Contrast-Bath Therapy and Sensation Over the Anterior Talofibular Ligament

Billy E. Cotts, Kenneth L. Knight, J. William Myrer, and Shane S. Schulthies

**Context:** It has been suggested that contrast-bath therapy alters sensation and enables patients to return to exercise more quickly. **Objective:** To determine whether contrast-bath therapy alters sensation of pressure in the ankle. **Design:** A $2 \times 4 \times 4$ factorial design with repeated measures on 2 factors. Independent variables included gender, time (preapplication and 1, 6, and 11 min postapplication), and treatment (control, cold bath, hot bath, and contrast bath). **Setting:** Laboratory. **Participants:** 12 men and 12 women, college track athletes actively engaged in preseason workouts 5–6 days/wk. **Interventions:** Sensation of pressure was tested preapplication and 1, 6, and 11 min postapplication. Each treatment lasted 20 min. **Main Outcome Measure:** Sensation of pressure at baseline and 1, 6, and 11 min postapplication over the anterior talofibular ligament of the right ankle. **Results:** There was no difference between genders. Sensation of pressure was greater for the heat condition than the other 3 conditions at 1 and 6 min postapplication. During the heating condition, sensation of pressure was greater at 1 and 6 min postapplication than during preapplication. During the contrast condition, sensation of pressure was less at 6 min postapplication than during preapplication. **Conclusion:** Contrast- and cold-bath therapy (at 13°C) do not affect numbness. **Key Words:** sensation of pressure, hot bath, cold bath, numbness, therapeutic modalities

Contrast-bath therapy is the immersion of an injured limb in hot- and cold-water baths in cycles of 1–10 minutes. Typically, contrast baths are applied to postacute injuries to reduce edema. The traditional hypothesis for contrast-bath therapy is that the alternating of hot and cold applications causes temperature fluctuations in the target tissue, which causes alternating vasodilation and vasoconstriction, thus creating a pumping action within the vessels. This hypothesis has been challenged, however.
Contrast therapy cannot reduce swelling via vascular events because cellular debris is removed via the lymphatic system and even if it were removed by the vascular system, intramuscular temperature (1 cm below skinfold) changes during contrast therapy are minimal and so would not induce significant vascular changes.

Another hypothesis for the use of contrast-bath therapy is that it might decrease sensation (including pain) and therefore facilitate active exercise. Thus, rehabilitation can begin sooner. Decreased pain has been seen with both heat and cold applications but no one has studied the effects of contrast bath on sensation nor suggested a mechanism for how contrast baths might reduce sensation.

One way to measure decreased sensation is by measuring sensation of pressure. Sensation of pressure is commonly used to measure sensory changes during hand rehabilitation, when treating diabetic feet and, recently, during ice massage. Although no one has demonstrated a direct correlation between pain and sensation of pressure, there is evidence that these sensations are related.

Ankle sprains are a common injury and one of the most common injuries treated with contrast baths. Thus, we have chosen to investigate sensation-of-pressure changes in the ankle after contrast-bath therapy.

**Methods**

This study followed a $2 \times 4 \times 4$ factorial design with repeated measures on 2 factors. Independent variables included gender (male and female), time (preapplication and 1, 6, and 11 minutes postapplication), and treatment (control, cold bath, heat bath, and contrast bath). Sensation of pressure and actual time of measurement were dependent variables. Each subject participated in all 4 treatment conditions. The 6- and 11-minute postapplication measurements began approximately 30 seconds after the previous measurement was completed. Thus, the final measurements were at approximately 6 and 11 minutes.

Subjects for this study included 24 Division I college track athletes, 12 men and 12 women (age 22.9 ± 2.5 years, height 174.2 ± 8.4 cm, weight 67.8 ± 13.3 kg, activity 5.7 ± 0.6 days). All subjects gave informed consent and completed a health questionnaire, as approved by the university institutional review board, before participating in this study.

Four treatment orders were established using a balanced Latin square. Subjects were randomly assigned to 1 of the 4 treatment orders.

All hydrotherapy treatments were performed in 2 metal lowboy 3- by 3-ft whirlpools (Whitehall Manufacturing, City of Industry, Calif, Model #S-90-M) in the athletic training room of Brigham Young University. A temperature of 41 °C was maintained by adding hot water, as needed,
for the hot bath. A temperature of 13 °C\textsuperscript{1,2,6,+,9,10,14,25} was maintained by adding ice, as needed, for the cold bath.

Semmes–Weinstein nylon monofilaments (Connecticut Bioinstruments, Danbury, Conn) were used to measure sensation of pressure. Handheld stopwatches (Ambassador Accusplit, Magnum XL 620X, San Jose, Calif) were used to monitor treatment and testing times.

All conditions (control, contrast, hot bath, and cold bath) lasted 20 minutes, during which time subjects sat on a whirlpool bench with the right leg immersed to midcalf. During the control treatment condition, the right foot rested on a bucket for support. Contrast-bath conditions consisted of a hot bath for 3 minutes followed by a 1-minute cold bath, repeating the cycle 5 times. Hot-bath conditions had subjects in hot whirlpool only. Cold-bath conditions had subjects in cold whirlpool only. Whirlpool jets were not turned on for any treatment conditions.

Subjects were asked to wear shorts and remove both their socks and shoes. They were in a supine position on treatment tables with their feet hanging off the tables. They were required to close their eyes, disallowing visual input. One of us (BC) palpated and marked the skin over the anterior talofibular ligament for a reference point. A brief explanation of how testing would be conducted was given by the tester. Palpation and explanation were done before baseline measurements only.

Sensation of pressure was measured with Semmes–Weinstein nylon monofilaments following the technique outlined by Bell-Krotski.\textsuperscript{11} The monofilament was held about 1 in above the mark on the right anterior talofibular ligament. Within approximately 1.5 seconds, the monofilament was brought into contact with the skin within 1 cm of the center reference point. Contact was sustained for approximately 1.5 seconds.

Subjects were told to respond by saying “yes” if they detected a sensation. Failure to respond when a monofilament was touching the skin was interpreted as a failure to detect the pressure of that monofilament.

Two or 3 attempts with each filament were made; if the first 2 attempts elicited the same response, the third attempt was unnecessary. If 2 touches resulted in positive responses from the subjects, the next-lower filament was used. This technique was continued until the subject could no longer detect a sensory stimulus, at which time the last filament felt was accepted as the measurement. If 2 touches resulted in negative responses, the next-higher filament was used. This continued until the subject could detect a sensory stimulus, at which time the filament became the baseline, or reference, monofilament. Each attempt was made within 1 cm of the reference mark. No touches were made in the same spot with the same filament. The same examiner performed all tests on the subjects.

Posttreatment tests began at approximately 10 seconds, 5.5 minutes, and 10.5 minutes from the time a subject’s legs exited the water and were completed by 1, 6, and 11 minutes. Actual time of measurement was monitored using a stopwatch. Testing began with the last monofilament detected by
the subject during their previous testing session. Adjustments made in monofilament size were based on given responses.

### Statistical Analysis

Means and standard deviations were calculated for both dependent variables by gender, time, and treatment. A 3-way ANOVA with repeated measures (on time and treatment) was used to determine overall differences among gender, time, and treatments. There was a significant 3-way interaction ($F_{9,48} = 269.7, P = .0001$), necessitating simple main-effects testing, which was accomplished with 1-way ANOVAs. Significant ANOVAs were followed by Tukey–Kramer multiple-range tests (TK). All tests were evaluated with an alpha of .05

### Results

There was no difference between genders’ treatment-time combination ($F_{1,22} < 4.65, P > .042$), so men’s and women’s data were combined for subsequent analysis. Sensation of pressure was greater for the heat condition than for the cold, contrast, or control conditions at 1 minute ($F_{3,69} = 9.59, P = .01, TK < .05$) and 6 minutes postapplication (Table 1; $F_{3,69} = 7.68, P = .01, TK < .05$). During the heating condition, sensation of pressure was greater at 1 minute and 6 minutes postapplication than during preapplication ($F_{3,69} = 8.48, P = .0001, TK < .05$). During the contrast condition, sensation of pressure was less at 6 minutes postapplication than during preapplication ($F_{3,69} = 2.93, P = .04, TK < .05$).

The time to obtain sensation-of-pressure measurements was the same between conditions (Table 2; $F_{3,3} = 1.44, P = .39$). There were some minor

### Table 1 Sensation of Pressure for All Subjects (g, mean ± SD, N = 24)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pre-application</th>
<th>1 min post-application*</th>
<th>6 min post-application*</th>
<th>11 min post-application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.28 ± 1.31</td>
<td>1.24 ± 1.29</td>
<td>1.16 ± 1.20</td>
<td>1.15 ± 1.19</td>
</tr>
<tr>
<td>Cold</td>
<td>1.45 ± 1.39</td>
<td>1.08 ± 0.89</td>
<td>1.07 ± 0.85</td>
<td>1.06 ± 0.74</td>
</tr>
<tr>
<td>Heat†</td>
<td>1.38 ± 1.25</td>
<td>2.29 ± 2.10</td>
<td>1.98 ± 1.97</td>
<td>1.46 ± 1.35</td>
</tr>
<tr>
<td>Contrast‡</td>
<td>1.25 ± 1.25</td>
<td>1.12 ± 1.19</td>
<td>1.02 ± 1.09</td>
<td>1.08 ± 1.11</td>
</tr>
</tbody>
</table>

*Heat > control, contrast, cold; $P < .05$
†1 minute postapplication > preapplication and 11 minutes postapplication; 6 minutes postapplication > preapplication; $P < .05$.
‡Preapplication > 6 minutes postapplication; $P < .05$.  

differences in time to measure sensation of pressure between genders and between testing times (see Table 2), but they were less than 5 seconds and therefore are probably not clinically significant.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Time Required to Obtain Sensation-of-Pressure Measurements (seconds, mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 min postapplication</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>23.75 ± 2.5</td>
</tr>
<tr>
<td>cold*</td>
<td>25.50 ± 3.3</td>
</tr>
<tr>
<td>heat†</td>
<td>26.67 ± 3.5</td>
</tr>
<tr>
<td>contrast†</td>
<td>25.25 ± 2.8</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>23.67 ± 2.8</td>
</tr>
<tr>
<td>cold*</td>
<td>27.33 ± 3.3</td>
</tr>
<tr>
<td>heat†</td>
<td>25.67 ± 3.0</td>
</tr>
<tr>
<td>contrast†</td>
<td>24.58 ± 1.6</td>
</tr>
</tbody>
</table>

*Women > men; P < .05. 1 minute postapplication > 11 minutes postapplication; P < .05.
†1 minute postapplication > 6 minutes postapplication, 11 minutes postapplication; P < .05.

Discussion

The theory that contrast-bath therapy affects sensation of pressure is not supported by this study. A similar study with colder water (we used 13 °C), however, might yield different results. In other research, 7 minutes of ice massage,8,20 20-minute immersion in 1 °C water,5 20-minute application of ice packs,8 and 5 minutes of forced chilled air8 caused a reduction in sensation (increase in sensation of pressure). Because all these studies and ours involved the same body part, it seems that the major difference between them is the temperature. Current pilot work from our laboratory indicates that 15-minute cold applications of 1 °C water increase numbness, whereas applications of 10 °C do not. Numbness after contrast therapy with a colder water temperature should be investigated.

It is possible that contrast baths have no effect on sensation. If so, we question whether there are any therapeutic benefits to them. Contrast-bath therapy does not alter intramuscular temperature significantly,2,4,7 even though 20- to 31-minute applications of heat or cold do alter intramuscular temperature.2,4,7,26,27 It is logical to think that the brief cold applications (1–5 minutes) and interspersed heat applications counter each other and prevent net intramuscular temperature changes.
Rogers et al\textsuperscript{20} reported that cold applications affected sensation of pressure. They applied ice massage for 7 minutes, which reduced surface temperature to 13 °C. We did not monitor skin temperature but doubt that it got this cold, because our water-bath temperature was only 13 °C. The effect of the massage part of ice massage also appears to be a factor in decreasing sensation.\textsuperscript{20}

Lehmann, Warren, and Scham\textsuperscript{28} suggested that tissue temperatures must reach 40 °C to produce significant physiologic responses. We wonder about that. We used hot baths of 41 °C, which probably were not hot enough to increase tissue temperature to 40 °C, yet sensation of pressure was affected. Future investigations should involve monitoring tissue and surface temperature so as to evaluate Lehman et al’s\textsuperscript{28} suggested temperature.

Is there a place for contrast-bath therapy in rehabilitation? Perhaps not. The traditional theory that contrast-bath therapy causes a “pumping action” to reduce swelling\textsuperscript{1,3-5} has been challenged.\textsuperscript{1,3-6} The alternative explanation that it might decrease sensation (including pain) and therefore facilitate active exercise\textsuperscript{3} is now in question, at least when used with 13 °C cold-water baths. If future research indicates that contrast baths at lower temperatures are effective in altering sensation, their use will be justified. We recommend, however, that proven treatments such as cryokinetics\textsuperscript{3,8} be used to treat acute joint injuries.

**Conclusion**

The use of 13 °C water-bath immersions for contrast- and cold-bath therapy does not affect sensation of pressure. Contrast-bath therapy with 1 °C water might alter sensation, but this has yet to be studied. Of the modalities we used, only hot baths (41 °C) resulted in numbness, which lasted through the 6-minute measurement.

Sensation of pressure was not different between genders, even though women’s sensation of pressure was consistently slightly lower than that of the men. Time to obtain sensation-of-pressure measurements after cold baths was slightly greater (<5 seconds) for women, but we do not think that this affected the results of the sensation of pressure.

**References**


