functional outcomes in a sport situation reported that the available evidence suggests that athletic performance is adversely affected when athletes return to play immediately after cryotherapy.

- Thirty-five studies involving 665 healthy participants were included in the review.
- Relevant outcomes included strength, power, vertical jump, endurance, agility, speed, performance accuracy, and dexterity.
- Studies used variable cooling protocols with differences in mode of cryotherapy, time, and temperature.
- Increases in force output and decreases in upper and lower extremity strength were reported; however, effect sizes were small and clinical relevance questionable.
- The majority of studies reported decreases in performance, as measured by vertical jump, sprint, and agility. Cryotherapy also appeared to decrease hand dexterity and throwing accuracy immediately after intervention.

Use of cryotherapy might increase postural sway and impair proprioception and balance; however, evidence regarding proprioception is inconsistent.

- A study to determine the effects of cryotherapy on shoulder proprioception showed that proprioception and throwing accuracy were decreased after ice pack application to the shoulder.

- Twenty-two healthy subjects in the United States participated.
- Ice pack was applied for 20 minutes.
- Subjects demonstrated significant increases in path of joint motion replication and decreases in Functional Throwing Performance Index.
- The authors caution that cryotherapy might compound decreases in performance and proprioception that occur postinjury.

The effect of immersion cryotherapy on medial-lateral postural sway variability was studied in the United States in individuals with a lateral ankle sprain (LAS).

- Fifteen male subjects with recent grade I LAS participated.
- A single session, repeated measure design was used.
- Medial-lateral postural sway variability was greater after LAS. This effect was augmented by immersion cryotherapy.
- Interventions that further impair postural sway might increase reinjury risk, so caution is advised.

In individuals without ankle injury, immersion cryotherapy to the ankle was also found to impair medial-lateral standing balance in a study conducted in the United States.

- Twenty participants were tested under 2 conditions: ice water immersion of the foot and ankle for 15 minutes immediately before balance testing and at room temperature.
- A Biodex Balance System was used to quantify anterior-posterior, medial-lateral, and overall balance.
- Cryotherapy had a negative effect on the medial-lateral component, but not on anterior-posterior or overall balance.
- The implications of decreased medial-lateral balance on return to athletic activity should be considered.

Researchers in the United Kingdom found that 10 minutes of joint cooling did not adversely affect muscle reaction time or muscle amplitude in response to a simulated ankle sprain.

- In a randomized controlled trial, a total of 54 physically active individuals with no history of ankle injury were randomized to receive wet ice application, cold water immersion, or an untreated control condition for 10 minutes.
- Muscle reaction time and muscle amplitude of the peroneus longus and tibialis anterior in response to simulated ankle sprain (incorporating ankle inversion and plantarflexion) were measured.
- After cryotherapy there was no change in muscle reaction time or muscle amplitude.
- These findings suggest that athletes can safely return to their activity after 10 minutes of ankle joint cooling and that ice can be applied before ankle rehabilitation without adversely affecting dynamic control.

Authors of a study of the effect of application of cold packs and cold spray to the knee showed that cryotherapy impairs knee joint position sense and balance.

- Fifteen healthy volunteers in Turkey participated in 2 applications 1 week apart.
- Joint position sense was decreased immediately after cold pack and cold spray application.
- Static one-leg balance was impaired after cold pack but not cold spray, and returned to normal after 5 minutes.
- Caution is advised when cryotherapy is followed by immediate return to athletic activity.

In a small study conducted in Taiwan, researchers found that cryotherapy for chronic ankle instability resulted in reduced proprioception and reduced balance immediately following icing. Researchers recommended that sports trainers/coaches be aware of this phenomenon and educate athletes when they return to the field following ankle cryotherapy.


In a crossover study conducted in the United States, no immediate differences in lower extremity performance outcomes were found after use of different cryotherapeutic interventions at the ankle compared to a control \(^{(20)}\).

- Thirty young, healthy, physically active volunteers participated.
- Three different treatment modes were applied: no ice, ice without compression, and ice with compression.
- Outcomes measured included center of pressure excursion, dynamic balance reach distances, and vertical jump height.
- The order of treatment and performance measures was randomized.
- Cryotherapy was not found to be detrimental to immediate measures of dynamic and static balance or functional performance. Further research is warranted to determine long-term effects.

Cold-water immersion for 30 minutes to the level of the umbilicus might not impair joint position sense \(^{(30)}\).

- Based on a randomized crossover trial conducted in Ireland.
- Fourteen healthy volunteers were randomized to cold (14°C [57°F]) vs. tepid (28°C [82°F]) lower-body water immersion followed by crossover to other intervention 1 week later.
- Water immersion was to the level of the umbilicus and lasted 30 minutes.
- No significant difference in knee joint position sense was detected between cold and tepid water immersion.

Results of a study conducted in Brazil indicate that a decrease in the EMG response to ankle inversion occurs in several lower extremity muscles after the use of cold-water immersion of the foot and ankle, with a residual effect that lasts up to 30 minutes \(^{(62)}\).

- The EMG responses of the lateral gastrocnemius, tibialis anterior, fibularis longus, rectus femoris, and gluteus medius were recorded following cold-water immersion of the ankle in 35 healthy active participants.
- Responses were significantly lower after cold-water immersion compared to pre-immersion for all muscles except the gluteus medius, indicating that after cold-water immersion special care should be taken in activities that require greater neuromuscular control.

Cold application even for short durations might detrimentally affect agility and power:

- A study in the United States of the effects of ice bag application to the hamstrings showed impaired functional performance in tasks that involved hamstrings immediately and 20 minutes later \(^{(31)}\).

Examination

Contraindications/precautions to examination

- In circumstances in which cryotherapy is being applied as a first-aid treatment in acute injury, elements of this examination should be deferred until later.

History

- History of present illness/injury for which the device is needed
  - Mechanism of injury or etiology of illness: Identify reason for referral.
Course of treatment
- **Medical management**: Medical management will vary depending on the specific underlying condition; document any reported diagnostic tests, therapeutic interventions, complications, and/or hospital stays.
- **Medications for current illness/injury**: Determine what medications have been prescribed and are being taken, and if they are effectively controlling symptoms.
- **Diagnostic tests completed**: Depending on the presenting condition, patient might have had diagnostic imaging and/or electromyography (EMG); review imaging and reports as able.
- **Home remedies/alternative therapies**: Document any use of home remedies (e.g., ice or heating pack) or alternative therapies (e.g., acupuncture) and whether or not they help.
- **Previous therapy**: Document whether patient has had occupational or physical therapy for this or other conditions and what specific treatments were helpful or not helpful.
- **Aggravating/easing factors**: (and length of time each item is performed before the symptoms come on or are eased)
- **Body chart**: Use body chart to document location and nature of symptoms.
- **Nature of symptoms**: Document nature of symptoms (e.g., constant vs. intermittent, sharp, dull, aching, burning, numbness, tingling).
- **Rating of symptoms**: Use a visual analog scale (VAS) or 0–10 scale to assess symptoms at their best, at their worst, and at the moment (specifically address if pain is present now and how much).
- **Pattern of symptoms**: Document changes in symptoms throughout the day and night, if any (A.M., mid-day, P.M., night); also document changes in symptoms due to weather or other external variables.
- **Sleep disturbance**: Document number of wakings/night.
- **Other symptoms**: Document other symptoms the patient is experiencing that could exacerbate the condition and/or symptoms that could be indicative of a need to refer to physician (e.g., dizziness, bowel/bladder/sexual dysfunction, saddle anesthesia).
- **Respiratory status**: Document if applicable.
- **Barriers to learning**
  - Are there any barriers to learning? Yes___ No___
  - If Yes, describe ________________________

Medical history
- **Past medical history**
  - **Previous history of same/similar diagnosis**
  - **Comorbid diagnoses**: Ask patient about other problems, including diabetes, cancer, heart disease, vascular compromise, peripheral neuropathy, complications of pregnancy, psychiatric disorders, and orthopedic disorders. Specifically ask about any history of Raynaud’s disease, cold urticaria, or cryoglobulinemia.
  - **Medications previously prescribed**: Obtain a comprehensive list of medications prescribed and/or being taken (including over-the-counterdrugs).
- **Other symptoms**: Ask patient about other symptoms he or she is experiencing.

Social/occupational history
- **Patient’s goals**: Document what the patient hopes to accomplish with therapy and in general.
- **Vocation/avocation and associated repetitive behaviors, if any**: Does the patient participate in recreational or competitive sports? Is the patient employed? What is the nature of the work tasks?
- **Functional limitations/assistance with ADLs/adaptive equipment**: Include limitations with self-care, home management, work, and community leisure.
- **Living environment**: Document information about the patient’s living situation including stairs, number of floors in home, with whom patient lives (e.g., caregivers, family members). Identify if there are barriers to independence in the home; any modifications necessary?

Relevant tests and measures: (While tests and measures are listed in alphabetical order, sequencing should be appropriate to patient medical condition, functional status, and setting.) Evaluation procedures should be modified according to the patient’s age, diagnosis, and any unique circumstances; the information listed below is meant to serve as a guide only. Complete a general evaluation as indicated and appropriate. Repeat measures after use of cryotherapy as indicated.
- **Anthropometric measurements**: Circumferential or volumetric measures of swelling.
- **Arousal, attention, cognition (including memory, problem solving)**: Complete a cognitive assessment as indicated and appropriate. Is the patient able to inform the provider about sensations being experienced?
- **Assistive and adaptive devices**: Does the patient utilize any assistive or adaptive devices? Are they appropriate?
• **Balance**: Assess the patient’s balance in sitting and standing as indicated. Use a standardized test such as Berg Balance Test.

• **Cardiorespiratory function and endurance**: Assess vital signs as indicated and appropriate, including perceived exertion via the Borg Rating of Perceived Exertion (RPE) Scale.

• **Circulation**: Assess for signs of diminished circulation, such as swelling, weak pulses, coldness, changes in skin color, and nonhealing sores.

• **Ergonomics/body mechanics**: Assess for faulty body mechanics that might be contributing to the patient’s symptoms.

• **Functional mobility**: Assess function as indicated by underlying condition. Use a standardized test such as FIM as indicated.

• **Gait/locomotion**: Complete a thorough gait assessment if indicated by reason for referral.

• **Joint integrity and mobility**: Assess joint integrity as indicated by symptoms and reason for referral.

• **Motor function (motor control/tone/learning)**: Depending on presenting condition, a thorough assessment of motor function, including voluntary movement, coordination, and muscle tone, might be indicated.
  – The Modified Ashworth Scale can be used to assess spasticity.

• **Muscle strength**: Complete a strength assessment throughout with a particular focus on the area where cryotherapy is to be applied. Manual muscle testing (MMT) might be used except where there is abnormal muscle tone or coordination.

• **Observation/inspection/palpation** (including skin assessment)
  – Inspect skin for any signs of irritation or breakdown
  – Assess for swelling
  – Assess for adverse reaction after cryotherapy application.

• **Posture**: Assess the patient’s general posture.

• **Range of motion**: Complete a ROM and flexibility assessment with a particular focus on the area where cryotherapy is to be applied.

• **Reflex testing**: Assess deep tendon reflexes.

• **Self-care/activities of daily living (objective testing)**: Complete an ADL assessment as indicated.

• **Sensory testing**: Complete a thorough sensory assessment (e.g., light touch, temperature, pin-prick) of the area where cryotherapy is to be applied.
  – Where applicable, assess proprioception after application of cryotherapy before return to athletic activity.

### Assessment/Plan of Care

› **Contraindications/precautions**
  • See Contraindications/Precautions to device/equipment, above.

› **Diagnosis/need for device/equipment**
  • Acute musculoskeletal trauma
    – Acute soft tissue injury
    – Post orthopedic surgical swelling and pain
    – Exercise-induced muscle damage
  • Decreased muscle strength/torque production after acute phase of injury
  • Chronic pain
  • Rheumatoid arthritis
  • Muscle tightness
  • Decreased ROM
  • Endurance performance
    – Recovery after/between endurance performance
    – Precooling prior to endurance performance in hot environmental conditions.

› **Prognosis**: Prognosis varies depending on the underlying condition and its severity.

› **Referral to other disciplines**: Refer to other disciplines if indicated by underlying condition.

› **Other considerations**
  • The physiological and biochemical basis for the use of cold-water immersion following exercise has yet to be fully elucidated.
  – Based on a systematic review of 16 studies evaluating the physiological and biochemical effect of brief periods of cold-water immersion.
  – Majority of the research was conducted in healthy persons.
Cold-water immersion was associated with:
- Increased heart rate, blood pressure, respiratory minute volume, and metabolism
- Decreased end tidal carbon dioxide partial pressure and decreased cerebral blood flow
- Among the included studies there were also reports of increased peripheral catecholamine concentration and increased oxidative stress

Authors of a 2013 systematic review of water immersion for postexercise recovery concluded that several factors influence its efficacy on acute recovery of performance\(^6\)\(^3\)
- Effect on performance was influenced by the time between cold-water immersion and the subsequent exercise
- Temperature and duration of exposure are important
- The optimal cold-water immersion duration might depend on the water temperature

Authors of a 2013 meta-analysis of studies that involved trained athletes found that effect sizes of cooling on performance recovery were relatively small, but that under certain conditions postexercise cooling seems to have effects that are large enough to be relevant for competitive athletes\(^6\)\(^4\)
- Twenty-one peer-reviewed randomized controlled trials were included
- The largest average effect size was found for sprint performance
- Endurance parameters, jump, and strength effect sizes were smaller
- Whole-body immersion was significantly more effective than immersing only the legs or arms
- Effects were most pronounced when performance was evaluated 96 hours after exercise

**Treatment summary**

- See Description, Indications of device/equipment, and Guidelines for use of device/equipment, above
- General considerations
  - Authors of a study in the United Kingdom of the cooling efficiency of different cryotherapeutic agents found that crushed ice and ice-water immersion provided significantly greater cooling efficiency than gel packs and frozen peas\(^6\)
    - A repeated measures design was used
    - Skin surface temperature of the ankle was measured after a 20-minute cryotherapy application
    - The crushed ice and ice-water immersion had the greatest cooling efficiency and sustained decreased surface temperature post application
    - Twenty-minute applications caused skin surface temperature to fall within the therapeutic temperature range
    - Further research is needed to investigate depth of cooling and the relationship between deeper tissue temperature and skin temperature
  - The cooling effectiveness of different types of ice used in ice packs was evaluated in a repeated measures study conducted in the United States\(^7\)
    - Ice packs were made of polyethylene bags filled with cubed ice, crushed ice, or cubed ice plus water (“wetted ice”)
    - Cutaneous and intramuscular temperature was measured
    - Wetted ice was more effective than cubed ice and crushed ice in lowering surface temperature during treatment and maintaining the lower temperature during recovery
    - Wetted ice and cubed ice were more effective than crushed ice in lowering intramuscular temperature and maintaining the lower temperature
  - Although the wetted ice bag is currently the clinical gold standard for decreasing intramuscular temperature, researchers in the United States reported in 2016 that salted cubed ice bags were as effective as wetted bags at decreasing intramuscular temperature at 2 cm subadipose, and suggested that salted ice bags may be more clinically practical\(^7\)\(^7\)
    - Based on a repeated measures study that involved 24 healthy participants
    - Ice bags made of wetted ice (2,000 mL ice and 300 mL water), salted crushed ice, and salted cubed ice were applied to the posterior gastrocnemius for 30 minutes
    - The presence of water in the ice bags provides better contact with the skin
    - When salt is applied to ice, the ice begins to melt and the substance’s freezing point is lowered, with the resulting water staying in liquid form at lower than freezing temperatures
    - Cutaneous and intramuscular temperatures of nondominant gastrocnemius were measured at baseline, immediately after treatment, and during a 45 minute rewarming period
  - The author of a study conducted in Thailand investigating the effect of the quantity of ice used in ice packs found that an ice pack containing at least 0.6 kg ice leads to greater cooling than a 0.3 kg ice pack regardless of the size of the contact area\(^9\)
Authors of a study conducted in the United States of the immediate effects of acupuncture and cryotherapy via ice packs on a model of anterior knee pain produced with hypertonic saline infusion found cryotherapy more effective than acupuncture to reduce the pain (33).

Authors of a study in the United States comparing the use of ice and the topical menthol Biofreeze on acute, uncomplicated neck pain found that both treatments significantly decreased pain levels; however, Biofreeze decreased pain nearly twice as much as ice, and lasted longer (34) (34).

- Fifty-one patients participated
- Patient comfort and preference favored Biofreeze

Combining crushed ice with topical menthol appears to have an additive effect on arterial blood flow (65).

- Based on a study conducted in the United States involving healthy participants
- A more rapid reduction in blood flow with the combined treatment might result in more rapid onset of maximum effect and decrease the need for sustained tissue cooling, thereby limiting risk of frostbite

• Acute soft tissue injury: Cryotherapy is widely practiced in the treatment of acute soft tissue injuries; however, there is insufficient evidence that it improves the clinical outcomes of soft tissue injury

- Authors of a randomized controlled trial conducted in Ireland comparing two icing protocols for acute ankle sprains found that both protocols produced good results (35).

- Eighty-nine participants received either intermittent ice pack application (10 minutes on, 10 minutes off, 10 minutes on) or a standard protocol (20 minutes continuous) every 2 hours for the first 72 hours after injury
- Outcome measures included ankle function, pain at rest and during activity, and ankle swelling
- At 6 weeks both groups had improved in all measures

- Therapeutic benefits of cryotherapy are enhanced by simultaneous application of compression (20, 21, 22).

- Static compression increases the depth of temperature reduction achieved
- Cryotherapy and compression modify the inflammatory response to soft-tissue injury
- Further research is needed to compare the different modes of compression application in conjunction with cryotherapy

- The author of a 2008 review of the literature pertaining to use of cryotherapy for soft tissue trauma reported a paucity of evidence for such a well-accepted practice (36).

- Results indicated there are few well-conducted trials, patient numbers are low, and direct comparisons between studies are difficult
- The author concluded that cryotherapy might be beneficial but that volume and quality of data are inadequate

- Authors of a systematic review of randomized controlled trials concluded that many more high-quality trials are needed to provide evidence-based guidelines for the use of ice in the treatment of acute soft tissue injury (35).

- Twenty-two trials met inclusion criteria
- Variations in treatment protocols made comparisons within and across studies impossible
- The basis for the application of cryotherapy in the immediate and rehabilitative phases of injury management is not clear
- Outside the immediate stages of injury management, cryotherapy might be most effective when combined with exercise

- There are several limitations of randomized controlled trials involving the application of cryotherapy for the treatment of acute soft tissue injury (37).

- Time from injury to presentation is variable
- Patients might apply ice to their injury prior to seeking treatment
- Icing protocols rely heavily on patients’ rigorous compliance
- Blinding is not possible

• Exercise-induced muscle damage: Cryotherapy is a commonly used treatment believed to reduce symptoms of exercise-induced muscle damage. Results of studies evaluating the effects of cryotherapy are conflicting, and protocols vary

- A 2012 Cochrane review found evidence that cold-water immersion reduces delayed-onset muscle soreness after exercise (38).

- Seventeen studies, with a total of 366 participants, were included in the systematic review
- Fourteen of the studies compared cold-water immersion after exercise to passive treatment (rest or no treatment)
- There was evidence that cold-water immersion reduced muscle soreness at 24, 48, 72, and 96 hours after exercise
- The optimum method of cold-water immersion is not clear, as temperature, duration, and frequency of cold-water immersion varied between the different trials
- Study quality was reported to be low, and most trials did not perform surveillance for adverse events. Further studies are recommended.

Authors of a 2016 systematic review and meta-analysis found that the available evidence suggests that cold-water immersion can be slightly better than passive recovery in the management of muscle soreness, and that there is a dose-response relationship. Nine randomized controlled trials that compared cold-water immersion to passive recovery were included. Meta-analysis indicated that cold-water immersion is more effective than passive recovery in terms of immediate and delayed effects. Water temperature between 11 and 15°C for 11–15 minutes provides the best results for both immediate and delayed effects.

Authors of a 2007 randomized controlled trial of the effect of 10-minute cold-water (10°C) immersion after muscle-damage-inducing exercise found that it reduced some of the indices of muscle damage. Twenty healthy males participated in this study in the United Kingdom. Muscle damage was induced by completion of 90 minutes of intermittent shuttle run. Indicators of muscle damage included perceived soreness, changes in muscular function, and efflux of intracellular proteins. Individuals who received cryotherapy treatment reported significantly less perception of muscle soreness at 1, 24, and 48 hours post exercise. They also had significantly smaller decrements in maximal voluntary contraction compared to controls and reduced serum myoglobin responses 1 hour post exercise.

Authors of a 2009 randomized controlled study in the United Kingdom on the effect of cold-water immersion therapy on recovery from exercise-induced muscle damage found no beneficial effects. Eighteen healthy females participated. Treatment group received a single 10-minute bout of cold-water (10°C) immersion after completing exercise to induce muscle damage. Indicators of muscle damage included plasma creatine kinase (CK) activity, perceived muscle soreness, and maximal voluntary contraction of the quadriceps. Results indicate that a single bout of cold-water immersion does not alleviate symptoms of exercise-induced muscle damage.

A 2007 randomized, double-blind, controlled trial in Australia did not find three 1-minute immersions in ice water (5°C) effective in minimizing delayed-onset muscle soreness symptoms. Forty untrained volunteers participated. Participants performed eccentric loading exercises to induce muscle soreness. Outcome measures included pain and tenderness, swelling, function, maximum isometric strength, and serum CK. No significant differences were observed between immersion in ice water or tepid water in any parameters except pain at 24 hours, which was greater in the intervention group than the control group.

Authors of a 2013 randomized controlled trial conducted in Taiwan found that topical cooling with cold packs did not improve, but rather delayed, recovery from eccentric exercise-induced muscle damage. A randomized crossover design (N = 11) was used. Participants received topical cooling or sham treatment during recovery from eccentric exercise. Plasma CK, myoglobin, muscle soreness and fatigue, and muscle strength were measured. Topical cooling resulted in significantly higher circulating CK-MB and myoglobin than in controls at 48 and 72 hours post exercise. There were no significant differences in the subjective pain or muscle strength scores. These results suggest that topical cooling might actually disrupt the normal adaptive responses to exercise.

Researchers in Japan found that regular post-exercise cold applications to muscles might attenuate muscular and vascular adaptations to resistance training. Fourteen subjects performed wrist-flexion resistance training for 6 weeks. Training included 5 sets of 8 wrist flexion exercises at 70–80% repetition max, 3 times per week. Seven participants immersed their experimental forearms in cold water (10°C) for 20 minutes after the exercises, and 7 did not.
Measurements taken before and after the training period included wrist flexor thickness, brachial diameter, maximal muscle strength, and local muscle endurance.

Wrist flexor thickness of the experimental arms increased in both groups, but the increase was significantly less in the cooled group compared to the noncooled group.

Maximal muscle strength and brachial artery diameter did not increase in the cooled group, but did increase in the noncooled group.

Local muscle endurance increased in both groups, but the increase was lower in the cooled group than the noncooled group.

Authors of a 2012 study in the United States comparing Biofreeze to ice for delayed-onset muscle soreness found that Biofreeze decreased perceived discomfort to a greater extent and permitted greater tetanic forces to be produced.

Sixteen subjects were randomly assigned to receive Biofreeze or ice 2 days after performance of elbow flexion exercises designed to induce muscle soreness.

Maximum voluntary contractions and evoked tetanic contractions were measured prior to inducing muscle soreness and 20, 25, and 35 minutes after treatment with ice or Biofreeze.

Pain perception was measured with a VAS.

Postoperative

The efficacy and safety of using cryotherapy devices in the postoperative setting was evaluated in a small study conducted in the United States in healthy individuals.

Three different cryotherapy devices were applied over different amounts of layering.

Skin temperature was recorded every 15 minutes for 180 minutes.

Safe and effective temperature range was achieved with all devices when applied over one layer of Jones compression dressing.

Effective temperature range was not achieved over 2 layers of Jones compression dressing.

Efficacy and safety was less predictable when devices were applied over thinner, standard surgical dressings.

Results of a prospective, double-blind, quasi-experimental study conducted in Taiwan indicate that cryotherapy with ice in a plastic bag is effective for relieving postarthroscopy pain, and can be applied in standard protocols for patients who have just undergone arthroscopic surgery.

Fifty-nine patients who received arthroscopy were assigned to receive cryotherapy or no cryotherapy.

Cryotherapy was applied in three 10-minute sessions over a 3-hour period.

Knee-joint icing early after total knee arthroplasty (TKA) has not been found to have an effect on knee extension strength or knee pain.

Based on a prospective single-blind randomized crossover study conducted in Denmark.

Twenty unilateral TKA patients participated.

Treatment consisted of 30 minutes of either knee icing or elbow icing, applied on day 7 and day 10 postoperatively.

Order of treatments was randomized.

Knee-joint icing had no acute effect on knee extension strength or pain.

Researchers in the United States also found that short-term application of cryotherapy post TKA did not significantly decrease pain nor did it improve patient satisfaction with pain management.

Based on a randomized controlled trial with crossover that involved 29 patients post TKA.

Two sequential episodes of pain requiring analgesic administration were studied in each patient, one with a 30-minute cryotherapy application and one without, in random order.

The benefit of short-term cryotherapy for pain relief post TKA was found to be questionable.

In a single-blinded randomized controlled study, researchers in China found cryotherapy to be effective in relieving pain and reducing analgesic consumption for patients post elbow arthrolysis.

Fifty-nine patients who received elbow arthrolysis were randomly assigned to a cryotherapy plus standard care group or to a control group receiving standard care only.

VAS scores were significantly lower in the cryotherapy group during the first 7 postoperative days, both at rest and in motion.

Chronic pain: Evidence supporting the use of cryotherapy in the management of chronic pain is not definitive, even though it is commonly used.

Studies suggest that cryotherapy might be a beneficial adjunctive tool for low back pain, chronic headache, trigeminal neuralgia, and chronic osteoarthritis.
• Acute low back pain: Although commonly used, there is no evidence for icing or other cold therapies as treatments for acute low back pain\(^{(42)}\)
  - Based on a 2011 review
  - For the majority of low back pain cases there is no obvious acute injury that would benefit from cryotherapy to slow nerve conduction and reduce inflammation, and no diagnostic tests or symptom patterns to link common low back pain to soft tissue injury
• ROM: Spray and stretch techniques using vapocoolants are widely used by clinicians to increase ROM of various joints\(^{(23)}\). The mechanism of action is unclear and might be counterirritation or diversion of blood from vasoconstricted superficial vessels\(^{(43)}\)
  - A randomized controlled trial of the effect of topical aerosol skin refrigerant on passive and active stretching conducted in France suggests that spray and stretch techniques are effective to increase hip flexion ROM\(^{(23)}\)
    - Thirty volunteers were randomly assigned to spray and stretch treatment or stretch only
    - A vapocoolant blend of pentafluoropropane and tetrafluoroethane was applied
    - The group receiving vapocoolant obtained greater increases in active and passive hip flexion
    - Vapocoolants might be beneficial in treatment of other joints – studies are needed
  - Products that are applied topically and produce a sensation of cooling do not necessarily have the effect of a cold application\(^{(43)}\)
    - Products containing a high concentration of menthol (e.g., Biofreeze gel) produce a cooling sensation without lowering skin temperature
    - Other mechanisms (e.g., gate control) are hypothesized for any resultant pain inhibition
• Muscle function: The analgesic effect of cryotherapy allows a patient to perform therapeutic exercises that would otherwise be painful. Evidence suggests that the beneficial effects of cryokinetics (the use of cryotherapy in conjunction with exercise) might be partially due to disinhibition of the musculature surrounding the injured joint\(^{(44)}\)
  - Arthrogenic muscle inhibition (AMI) is a condition that involves neural inhibition of uninjured musculature surrounding an injured joint
    - Increased torque production following cryotherapy treatment at the knee and ankle has been reported\(^{(44)}\)
    - Since participants were not experiencing pain, the effect was not due to analgesia
    - It is hypothesized that the cryotherapy causes a decrease in the reflex inhibition of the motor system
  - Volitional activation of quadriceps has been shown to increase following focal knee-joint cooling in noninjured volunteers\(^{(45)}\)
    - Based on a counterbalanced, crossover study conducted in the United States
    - Ice packs were applied to the knees of 11 healthy volunteers
    - Quadriceps central activation ratio was measured after knee-joint cooling and in control conditions
    - Results suggest that the increased central activation ratio can last up to 45 minutes
    - Increasing the ability to activate inhibited musculature before exercising could potentially improve outcomes and reduce risk of injury
  - The effects of TENS and focal knee-joint cooling on quadriceps activation were studied in patients with osteoarthritis in a single-blind randomized controlled trial conducted in the United States\(^{(46)}\)
    - Thirty-three subjects were randomly assigned to a TENS group, a joint cooling group, or a control group
    - Knee-joint cooling was achieved by 20 minutes of ice pack application
    - The quadriceps central activation ratio increased in both the TENS group and the focal knee-joint cooling group
  - Short-duration cryotherapy might be a useful adjunct to treatment with neuromuscular electrical stimulation (NMES)\(^{(67)}\)
    - Based on a study conducted in the United States
    - Cryotherapy can improve tolerance to higher levels of current and strong contractions; however, higher tolerance might not result in generation of higher isometric torque
    - Longer duration of cold modalities (> 20 minutes) might decrease the maximum twitch response and tetanic responses during NMES
  - Superficial cooling over a damaged muscle was found to inhibit force loss in a 2008 study conducted in the United States\(^{(47)}\)
    - Seven healthy volunteers participated
    - Muscle damage in the medial gastrocnemius was created using transcutaneous electrical stimulation
- Cooling was achieved using ice packs for 15 minutes
- Without superficial cooling, peak torque generated in the muscle was lower than with cooling

**• Muscle tone:** Use of cryotherapy to reduce tone in spastic muscles is sometimes recommended for patients with neurological disorders such as stroke or traumatic brain injury

–Cryotherapy might temporarily reduce spasticity symptoms, and is thought to cause its effect by lowering the stretch sensitivity of muscle spindles by decreasing nerve conduction velocity in the gamma system\(^\text{[48]}\)

- Authors of a randomized crossover trial conducted in Brazil investigated the immediate effects of TENS and cryotherapy in the reflex excitability and voluntary activity in hemiparetic participants\(^\text{[48]}\)

- Twenty patients at least 6 months post stroke participated
- Spasticity, measured in the soleus muscle using the Modified Ashworth Scale, was between 1 and 3 in all subjects
- Ice compresses were applied over the gastrocnemius and soleus muscles for 30 minutes
- H reflexes and maximum M waves were recorded before and after treatment
- A statistically significant reduction in the Hmax/Mmax ratio occurred after TENS application; however, a statistically significant increase in Hmax/Mmax ratio occurred after icing
- An increase in H reflex latency was also observed, due to a decrease in conduction velocity caused by cooling
- These findings suggest that TENS might be the treatment of choice for immediate reduction of reflex excitability and that cryotherapy might increase reflex excitability in hemiparetic patients
- This conflicts with findings of prior studies, suggesting that further investigation is warranted

**• Trigger points**

–Spray and stretch technique (using vapocoolant spray) appears to be as effective as ultrasound and Lewitpost-isometric relaxation technique for improving ROM, disability, and pain in patients with acute active central trigger points of the upper trapezius\(^\text{[49]}\)

- Based on a randomized trial conducted in India
- Forty-five patients with acute active central trigger points of the upper trapezius were randomized to 1 of 3 groups
  - Spray and stretch technique – vapocoolant spray applied over trapezius muscle followed by stretching
  - Lewitpost-isometric relaxation technique – specialized technique involving isometric contraction followed by relaxation with subsequent stretch
  - Ultrasound therapy – 1.2 to 1.5 watt/cm\(^2\) at 3 MHz for 5 minutes per session
- All 3 groups had significant improvements in ROM, pain, and disability at 10 days compared to baseline
- No significant differences between groups were detected in ROM, pain, or disability at 10 days

**• Endurance performance/exercise-induced hyperthermia:** Despite a lack of scientific research on its effects, cold-water immersion as a recovery strategy following high-intensity exercise has become increasingly popular.\(^\text{[18]}\) It has also been investigated as a cooling intervention before physical activity (i.e., precooling)

–Body cooling is associated with improved aerobic performance in athletes\(^\text{[50]}\)

- Based on a systematic review
- Systematic review included 13 randomized trials evaluating the effect of body cooling on aerobic and anaerobic athletic performance
- Body cooling was associated with a significant increase in
  - aerobic performance in 7 of 9 trials that evaluated the effect of cooling on aerobic performance
  - anaerobic performance in 1 of 6 trials that evaluated the effect of cooling on anaerobic performance
–Authors of a 2009 systematic review of whole-body cooling for exercise-induced hyperthermia concluded that ice water provides the most efficient cooling\(^\text{[16]}\)

- Exertional heat stroke is a medical emergency marked by an elevated core body temperature above 40°C and CNS dysfunction
- Rapid cooling is required
- Randomized controlled trials are impossible and unethical for this condition
- Published research specific to cooling modalities for exercise-induced hyperthermia is scarce
- Athletic trainers are advised to have ice and tubs for immersion available at athletic events
–Authors of a 2015 meta-analysis investigating the optimal procedures for cold-water immersion for exertional heat stroke concluded that prompt, vigorous cold-water immersion should be encouraged for treating exercise-induced hyperthermia
whenever possible, using cold-water temperature of approximately 10°C and maximizing body surface contact (whole-body immersion)\(^{(82)}\)

- Nineteen studies were included
- Results demonstrated that cold-water immersion had a significant effect. Cold-water immersion cooled individuals twice as fast as passive recovery
- Immersion duration of 10 minutes, immersing torso and limbs, was most effective. There is insufficient evidence of effectiveness of immersing just forearms and hands for rapid cooling

Authors of a 2008 Australian study of the effect of cold-water immersion on repeat cycling performance supports its use at times when two training sessions are performed in hot environmental conditions\(^{(18)}\)

- Ten well-trained male cyclists participated
- Cyclists performed a 30-minute cycling exercise protocol followed by a recovery protocol, before repeating the 30-minute exercise protocol
- Five different recovery protocols were compared: intermittent cold-water immersion in 10°C, 1°C, and 20°C water; continuous immersion in 20°C water; and “active recovery” (continued cycling at 40% VO2 peak)
- Outcome measures were core and skin temperature, blood lactate, heart rate, rating of thermal sensation, and rating of perceived exertion
- All cold-water immersion protocols were effective in reducing thermal strain and were more effective in maintaining subsequent high-intensity cycling performance than active recovery

The effects of cold-water immersion between matches on performance of soccer players have been studied\(^{(51,52)}\)

- Cold-water immersion (10°C) was compared to thermoneutral water immersion (34°C) in one study\(^{(51)}\)
  - Twenty high-performance junior soccer players participated
  - Results suggest immediate post-match cold-water immersion does not affect physical test performance or indices of muscle damage and inflammation but does reduce the perception of general fatigue and leg soreness
- Cold-water immersion (12°C) was compared to quiet sitting for 15 minutes in another study\(^{(52)}\)
  - Twenty-two U.S. Division I collegiate soccer players participated
  - Cold-water immersion performed immediately and 24 hours after volitional fatigue did not affect subsequent physical performance

Authors of a study in the United States of the impact of cold-water immersion on 5 km racing performance did not support its use to enhance recovery between performances\(^{(14)}\)

- Twelve runners participated
- Runners were treated with 12 minutes of cold-water immersion after a baseline 5 km run followed by 24 hours of passive recovery
- Performance on a second 5 km run was evaluated
- Outcome measures were finishing times, heart rate, perceived exertion, fatigue, and soreness
- Individual variability existed in response to treatment
- Future research is needed to evaluate effect of length of treatment, water temperature, and distance of run

Authors of a 2012 meta-analysis of precooling and sports performance found that precooling can effectively enhance endurance performance, particularly in hot environments. The effect of precooling on sprint and intermittent sprint performance was considerably smaller\(^{(53)}\)

- Twenty-seven randomized controlled trials were analyzed
- Eighteen studies were performed in a hot environment
- Cooling protocols included water application, cold drinks, cooling vests, and a cooled room

Authors of a 2013 systematic review found clear evidence of benefits for precooling strategies in laboratory settings that suggests that these strategies could be used by athletes competing in hot conditions to improve exercise safety, reduce perceived thermal stress, and improve sports performance\(^{(68)}\)

- Fifty-five studies that met the following criteria were included:
  - Cooling was conducted before exercise
  - Cooling was conducted in a manner that was achievable during sports competition
  - Athletic performance was measured
  - Subjects were able-bodied and free of disorders that would affect thermoregulation
  - Subjects were endurance trained
- Cooling was not performed on already hyperthermic subjects in immediate danger of heat-related illness
- Drink ingestion protocols were used
- Studies included at least 6 subjects
- Most laboratory studies have shown improvements in exercise performance with precooling
  – Cooling the surface of the neck has been reported to improve running performance in a hot environment (54)
- Based on a study conducted in the United Kingdom
- Three experimental conditions were completed: wearing a cooling collar from the start, wearing a cooling collar that was replaced at 30 minute intervals to maintain the low temperature, and not wearing a cooling collar
- Participants ran for 75 minutes at 60% VO2 max followed by a 15-minute time trial
- Runners ran farther while wearing the cooling collar. No additional benefit was obtained from replacing the collar as it warmed up
  – The effects of 2 precooling techniques on cycling performance were compared in trained cyclists (55)
- Performance time was faster following a precooling protocol that combined the use of a cooling jacket with immersion in cool water (24-28°C)
- The goal of the protocols was to actively cool participants prior to the start of exercise
- The combined protocol reduced core body temperature more than the cooling jacket alone
  – The use of an ice-cooling vest for 20 minutes before exercising improved running performance in a study conducted in Germany of the effect of precooling on endurance in the heat (56)
- Twenty physical education students were tested
- A randomized 3-condition crossover design was used
- Three different exercise preparation conditions were compared: warming up by running 20 minutes at 70% maximum heart rate, precooling by wearing a cooling vest for 20 minutes, and no preparation procedure (control)
- Subjects completed treadmill runs to exhaustion in 3 sessions 5 days apart
- Running performance, heart rate, blood lactate concentration, tympanic temperature, and skin temperature were measured
- Performance time improved and overall cardiovascular strain decreased with precooling
  – A combination of internal and external body-cooling techniques might enhance repeated athletic performance in heat more than individual cooling methods do (69)
- Based on a randomized controlled trial conducted in Australia
- Twelve repeated sprint cyclists were randomized to 1 of 4 experimental conditions: a cooling jacket, ingestion of an ice slushy, combination of cooling jacket and ice slushy, or control
- All of the cooling techniques improved performance in comparison to the controls. In comparison to the individual cooling techniques, enhancement of sprint performance was greater with the combination of internal and external body cooling techniques

<table>
<thead>
<tr>
<th>Problem</th>
<th>Goal</th>
<th>Intervention</th>
<th>Expected Progression</th>
<th>Home Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute soft tissue injury</td>
<td>Reduce pain, swelling, and inflammation (3,4)</td>
<td>Physical agents and mechanical modalities</td>
<td>10–20 minutes every 2 hours for first 48–72 hours</td>
<td>Decrease or discontinue after 72 hours or when pain and swelling subside</td>
</tr>
<tr>
<td>Subacute or repair phase of soft tissue injury&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Enable active exercise of muscles around soft tissue injury</td>
<td><strong>Physical agents and mechanical modalities</strong>&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Apply cold prior to active exercise throughout repair phase</td>
<td>Continue with cold application even after pain subsides, to obtain stronger contractions</td>
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<tr>
<td>Muscle spasm</td>
<td>Interrupt pain-spasm-pain cycle</td>
<td><strong>Physical agents and mechanical modalities</strong>&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Spasm reduction might continue after cold removed</td>
<td>As needed</td>
</tr>
<tr>
<td>Decreased range of motion</td>
<td>Increase ROM</td>
<td><strong>Physical agents and mechanical modalities</strong>&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Progression variable depending on condition</td>
<td>Variable depending on condition and results</td>
</tr>
<tr>
<td>Rheumatoid arthritis flare</td>
<td>Decrease active joint temperature to decrease inflammation and repress lysosomal activity&lt;sup&gt;(24)&lt;/sup&gt;</td>
<td><strong>Physical agents and mechanical modalities</strong>&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Continue until disease activity and pain in joint subsides</td>
<td>Rest and exercise as indicated by disease activity. Resume cryotherapy with disease flare-ups</td>
</tr>
<tr>
<td>Hyperthermia</td>
<td>Decrease core body temperature&lt;sup&gt;(16,82)&lt;/sup&gt;</td>
<td><strong>Physical agents and mechanical modalities</strong>&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>Severe hyperthermia is a medical emergency that requires treatment in a medical facility (i.e., if patient is confused, unconscious or body temperature &gt; 40)</td>
<td>N/A</td>
</tr>
<tr>
<td>Submaximal athletic performance – cardiovascular and muscular endurance and muscle strength</td>
<td>Enhanced athletic performance</td>
<td><strong>Physical agents and mechanical modalities</strong>&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Desired Outcomes/Outcome Measures
› Desired outcomes and examples of outcome measures
  • Reduced pain, swelling, and inflammation\(^3,4\)
    – VAS, circumferential measurements
  • Enabled active exercise of muscles around soft-tissue injury
    – Maximal voluntary contraction (e.g., 1 RM), central activation ratio (CAR), MMT, RPE, timed performance tests
  • Interrupted pain-spasm-pain cycle
  • Decreased neurogenic tone, spasticity
    – Modified Ashworth Scale
  • Increased ROM
    – Goniometry
  • Decreased active joint temperature to decrease inflammation and repress lysosomal activity\(^24\)
    – Disease activity scores\(^24\)
  • Decreased core body temperature\(^16\)
    – Temperature

Patient Education
› See “Cryotherapy (Cold Therapy) for Pain Management.” Brigham and Women’s Hospital Health Information website, http://healthlibrary.brighamandwomens.org/Library/DiseasesConditions/Adult/Orthopedic/134.95

Coding Matrix
References are rated using the following codes, listed in order of strength:

<table>
<thead>
<tr>
<th>M</th>
<th>Published meta-analysis</th>
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</thead>
<tbody>
<tr>
<td>SR</td>
<td>Published systematic or integrative literature review</td>
</tr>
<tr>
<td>RCT</td>
<td>Published research (randomized controlled trial)</td>
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<tr>
<td>R</td>
<td>Published research (not randomized controlled trial)</td>
</tr>
<tr>
<td>C</td>
<td>Case histories, case studies</td>
</tr>
<tr>
<td>G</td>
<td>Published guidelines</td>
</tr>
</tbody>
</table>

| RV  | Published review of the literature |
| RU  | Published research utilization report |
| QI  | Published quality improvement report |
| L   | Legislation                       |
| PGR | Published government report       |
| PFR | Published funded report           |
| PP  | Policies, procedures, protocols   |
| X   | Practice exemplars, stories, opinions |
| GI  | General or background information/texts/reports |
| U   | Unpublished research, reviews, poster presentations or other such materials |
| CP  | Conference proceedings, abstracts, presentation |

References


75. Thain PK, Bleakley CM, Mitchell ACS. Muscle reaction time during a simulated lateral ankle sprain after wet-ice application or cold-water immersion. *J Athl Training*. 2015;50(7):697-703. doi:10.4085/1062-6050-50.4.05. (R)


