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Cold Steerage

Harnessing the healing power of cryotherapy -- Given the many variables that determine cold therapy effectiveness, practitioners should realize that no single protocol will be ideal for all patients. Understanding the factors that determine the effectiveness of cyotherapy will facilitate earlier exercise and complete rehabilitation.

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Cryotherapy is possibly the most frequently used modality for the treatment of acute musculoskeletal injuries. Unfortunately, it may also be the most misused. Commonly, we apply ice for 15 to 20 minutes every 1 1/2 to 2 hours, (1) regardless of the type, location, severity, or stage of injury. But because not every injury is the same, it doesn't make sense to treat each injury similarly.

Cryotherapy is the local application of cold to remove heat from the body (2). This is often accomplished through the physical principle of conductive heat exchange. The cooler object absorbs the heat energy of the warmer object when there is direct contact. Factors that determine the effectiveness of the treatment include target tissue type, depth of injury, temperature difference between modality and body, treatment duration, treatment area, and mode of treatment.

Indications for using cryotherapy include immediate care of acute injuries, rehabilitation of acute sprains and strains, and preventive maintenance (1,2). Previous research and clinical practice have demonstrated that cryotherapy is effective in treating these types of injuries (3,4).

The most appropriate explanation for the effectiveness of cryotherapy in treating acute injuries is the direct relationship between cellular metabolism and temperature; as temperature declines, the rate of oxygen consumption also decreases. Knight (5) first proposed secondary hypoxic injury and the use of cryotherapy to limit its effects based on the relationship between metabolism and tissue temperature (5). Since that time evidence in support of cryotherapy to prevent hypoxic injury has come from investigation of the inflammatory process (6,7).

Normal tissue composition is disrupted with trauma; this is referred to as primary injury (2,5-7). The theory of secondary hypoxic injury states that following injury oxygen availability is reduced in cells that surround the area of primary injury. That oxygen depletion causes hypoxia or ischemia in those cells even though they were undamaged during initial musculoskeletal trauma (5). Traumatic injury damages the blood vessels supplying tissues with oxygen and nutrients; therefore, delivery of oxygen and removal of waste is reduced or impossible. The cells surrounding the initial injury will die once all available oxygen has been consumed, causing secondary hypoxic injury (5). Eventually the cells damaged or destroyed due to secondary hypoxic injury break down via phagocytosis and add to the total amount of free protein and cellular debris in the tissue . This increased concentration of waste material accelerates edema accumulation and prolongs total healing time (2).

The application of cryotherapy for a sufficient length of time will lower the temperature of the surrounding tissues and reduce the metabolic activity, mainly oxygen consumption, in undamaged neighboring cells, thus limiting hypoxic or ischemic injury and limiting secondary injury (6). Prolonged cooling of tissues with appropriate treatment parameters will maintain reduced metabolism, thus limiting edema formation. Recently, it has been shown that cryotherapy limits edema formation (8) and markers for cell damage following injury (6).

Knowing how cryotherapy limits edema formation and assuming the method is by decreasing secondary injury is only part of making treatments more effective. We must also understand the effects of each variable involved in cold application. Included in those factors is the type of thermal energy applied: ice pack, chemical gel packs, ice baths, or ice massage. Not all methods of cold application are the same, and based on a collection of previous works,(3) crushed ice is the most effective tool.

Crushed ice packs last longer than gel packs, cool the body more, and draw four times more heat energy out of tissue. Chemical gel packs have the capacity to absorb 92,092 J when increasing temperature 22 degrees from -17 degrees to 05 degrees C, while a crushed-ice pack can absorb 356,022 J when increasing from -1 degrees C to 5 degrees C. The crushed ice pack may have a higher temperature (0 degrees C or 32 degrees F) than a chemical gel pack (-17 degrees C, the temperature of the freezer), but the important difference is that the ice pack undergoes a phase change. As ice melts, the energy required to change ice at 0 degrees C to water at 0 degrees C is 333,000 J/kg.

A chemical gel pack may cause frostbite in the first few minutes of application because of its low temperature when removed from the freezer. The combination of the additional heat energy removed from the body (greater effectiveness) and the higher initial temperature (reduced chance of frostbite) make an ice bag the more effective and safer choice. Adding a protective barrier when chemical gel packs are applied directly to the skin can reduce the risk of frostbite but compromises the effectiveness of the treatment, further supporting the choice of crushed-ice packs for the treatment of acute injuries (2).

When treating at home, however, where crushed ice is often unavailable, a chemical gel pack may be the convenient method of treatment, because of its reusability. Care must be taken to protect the skin from frostbite and many of the commercially available gel packs have a convenient method of securing the pack to the limb with a lining designed to act as a barrier between the skin and gel pack.

The intensity of the cold, duration of application, specific tissue response to cold, and area of application all affect the efficacy of the treatment. Intensity of the treatment is adjusted by changing the temperature of the pack; we often assume that colder or closer to 0 degrees C (32 degrees F) is better, but we currently don't know the most effective temperature. Treatment time should be based on the depth of the target tissues, and previous research suggests that lowering temperature by 5 degrees in muscle tissue at depths of 2 cm to 3 cm takes more than 30 minutes (9). This is contrary to the traditional thinking, which holds that 20 minutes is appropriate for all injuries (1).

Tissue type is an important factor to consider and will affect treatment time. Muscle tissue is a good conductor of heat energy, due to its high water content, while adipose tissue (fat) is a poor conductor of heat energy; in fact, it acts as an insulator, reducing the effectiveness of most cryotherapy treatments. Additionally, the thickness of tissue surrounding an injury must also be considered. The treatment time for a joint injury can be shorter than that for a muscle injury. Treatment time must be adjusted to each individual and each of type injury.

The goals of cryotherapy during acute care are to lower tissue temperature, slow metabolism, decrease secondary hypoxic injury, reduce edema formation, facilitate exercise, and speed time to recovery (2). These goals are accomplished with the RICES (rest, ice, compression, elevation, and splinting) treatment protocol. The decision when to use RICES is based on injury history, the state of wound healing, the tissues targeted for treatment, and the contraindications for ice application. Contraindications include cardiac conditions, uncovered open wounds, circulatory insufficiency, decreased sensation, neuropathy, systemic diseases, hypersensitivity to cold, and a history of frostbite (1,2).

During acute injury management RICES will help achieve each of the goals of acute injury care. RICES is most effective if applied within five to 10 minutes after the initial trauma; the greater the delay between injury and application, the less effective the treatment will be. RICES techniques often include crushed ice in a bag or in a bucket, applied directly to skin. The treatment time should be 30 to 45 minutes every two hours, with deeper target tissues receiving the longer treatment (45 min) while joints with very little superficial tissue can be treated for less time (30 min). Treating an injury with cryotherapy, in conjunction with compression and elevation, allows for speedier recovery than no cryotherapy treatment or treating with thermotherapy (heat).4 Cryotherapy will facilitate pain reduction by slowing nerve conduction velocity10 and reducing edema formation (8).

Compression should be applied continuously and evenly with an elastic wrap; a horseshoe pad should not be used. Proper application of the elastic wrap puts equal compression around the entire limb, while a horseshoe pad allows for the accumulation of swelling in pockets around the pad where there is no compression.11 The combination of compression and crushed ice results in greater decreases in surface and intramuscular temperature than ice alone, (9) and reapplication of an elastic wrap immediately after treatment retards the rate of re-warming.(9). Re-warming after initial ice pack application is slower than initial cooling, and intermittent (30 to 45 minutes every two hours) application of ice will maintain decreased metabolism. However, even mild activity (showering, getting dressed and going home) causes rapid re-warming, so ice packs should be reapplied immediately following activity for an additional 20 minutes to maintain decreased metabolism (12).

A common misconception is that the application of ice to a swollen joint or body part will reduce swelling; in fact, it is the combination of compression and elevation that counteracts edema formation. Swelling is removed from the intracellular space to the lymphatic system only by gravity, osmosis, and changes in concentration gradients. Active exercise facilitates lymphatic drainage by passively pumping lymph with each muscle action through a system of one-way valves in the lymph system.2

The combination of ice, elevation (at six to 10 inches above the heart), massage, and exercise will remove swelling and edema. Finally, stabilizing the injured limb allows musculature around the injury to relax and prevents further injury and swelling, while allowing for wound healing and scar formation. When needed, crutches and splints should be used to protect the injured area.

Rehabilitation

Once we begin to rehabilitate an injury, our cryotherapy treatment goals change. We need to focus on promoting healing, reducing swelling, easing pain, and restoring function.2 Each of these goals can be accomplished with active exercise, which is facilitated with the appropriate application of cryotherapy. Exercise facilitates wound healing and recovery by increasing range of motion, strength, muscular endurance, and function. It is by reducing pain, muscle spasm, and neural inhibition that exercise reestablishes normal motor patterns and function. This will be achieved sooner with cryotherapy than without.2 The appropriate application of RICES will reduce the total amount of injured tissue, decrease swelling, lessen pain, and allow injured individuals to exercise within the limits of their pain, assuming the injury is stable.

The results of controlled submaximal active exercise include quicker wound healing, increased macrophage activity, and hematoma resolution (2). Exercise, or loading of tissues, will promote vascular growth and regeneration of muscle and align scar tissue; and the stress of the exercise will also increase the tensile strength of those tissues (2)

Some may feel that applying ice prior to exercise is contraindicated, based on previous research that suggests cryotherapy reduces maximal strength (13). Cryotherapy is used primarily in rehabilitation to reduce pain and facilitate active submaximal exercise, not maximal exercise. Others may argue that with the application of ice the injured patient would not be able to feel pain during early exercise and could cause further damage. Ice is an analgesic, which causes an absence of a normal sense of pain, not an anesthetic that completely blocks pain stimuli. Cryotherapy used in conjunction with controlled graded exercise is very effective and safe (3).

When to start rehabilitative exercise depends on injury severity. For a first-degree sprain or strain, rehabilitation should start immediately with cryokinetics (the combination of cold application and active exercise) for joint injuries or cryostretch (the combination of cold application, passive stretching, and active exercise) for muscle injuries.

When the injury is more severe, refraining from rehabilitative exercise until after 48 hours of RICES management is prudent. With a second- or third-degree injury we must assume joint instability and take a conservative approach to rehabilitation. However, waiting too long will result in excessive scar or adhesion formation, neuromuscular inhibition, and a longer recovery time.

Appropriate application of cryotherapy for acute musculoskeletal injury based on target tissue type, depth of injury, temperature difference between ice bag and body, treatment duration, and treatment area will reduce tissue temperature and metabolism, limit secondary hypoxic injury, reduce pain, and limit edema formation. Cryotherapy will facilitate earlier exercise, which is the most direct route to complete rehabilitation of an athletic injury.

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