Cryotherapy is commonly administered to relieve musculoskeletal pain for both acute and chronic injuries. Although cold application is often used for inflammation, recent research evidence suggests that the primary benefit of cryotherapy treatment may be decreased pain that results from changes in skin sensation. The beneficial effects of cold on joint function also appear to relate to a sensory effect. Cryotherapy alters cutaneous sensory input to the central nervous system through various mechanisms, including decreased receptor sensitivity, decreased receptor-firing rate, decreased nerve conduction velocity, increased action potential latency, and by providing a counter-irritation effect. Cold treatments are often described as producing a series of sequential sensations, such as cold, burning, aching, and numbness, which may relate to the mechanism of pain modulation.

There are numerous methods for therapeutic application of cold, including ice packs, ice massage, and

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**Context:** Alterations in skin sensations may be responsible for pain reduction provided by cryotherapy, but the exact physiological mechanism is unknown. **Objective:** To investigate perceptions of skin sensations associated with different modes of cryotherapy administration and skin temperature at the point of perceived numbness. **Design:** Repeated measures. **Participants:** 30 healthy subjects (12 Male, 18 Female, Age = 21.1 ± 1.9 years). **Interventions:** Crushed ice bag, ice massage, and cold water immersion. **Main Outcome Measures:** Perceptions of sensations during each mode of cryotherapy administration were derived from a Modified McGill Pain Questionnaire. Skin temperature was recorded when numbness was reported for each treatment. **Results:** Participants experienced sensations that included cold, tight, tingling, stinging, and numb. Ice massage sensations transitioned rapidly from cold to numb, whereas cold water immersion and ice bag treatments produced altered sensations for longer duration. Ice massage decreased skin temperature significantly more than the other two modes of cryotherapy administration. **Conclusions:** Ice massage may be the best mode of cryotherapy administration for achievement of anaesthesia as rapidly as possible, whereas cold water immersion and ice bag application may be better for attainment of pain reduction associated with noxious stimulation of skin receptors. **Key Words:** cold water immersion; ice massage; ice bag; pain; McGill Pain Questionnaire
cold-water immersion. Despite cryotherapy being the most common treatment intervention for acute and chronic injuries, there are no definitive application parameters. The application mode and duration are often based on convenience or an attempt to get the deep tissues cold as quickly as possible. The lack of clear clinical guidelines relates to an incomplete understanding of the effect of cold on pain reduction. Because beneficial effects have been reported for the use of vapocoolant sprays and short-duration ice bag application (5–10 min), their analgesic effect is probably linked to changes in skin sensation, rather than cooling of deep tissues. Perhaps the primary benefit of cold therapy relates to its effect on the skin in one of two ways: either by reducing sensory information (anaesthesia) or by inducing a painful stimulus that initiates a complex central nervous system pain-reducing response.

The skin acts as a thermosensory organ that is capable of detecting small changes in surface temperature. To achieve localized analgesia, the skin temperature must decrease below 13.6°C. In a clinical setting, the duration of cryotherapy treatments ranges from 30 seconds to 30 minutes. Examining the sensations that cryotherapy induces may provide insight about the mechanisms by which pain relief is achieved. The purpose of this study was to investigate perceptions of skin sensations associated with different modes of cold application, as well as the skin temperature corresponding to a sensation of numbness. Part 2 of this two-part report will address the treatment duration required to attain a sensation of numbness and the length of time that numbness persists after treatment termination.

**Procedures and Findings**

Thirty healthy adults (12 males, 18 females, age = 21.1 ± 1.9 years) received one of three different modes of cryotherapy application to the lower leg on three separate occasions. Potential participants were excluded if they reported a history of neurological disorder known to affect sensation, cardiovascular disease, peripheral nerve disease, cold allergies or sensitivity, or lower extremity injury within six weeks prior to testing. A modified version of the McGill Pain Questionnaire, replacing the word pain with the word sensation, was used to quantify localized sensation. A document with the detailed procedures and methods is available with the online version of this article.

**Cryotherapy Intervention**

The order of administration of different modes of cryotherapy was randomized through use of a random number generator. Ice massage was administered with a 6-ounce frozen block of ice in a paper cup, which was applied in continuous circular motions at a speed of 4 cm/sec (timed with a metronome). Each ice bag was assembled by placing 1.5 L of crushed ice into a plastic bag (38 × 21 cm), with excess air evacuated prior to bag closure. Ice bags were secured against the skin surface by an elastic wrap. Cold water immersion of the lower leg utilized a 10-gal tub of water and ice that was maintained at 12°C (periodically stirred). Each application of cold was terminated when the subject reported a sensation of numbness.

Participants experienced various sensations during the cryotherapy treatments, with the most common being described as cold, tight, tingling, stinging, and numb. During ice massage, participants primarily reported cold during the first 3 minutes, which transitioned to altered sensation from minutes 3–5, and numbness at minute 5. During cold water immersion, participants reported feeling cold for the first 3 minutes, altered sensation for minutes 4–5, and numbness at minute 5. During the crushed ice bag treatment, participants reported cold for the first 2 minutes, altered sensation during minutes 3–9, and numbness at minute 10. The types of sensations reported during each mode of treatment are presented in Figure 1.

We also compared the decreases in surface temperature among the 3 types of cryotherapy treatments, with statistical comparison based on the mean decrease in temperature at treatment termination. Ice massage was found to produce a significantly greater decrease in skin temperature than the ice bag and cold water immersion modes (Table 1).

**Discussion**

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. Thus, ice massage is the treatment of choice for rapid lowering of skin temperature to a level that produces localized analgesia (< 13.6°C) and reduced nerve conduction velocity (< 12.5°C). Numerous studies have documented that cryotherapy is effective in reducing pain. The analgesic effect of
cryotherapy is probably associated with the sensory responses, because pain reduction has been shown to result from short-duration treatment that is unlikely to reduce deep tissue temperature. We found differences in responses to ice massage, crushed ice bags and cold water immersion. Prior to conducting the study, we did not know that participants would be able to identify a specific point in time corresponding to the onset of numbness. Our results suggest that selection of treatment parameters might be better focused on attainment of pain reduction, rather than a target amount of reduction in intramuscular temperature.

One mechanism of pain relief associated with ice application is achieved through an anaesthetic effect, which is believed to relate to a reduction in nerve conduction velocity (NCV). To achieve cold-induced analgesia, the skin surface temperature must be lowered to approximately 13.6°C, whereas skin temperature must reach 12.5°C for a 10% reduction in nerve conduction velocity. Algafly et al. reported that a reduction in NCV was associated with an increase in pain threshold and pain tolerance. Although change in NCV was not directly related to analgesia, the neural signal transmission velocity probably affects the manner in which the nervous system processes information.

Another possible mechanism of pain reduction from the use of cryotherapy relates to the hypothesis of diffuse noxious inhibitory control (DNIC). To maximize the noxious stimulus provided by cryotherapy, the application mode that produces the greatest magnitude of “altered” sensations (e.g., pain, tightness, tingling, and discomfort) would be preferred. The crushed ice bag treatment and cold water immersion produced altered sensations for a longer duration than ice massage. Whether cryotherapy provides analgesia through the DNIC mechanism is unknown at present, but future research may provide evidence to support the use of cold therapies that prolong and intensify noxious sensations.

An important limitation of this study’s findings is that they were derived from the responses of healthy individuals who were not experiencing pain. Another factor that may have affected the results is that differing portions of the lower extremity were affected by the different modes of cryotherapy. An elastic wrap

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**Table 1. Skin Temperature in the Treatment Area at Pre- and Postintervention for Three Modes of Cryotherapy. Presented as Mean ± Standard Deviation, N=30.**

<table>
<thead>
<tr>
<th></th>
<th>Ice Bag</th>
<th>Ice Massage</th>
<th>Cold Water Immersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preintervention (°C)</td>
<td>33.7 ± 2.0</td>
<td>32.9 ± 3.0</td>
<td>33.9 ± 1.4</td>
</tr>
<tr>
<td>Postintervention (°C)</td>
<td>15.7 ± 5.1</td>
<td>6.5 ± 2.0</td>
<td>14.4 ± 1.5</td>
</tr>
</tbody>
</table>
was used to secure the ice bag to the calf, which may have yielded different results from application of an ice bag without compression.

**Conclusions**

Ice massage reduced skin temperature to a greater extent, with a lesser amount of altered sensation, prior to numbness. Thus, ice massage may be the best mode of cryotherapy administration for achievement of anaesthesia as rapidly as possible. Cold water immersion and ice bag application produced altered sensations for longer duration, which would be best for attainment of the analgesic effect that may result from a noxious stimulus.

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**References**


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