Neurological Responses to Cold

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"Just ice it." This is a mantra that is articulated to patients in athletic-medicine settings every day. Cryotherapy is a popular and well-investigated treatment modality used for reconditioning after musculoskeletal injury. The physiological and neurological responses of musculoskeletal tissues to cooling have been well examined. Cold application has been observed to decrease skin, muscle, and intra-articular temperature; decrease blood flow, inflammation, cell metabolism, pain, and muscle spasm; and alter nerve and muscle function. Knowledge of the neurophysiological mechanisms is critical to proper application of cold modalities. In the forthcoming health-care climate, athletic trainers and therapists in all settings will be held to a higher standard of care than "just ice it."

Clinically, cooling the ankle joint considerably improves a patient's ability to perform active exercise and decreases injury-recovery time. As such, cryotherapy should be used differently in the acute and subacute phases of injury. In the acute phases of rehabilitation, cryotherapy reduces secondary hypoxic and enzymatic injury. In the subacute and functional phases, it decreases pain and facilitates active exercise. Furthermore, cryotherapy should accompany progressive reconditioning of joint structures and functional activity. There is still controversy, however, regarding how this modality influences neuromuscular function. The objective of this column is to briefly review the neuromuscular effects of cryotherapy and discuss novel and theoretical ideas for the use of cryotherapy during joint-injury rehabilitation.

Neural Activity

Many of the physiologic benefits and therapeutic disadvantages of cryotherapy are directly related to neural activity. Pain is controlled by cold application as peripheral cold receptors are excited, producing analgesia. Cooling decreases nerve-conduction velocity, synaptic transmission, and sensory-nerve action potentials. Sensory-nerve action potentials are supposedly increased as a result of decreases in nerve-membrane currents. Directly cooling muscle tissue decreases muscle-spindle sensitivity, firing rates, and Type Ia afferent conduction velocity. Specifically, every 10 °C decrease in temperature slows afferent impulses from Type Ia receptors by nearly 60%, Type Ib by 40%, and Golgi-tendon-organ by nearly 50%. It has been established, however, that proprioception is not significantly altered by direct cooling. This is important clinically, because proprioceptive reeducation is vital to early progression to functional activity.

Muscle Activity

The effects of cryotherapy on neuromuscular function are varied, as well as its reported effects on muscle strength and force production. Muscle force has been observed to increase, decrease, or not change after cold application. In addition, functional measures of motor activity such as agility remain unaffected by cryotherapy. If muscle is cooled locally, the latency and motor-unit action potentials are extended. Furthermore, muscle cooling has been shown to significantly decrease stretch reflexes.

These observations about muscle activity were made during or after direct muscle cooling (Figure 1). In joint-injury rehabilitation, the supporting musculature is often weak, atrophied, or inhibited but is not damaged. Cryotherapy during joint injury might affect the surrounding musculature differently than direct muscle cooling does. Cooling a joint in pathological and normal subjects facilitates muscle activity and force production in muscles that stabilize the joint. These data corroborate previous reports that local cooling stimulates central-nervous-system activity and might provide evidence that further supports the rehabilitative use of cryotherapy. These observations imply that not only peripheral- but also central-nervous-system mechanisms might enhance neuromuscular function.
Sympathetic Activity

Changes in ambient temperature stimulate sympathetic-nervous-system output. Furthermore, local thermal stimuli elicit sympathetic drive to peripheral vessels and muscle tissue. Increases in blood pressure, heart rate, cardiac output, and sympathetic-nerve activity have been observed during cold-pressor tests (ice-water immersion of the hand). Cooling entirely away from the joint musculature of interest can evoke changes in muscle function similar to those in cold-pressor testing. Increases in sympathetic activity in the peroneus longus have also been recorded during and after ice immersion of the hand. This demonstrates that local cooling not only affects the peripheral nervous system but also activates thermoregulatory mechanisms in response to afferent drive from cold-specific receptors. Changes in neuromuscular recruitment have been observed in the soleus muscle during cooling of the axilla\textsuperscript{13} (Figure 2). Placing an ice bag in the armpit is not a proper clinical approach to cryotherapy, but this observation should prompt clinicians again to think critically about therapeutic uses of cold. Clinicians should not ignore the cold stress that cryotherapy places on thermoregulatory and neuromuscular function.

The extent to which afferent neural activity alters central-nervous-system function remains to be determined. Nonetheless, clinicians should think more critically about cold application during functional rehabilitation of a joint. Cold is a powerful clinical tool because the stress it places on the body might centrally stimulate neurological and muscular function. In rehabilitation, athletic trainers and therapists use cryotherapy to modulate pain, facilitate functional activity, and, potentially, even stimulate central-nervous-system activity. This might ultimately lead to the stimulation of neuromuscular activity during functional rehabilitation. In fact, as we enhance our rehabilitation tools with more dynamic stabilizing activity, muscle energy, and ballistic activities to promote neuromuscular function, it stands to reason that cryotherapy would be a critical component of rehabilitation.

Summary

We as clinicians must continue to think more carefully about all our treatments and therapies, including those with which we are most familiar. The cold stress that cryotherapy places on the body modulates many neurophysiological functions. Even though there is a rather significant body of knowledge about cryotherapy, there is a need for more laboratory and clinical investigation of its application. The purpose of this column was to reinforce the holistic affects that cryotherapy, therapeutic modalities, and therapeutic reconditioning have on nervous-system function.

References