Ice Bag Application Induced Numbness in Uninjured Ankles with Less Discomfort than Cold Water Immersion

An Honors Thesis (HONRS 499)

by

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ABSTRACT

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Objective: Cryotherapy is commonly used to treat orthopedic pain because it induces numbness. Longer and colder immersion treatments result in greater numbness. We were unable to find numbness data for other cryotherapy modes. The purpose of this study was to compare numbness, cold discomfort, and skin temperature in uninjured ankles using ice bag and cold water immersion therapies. Design and Settings: A 2 x 6 repeated measures design guided this laboratory study. Independent variables were cryotherapy mode (20 minute 1 °C cold water immersion & 20 minute, 1 kg, ice bag application) and time (1 min pre-treatment & 2, 4, 6, 8, 10 min post-treatment). Dependent variables were cold discomfort (visual analog scale), skin temperature (°C), and sensation of pressure (Monofilaments, grams of pressure). Subjects: Twenty, healthy college students (M:6 F:14, age: 20.6 yrs, ht: 162 cm, wt: 63.2 kg) volunteered. Subject exclusion criteria included: allergies to cold (including Raynaud's phenomenon), cardiovascular disease, neurological disorders, abnormal sensation in their extremities, or lower extremity injury in the last 6 months. Measurements: We measured discomfort with a 10 cm visual analog scale; skin, room and water temperatures with Copper-constant thermocouples connected to an Iso-Thermex unit; and sensation of pressure with Semmes-Weinstein nylon monofilaments. Measurements were taken 1 min pre-, and 2, 4, 6, 8, 10 min post-treatment. Subjects were treated with a 20 minute ice bag application or ice water immersion (1°C) on 2 days separated by a minimum of 24 hours. Treatment order was randomized. Group means and standard deviations were calculated for each time. A repeated measures ANOVA determined differences and Tukey-Kramer comparisons located those differences. Our P-level was .05. Results: For both treatments, sensation was reduced at 2 min post-treatment (5.7 ± 4.3 g) compared to 1 min pre- , 4, 6, 8, & 10 min-post (3.6 ± 2.1 g; 3.7 ± 2.1 g; 3.2 ± 1.8 g; 3.3 ± 1.7 g; 3.0 ± 1.9 g respectfully) (F5,95=13.94, P<.00001; Tukey-Kramer <.05). For both conditions, skin temperature was lowest at 2 and 4 min post-immersion (11.2 ± 1.5°C, 12.6 ± 3.1°C, respectfully) (F5,95=6.38, P=.00004; Tukey-Kramer, p<.05). There was more discomfort at 2 min post-immersion (17.5 ± 23.5 mm) than all other pre-and post-ice bag and immersion measurements, except for 4 min post-immersion (12.7 ± 19.1 mm)(F5,95=5.93, p=.00008). Conclusions: Decreases in skin temperature are related to sensation loss for both conditions. Immersion is more uncomfortable than ice bag treatment, and both are most uncomfortable at 2 min post-treatment. Despite differences in temperature decreases, both cryotherapy treatments caused numbness. Ice bag treatments appear to induce numbness without as much discomfort as immersion treatment.
Our understanding of cryotherapy’s therapeutic effects is limited. Although, cryotherapy has been shown to decrease pain, tissue temperature, secondary injury, muscle spasm, and blood flow, clinical implications of these effects are limited.

Various modes of cryotherapy treatment are used to induce numbness and decrease patients’ pain. Different modes include ice packs, gel packs, cold water immersion, cold whirlpools, and cold sprays. Ice packs are the most common type of cryotherapy treatment. Ice packs consist of crushed or cubed ice placed in a plastic bag. Cold water immersion consists of placing a body part in cold water. Cold water immersions are typically used to treat the foot, ankle, and lower leg because it is better able to contact the large treatment area and is therefore more effective.

Cold induced numbness has been measured by sensation of pressure, which is the smallest amount of pressure needed to affirm one is being touched by a Semmes-Weinstein nylon monofilament. These fibers come in a wide array of diameters which determines the amount of pressure they transmit to the skin. Sensation of pressure is reported to increase (more force is needed for the individual to feel the sensation) following tissue cooling and returns toward initial levels as the tissues rewarms.

Colder water bath temperatures (1°C v. 10°C or 15°C) and longer treatment times (20 min. v. 10 min or 15 minutes) result in greater decreases in the sensation of pressure.

Cryotherapy is commonly used after orthopedic injury because it reduces orthopedic related pain (induces numbness), yet the intensity and length of numbness has only been reported for cold water immersion treatments. Therefore the purpose of this study is to determine if ice bags are as effective as cold water immersion at causing numbness.

METHODS

Design
The study was guided by a 2x6 repeated measures design. The independent variables were cryotherapy treatment mode (ice bag & cold water immersion) and time (pre- and 2, 4, 6, 8, 10 minutes post-immersion). Dependent variables were the sensation of pressure (grams of force needed for sensation), cold induced pain (as measured by a visual analog scale), and skin temperature (°C). Healthy subjects were randomly assigned to 1 of 2 treatment orders, using a 2x2 Balanced Latin Square. Treatment sessions (day 1 & day 2) were separated by at least 24 hours.

Subjects
Twenty, healthy, volunteers (ht: 162.0 cm; wt: 63.2kg; age: 20.6yrs; male: 6, female: 14) without allergies to cold (including Raynaud’s phenomenon), cardiovascular disease, neurological disorders, or abnormal sensation in their extremities were recruited for this IRB approved study. In addition, subjects reported no injuries to the lower extremities or cold treatments in the past 6 months.

Equipment
We used copper-constant thermocouples (Physiotemp Instruments, Clifton, NJ) connected to an Iso-thermex electrothermometer (Columbus Instruments International, Columbus, OH) to collect temperature data. We quantified sensation of pressure with
Semmes-Weinstein nylon monofilaments (Connecticut Bioinstruments, Danbury, CT). We quantified pain with a 10 cm visual analog scale (Appendix B).

**Figure 1: Measuring subject's sensation of pressure using monofilaments.**

**Procedures**

Subjects reported to the lab on 2 separate occasions separated by a minimal of 24 hours. During the first session, subjects completed a Consent Form (Appendix A) and health questionnaire (Appendix B). Subjects removed both their socks and shoes for standardization. For consistency of thermocouple application and monofilament testing, a dot was applied with a permanent marker to the subjects’ dominate ankle over the anterior talofibular ligament (Figure 1). A copper-constant thermocouple was secured to the ankle 1 cm behind the permanent marker dot with medical tape. The subjects sat for 5 minutes while ankle temperature stabilized.

After 5 minutes of stable (± 0.5°C) skin temperature readings, the sensation of pressure, pain, and temperature were measured on subjects dominate ankle. Sensation of pressure was measured at the permanent marker dot with Semmes-Weinstein nylon monofilaments following the technique outlined by Bell-Krotoski\textsuperscript{13} with the subject blindfolded (Figure 1). Following the sensation of pressure measurement the blindfold was removed and cold induced pain was measured with a 10 cm visual analog scale (Appendix A). Temperature was recorded with the Isothermex electrothermometer.

After pre-treatment measurements were recorded, one of the cold treatments, either ankle immersion in a 1°C water bath or application of an ~0.5kg ice pack, was applied for 20 minutes. After 20 minutes, the cold treatment was removed. The post-treatment sensations of pressure and pain measurements were conducted every 2 minutes for 10 minutes after treatment.

**Statistical Analysis**

Differences between groups were determined by repeated measures ANOVA, followed by Turkey-Kramer post-hoc testing when appropriate. The Alpha level was set at .05.
RESULTS

Pain
Ice bag & cold water immersion treatment pain differed across time ($F_{5,95} = 5.93; P = .00008$) (Figure 2). Pain 2 minutes post-immersion was greater than all other times ($P < .05$), except for 4 minutes post-immersion. There were no differences in pain between pre-treatment measures and 8 or 10 minutes post-immersion or 4, 6, 8, & 10 minutes post-ice bag.

<table>
<thead>
<tr>
<th>Average Pain (mm) with Ice Bag vs. Immersion</th>
<th>Ice Bag</th>
<th>Immersion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>0.9 ± 3.4*††</td>
<td>1 ± 3.2*††</td>
</tr>
<tr>
<td>2 min-post</td>
<td>7.4 ± 12.5*</td>
<td>17.5 ± 23.5‡</td>
</tr>
<tr>
<td>4 min-post</td>
<td>3.5 ± 4.5*†</td>
<td>12.7 ± 19.1</td>
</tr>
<tr>
<td>6 min-post</td>
<td>1.7 ± 2.3*††</td>
<td>7.3 ± 10.1*</td>
</tr>
<tr>
<td>8 min-post</td>
<td>1.2 ± 2.0*††</td>
<td>4.5 ± 7.5*†</td>
</tr>
<tr>
<td>10 min-post</td>
<td>0.8 ± 1.5*††</td>
<td>2.8 ± 4.9*††</td>
</tr>
</tbody>
</table>

Figure 2: Average Pain (mm) with Ice Bag vs. Immersion
* Less than 2 min-post immersion
† Less than 4 min-post immersion
‡ Less than 2 min-post ice bag

Temperature
Skin temperatures were different between the ice bag & cold water immersion over time. The skin temperature at 2 minutes post-immersion was less than all other times except 4 post-immersion ($F_{5,95} = 6.38; P = .00004$).

Figure 3: Temperature Graph
Sensation

For both ice bag and cold immersion sensation of pressure was reduced at 2 minutes post-treatment, compared to 1 minute pre- and 4, 6, 8, and 10 minute post-treatment ($F_{5,95}=13.94; P<.00001$).

![Sensation Graph]

Discussion

Our results demonstrate that there is no difference in amount of “numbness” as measured by sensation of pressure between an ice bag and cold water immersion. The cold water immersion decreased skin temperature ~5°C more than ice bag treatment. Despite the differences in skin temperature “numbness” was unaffected. This is unlike a previous study by Jutte et. al. which demonstrated increased “numbness” with lower water bath temperatures.\(^9\)

There are many reasons for the temperature differences between the cold water immersion and the ice bag treatment. First, cold water immersion contacts a larger surface area of the foot and ankle than the ice bag treatment. Therefore the surrounding tissue, including blood, was colder and could not contribute to tissue reheating. Our data supports this idea because cold water immersion treatments had a greater reduction in skin temperature. Second, the ice bag was applied with a compression wrap and therefore would result in a greater and deeper reduction in tissue temperature.\(^2\) The increased depth of temperature reduction may have greater influences on the skin sensory receptors. Our data supports this idea because even though the reduction in skin temperature was less, the amount of “numbness” was similar to the cold water immersion. Third, cold modalities that involve a phase change cause a greater decrease in skin surface temperature.\(^12\) Our data does not support this idea because modality temperatures were despite the phase changes the ice bags underwent.

Throughout our study measurements of pain were taken to determine the discomfort from the cryotherapy, not from orthopedic related pain. However, there is a noticeable difference in the decrease in skin temperature and increase in cold discomfort when comparing the cold water immersion to the ice bag treatment. Our data suggests that the decrease in skin temperature is related to the amount of induced cold discomfort.
In our study, the amount of cold discomfort was greater at 2 min post-immersion compared to any ice bag cold discomfort. Also, the discomfort returns to the baseline levels 4 minutes faster for the ice bag treatment. This suggests that cold discomfort returns to normal faster after the ice bag treatment compared to the cold water immersion.

There are many different reasons to apply cryotherapy treatments. If the clinician’s goal is to reduce mild orthopedic pain, the ice bag may be a better option than cold water immersion. Ice bags produce the same amount of numbness as cold water immersion, but produce less cold discomfort for the patient. If the treatment goal is to lower skin temperature, or to help slow the inflammation process, then a cold water immersion would be recommended. Cold water immersion causes greater & longer decreases in skin temperature than an ice bag. Cold discomfort could cause the production of endogenous opioids or enkephalins to reduce severe pain. If the goal is to reduce severe pain, then a cold water immersion would be the recommended cryotherapy modality because the increased cold discomfort may result in less orthopedic pain.

We would recommend clinicians use ice bags for mild pain control and cold water immersion for acute injuries to decrease inflammation and help relieve severe pain.
REFERENCES


Appendix A- Consent Form

The effects of different types of cryotherapy treatments on the sensation of pressure in the ankle.

Purpose of research:
The purpose of this study is to compare the sensation decreases of 2 common cold treatments.

Rationale of research:
Although cold is commonly used to treat orthopedic injuries (i.e. sprained ankles, bruises, and muscle strains), we have limited understanding of most effective treatment parameters. It is thought that cold reduces injury pain by causing numbness, or a decrease in sensation. To determine if one cold treatment is superior to another at producing numbness, we need to compare the sensation decreases caused by the 2 cold treatments.

Subject's expectations during research project:
As a subject in this project, you will be expected to come to the Athletic Training Laboratory (HP 226) on 2 different occasions with a minimum of 24 hours between sessions. Each session will last less than 1 hour. During these sessions we will measure your dominate ankle skin temperature, pain level, and sensation before and after a cold treatment to one of your ankles. We ask that you do not participate in physical activity 2 hours prior to testing sessions. You will not be required to bear any monetary costs for participating in this study, besides transportation costs to Ball State University Athletic Training Laboratory.

Procedures:
During each treatment session we will set up our temperature probe. This will require us to place a permanent marker dot on your dominate ankle to insure consistent location of measurements. You will be asked to sit for 5 minutes prior to any measurements. We will then measure skin temperature, sensation of pressure, and cold induced pain. We will apply one of two cold treatment, ice pack or cold water immersion, to your ankle for 20 minutes.

The cold treatments may cause some temporary discomfort. Application of cold typically usually causes feeling of cold, aching or burning, "pins and needles," and numbness. This discomfort is temporary and quickly diminishes after removal of the cold treatment.

After the cold treatment is removed we will repeat our measurements every 2 minutes for 10 minutes. To measure any pain you may experience, you will be asked to fill out a pain scale by placing a vertical line on a horizontal line scale. Your ankle skin temperature will be measured with a small probe attached to your skin with a small piece of tape. Sensation of pressure will be measured using nylon monofilaments, which are similar to a hairbrush bristle. The monofilaments will be applied to the skin for a second. If you can feel the monofilament a smaller one, which transfers less pressure, will be applied. This will continue until you cannot feel the monofilament used. During the minutes needed to make each sensation measurement you will be asked to wear a blindfold. At the end of testing the skin probe will be removed and you will be allowed to leave.

Foreseeable risks or discomfort:
The risks associated with cold application are minimal. There is a possible risk of allergic reaction to cold if you have never experienced a cold treatment. This should be avoided with the three-minute cold hypersensitivity test. In addition, the cold treatments may cause some discomfort. We will minimize any discomfort by allowing you to wear a toe cap during the cold
water immersion. The discomfort you experience should be no greater than the pain associated with an ice pack use to treat an injury.

Emergency medical treatment is available if you become injured or ill during your participation in this research project. You will be responsible for the costs of any medical care that is provided. It is understood that in the unlikely event of an injury or illness of any kind as a result of your participation in this research project that Ball State University, its agents, and employees will assume whatever responsibility is required by the law. If any injury or illness occurs in the course of your participation in this research project, please notify the primary investigator.

Benefits to subjects:
We cannot and do not guarantee or promise that you will receive any benefits from this study, beside personal satisfaction in the participation of expanding our knowledge in regards to the use of cryotherapy. You will not receive compensation for your participation in this study.

Confidentiality of records:
It is our intent to publish the results of this study. Your individual results will remain confidential and will not be associated with your identity in any way during the presentation or publication of the data from this study.
Your data will be stored in a locked filing cabinet in the principle investigator’s office. We will assign you a subject number (it will be written on your health questionnaire) that will be used instead of your name in all databases. The consent forms and questionnaires from this study will be destroyed 2 years after publication of the data.
Your decision whether or not to participate will not prejudice your future relation with Ball State University or the investigators. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without prejudice from the investigators. The investigator may terminate your participation at any time. Reasons for termination would include protecting you from adverse reactions to the cold treatment.

Do you have any questions (please circle one)? YES No

If yes, then, you may ask the investigators any questions you have. Do NOT sign below until your questions have been answered satisfactorily. You may take as much time as necessary to think this over.

AUTHORIZATION:

You are making a decision whether or not to participate. Your signature indicates that you have decided to participate, having read the information provided above and all questions have been answered to your satisfaction.

Subject Signature ___________________________ Date ___________________________

Witness ___________________________ Principal Investigator ___________________________

If you have any questions regarding this research project you may contact:
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If you have any questions regarding your rights as a participant in this research project, you may contact:

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(765) 285-5070
mlmorris@bsu.edu)
Appendix B- Visual Analog Scale

No Pain

Most Pain Ever Experienced
Appendix C – Poster Presentation