

# Immediate Comparative Effects of Cryotherapy and Thermotherapy on Pain, Ankle Dorsiflexion Range of Motion And Swelling in Adults With Acute Grade I Lateral Ankle Sprain: A Randomized Controlled Trial

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## ABSTRACT

**Background:** Acute ankle sprain is one of the most common musculoskeletal injuries, and cryotherapy and thermotherapy are both used as early conservative treatment despite their opposing physiological mechanisms and differing levels of evidentiary support.

**Objective:** To compare the immediate effects of cryotherapy and thermotherapy on pain, active ankle dorsiflexion range of motion, and swelling in adults with acute Grade I lateral ankle sprain.

**Methods:** A randomized controlled trial was conducted on 60 adults (age 18–43 years) presenting 24–72 hours after acute Grade I lateral ankle sprain, allocated into a Cryotherapy group (n = 30; single 15-minute cold pack application) and a Thermotherapy group (n = 30; single 15-minute moist hot pack application). Outcomes — Numerical Rating Scale (NRS), active dorsiflexion range of motion, and Figure-of-8 swelling — were recorded immediately pre- and post-intervention and analyzed using paired and independent t-tests (p < 0.05).

**Results:** Both groups showed significant within-group improvement in pain and dorsiflexion range of motion (p < 0.001). Swelling significantly decreased in the Cryotherapy group but significantly increased in the Thermotherapy group (p = 0.003). Intergroup comparison showed significantly greater pain reduction with cryotherapy (p = 0.003) and a highly significant divergence in swelling change between groups (p < 0.001), while dorsiflexion improvement was comparable between groups (p = 0.933).

**Conclusion:** Cryotherapy produced significantly greater immediate reduction in pain and swelling than thermotherapy, while both modalities produced comparable immediate gains in dorsiflexion range of motion. Cryotherapy should be preferred as the initial thermal modality in the first 24–72 hours after acute Grade I lateral ankle sprain, particularly for controlling pain and swelling.

**Keywords:** Ankle Sprain; Cryotherapy; Thermotherapy; Pain; Dorsiflexion; Swelling; Figure-of-Eight Method; Randomized Controlled Trial.

## INTRODUCTION

Ankle sprain is one of the most common musculoskeletal injuries encountered in orthopaedic and physiotherapy practice. An estimated 7.4 million ankle sprains presented to United States emergency departments between 2010 and 2024, with the highest rates among adolescents and a higher overall incidence in females than males<sup>1</sup>. Most sprains involve an inversion mechanism injuring the anterior talofibular ligament; Grade I sprains, the focus of this study, involve microscopic stretching or minimal tearing without mechanical instability<sup>2</sup>.

The conservative management of acute soft-tissue injury has evolved from RICE (Rest, Ice, Compression, Elevation) to POLICE (Optimal Loading) and, more recently, to the PEACE and LOVE framework, which explicitly questions the routine use of cryotherapy and anti-inflammatory modalities in the acute phase, arguing that the inflammatory response serves a necessary role in tissue healing.

Cryotherapy and thermotherapy are proposed to act through largely opposing mechanisms: cold produces local vasoconstriction, reduced blood flow, and reduced nerve conduction velocity, while heat produces vasodilation, increased blood flow, and increased tissue extensibility<sup>3</sup>. Despite this, cryotherapy remains widely used as first-line treatment, and systematic reviews have repeatedly found the underlying evidence base to be limited and inconsistent<sup>4</sup>, motivating recent high-quality trials such as the FROST protocol<sup>5</sup>. Thermotherapy, though less commonly recommended acutely, continues to be used in some settings, making a direct comparison of clinical and practical value.

Despite the widespread use of both modalities, direct head-to-head comparisons of their immediate effects on pain, dorsiflexion range of motion, and swelling remain limited. The present study was therefore designed to directly compare cryotherapy and thermotherapy on all three outcome domains concurrently in adults with acute Grade I lateral ankle sprain.

## MATERIALS AND METHODS

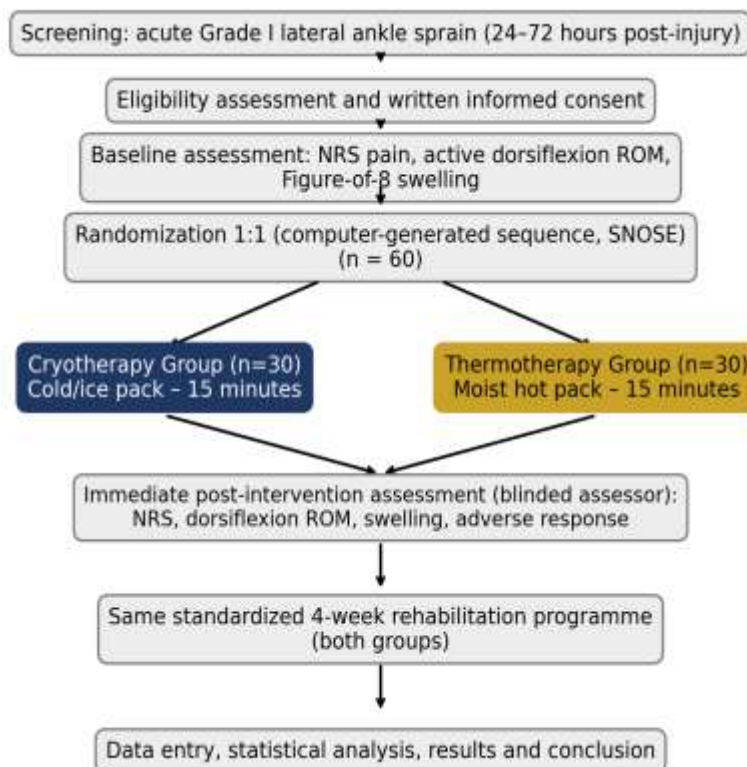
### Study Design and Setting

This randomized controlled trial with pre-test/post-test assessment was conducted in the outpatient Department of Physiotherapy at the Institute of Applied Medicines and Research (IAMR), Ghaziabad, Uttar Pradesh.

### Participants and Sample Size

Sixty adults with a clinically diagnosed Grade I lateral ankle sprain, presenting 24–72 hours after injury, were recruited by consecutive sampling and randomly allocated 1:1 into a Cryotherapy group (n = 30) and a Thermotherapy group (n = 30) using a computer-generated random sequence with allocation concealment via Sequentially Numbered, Opaque, Sealed Envelopes (SNOSE).

**Figure 1: Study Flow Diagram**



### Eligibility Criteria

Inclusion criteria were: age  $\geq 18$  years; clinically diagnosed Grade I lateral ankle sprain; injury 24–72 hours prior; primarily inversion mechanism; and ability to bear weight with none or mild discomfort. Exclusion criteria included Grade II/III sprain, suspected fracture, previous ankle surgery, chronic instability, impaired thermal sensation, peripheral vascular disease, and skin lesions over the treatment area.

### Ethical Considerations

Ethical approval for this study was obtained from the Institutional Ethics Committee of the Institute of Applied Medicines and Research (IAMR), Ghaziabad. Written informed consent was obtained from all participants prior to enrolment. The outcome assessor was blinded to group allocation throughout the study.

## Intervention

The Cryotherapy group received a single 15-minute application of a cold/ice pack over the injured lateral ankle with a thin protective barrier. The Thermotherapy group received a single 15-minute application of a moist hot pack (approximately 40–45°C) with an appropriate towel barrier. No other physiotherapy modality was administered during this period. Following the immediate post-intervention assessment, both groups commenced an identical, standardized four-week rehabilitation programme progressing from protection and early mobility (Week 1) through strengthening, balance, and proprioception (Weeks 2–3) to functional training (Week 4).

## Outcome Measures

Outcome measures were recorded immediately pre- and post-intervention: the Numerical Rating Scale (NRS; 0–10) for pain; active dorsiflexion range of motion (universal goniometer); and ankle swelling using the Figure-of-Eight method, a reliable technique for quantifying ankle girth<sup>6</sup>.

## Statistical Analysis

Descriptive statistics (mean  $\pm$  SD) summarized demographic and outcome data. Within-group change was assessed using the paired t-test and between-group differences in mean change using the independent-samples t-test, with significance set at  $p < 0.05$ .

## RESULTS

The Cryotherapy and Thermotherapy groups were comparable at baseline for age, sex, time since injury, and baseline NRS, dorsiflexion, and swelling scores ( $p > 0.05$  for all).

### Demographic and Clinical Characteristics

**Table 1: Demographic and Clinical Characteristics of Participants**

| Characteristic    | Cryotherapy (n=30) | Thermotherapy (n=30) | Total (n=60) |
|-------------------|--------------------|----------------------|--------------|
| Age 18–25 years   | 6                  | 7                    | 13           |
| Age 26–32 years   | 14                 | 14                   | 28           |
| Age 33–38 years   | 8                  | 7                    | 15           |
| Age 39–43 years   | 2                  | 2                    | 4            |
| Male              | 15                 | 17                   | 32           |
| Female            | 15                 | 13                   | 28           |
| Sports activity   | 7                  | 11                   | 18           |
| Running           | 9                  | 6                    | 15           |
| Inversion walking | 6                  | 8                    | 14           |
| Stairs/misstep    | 8                  | 5                    | 13           |

**Figure 2: Distribution of Subjects According to Age**

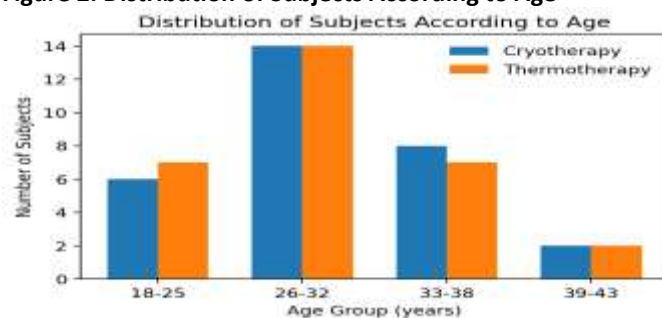
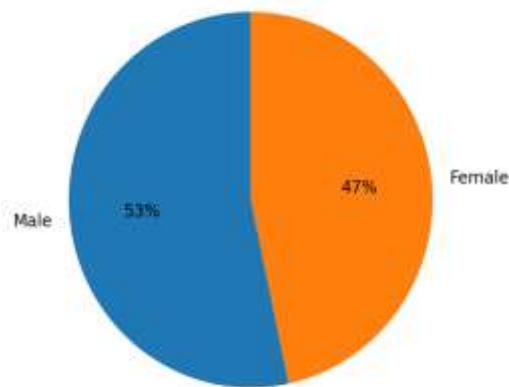


**Figure 3: Distribution of Subjects According to Sex**

Distribution of Subjects According to Sex



The mean age was  $29.33 \pm 6.34$  years in the Cryotherapy group and  $29.23 \pm 6.02$  years in the Thermotherapy group ( $p = 0.947$ ). Sports activity, running, and inversion while walking were the most common mechanisms of injury in both groups.

#### Within-Group Comparison of Outcome Measures

Table 2: Comparison of Pre- and Post-treatment Scores Within Each Group

| Outcome                     | Group         | Pre-treatment (Mean $\pm$ SD) | Post-treatment (Mean $\pm$ SD) | p-value  |
|-----------------------------|---------------|-------------------------------|--------------------------------|----------|
| NRS                         | Cryotherapy   | $5.40 \pm 1.04$               | $3.95 \pm 1.15$                | $<0.001$ |
| NRS                         | Thermotherapy | $5.52 \pm 1.02$               | $4.42 \pm 1.05$                | $<0.001$ |
| Dorsiflexion ( $^{\circ}$ ) | Cryotherapy   | $12.03 \pm 2.35$              | $13.76 \pm 2.58$               | $<0.001$ |
| Dorsiflexion ( $^{\circ}$ ) | Thermotherapy | $12.58 \pm 3.06$              | $14.28 \pm 3.29$               | $<0.001$ |
| Swelling (cm)               | Cryotherapy   | $54.38 \pm 2.50$              | $54.06 \pm 2.52$               | $<0.001$ |
| Swelling (cm)               | Thermotherapy | $53.81 \pm 2.41$              | $54.01 \pm 2.35$               | 0.003    |

Both groups showed statistically significant within-group improvement in pain and dorsiflexion range of motion. Swelling significantly decreased in the Cryotherapy group but significantly increased in the Thermotherapy group.

Figure 4: Pre- and Post-treatment NRS Scores by Group

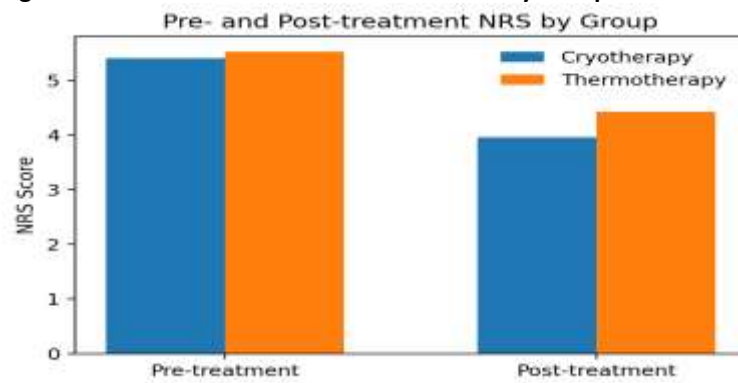


**Figure 5: Pre- and Post-treatment Dorsiflexion ROM by Group**

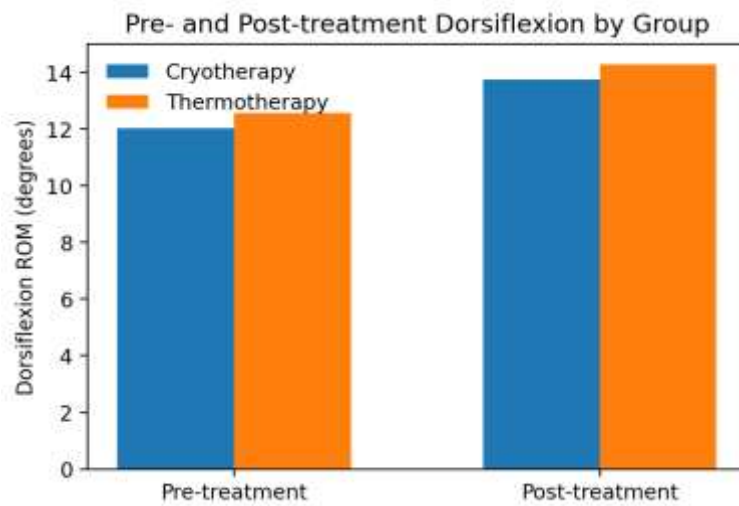
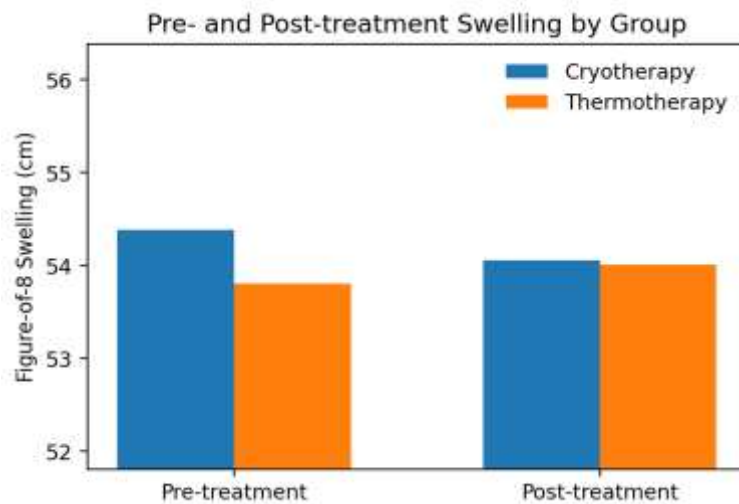


**Figure 6: Pre- and Post-treatment Swelling by Group**

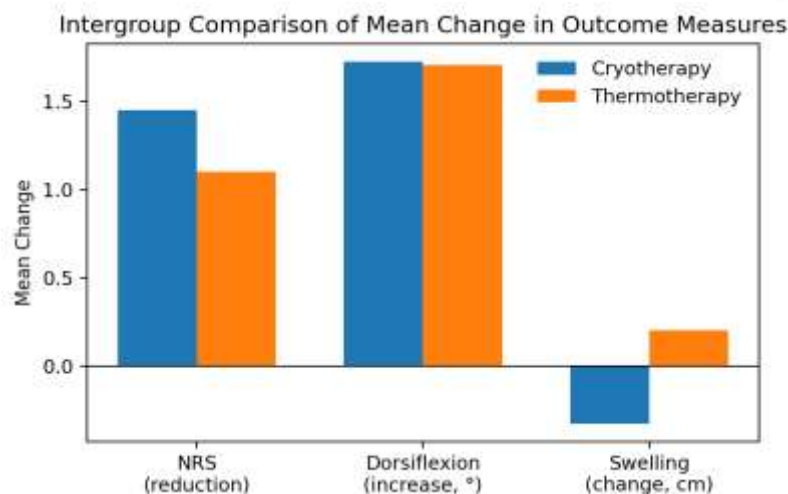


#### Intergroup Comparison of Outcome Measures

**Table 3: Intergroup Comparison of Mean Change**

| Outcome                              | Cryotherapy (Mean $\pm$ SD) | Thermotherapy (Mean $\pm$ SD) | t-value | p-value |
|--------------------------------------|-----------------------------|-------------------------------|---------|---------|
| NRS (reduction)                      | 1.45 $\pm$ 0.45             | 1.10 $\pm$ 0.44               | 3.06    | 0.003   |
| Dorsiflexion (increase, $^{\circ}$ ) | 1.73 $\pm$ 0.88             | 1.71 $\pm$ 0.95               | 0.08    | 0.933   |
| Swelling (change, cm)                | -0.33 $\pm$ 0.34            | +0.20 $\pm$ 0.35              | 5.93    | <0.001  |

**Figure 7: Intergroup Comparison of Mean Change in Outcome Measures**



The Cryotherapy group achieved significantly greater reduction in pain than the Thermotherapy group ( $p = 0.003$ ). The increase in dorsiflexion range of motion was comparable between groups ( $p = 0.933$ ). The divergence in swelling change between groups was highly statistically significant ( $p < 0.001$ ), with cryotherapy reducing swelling and thermotherapy increasing it.

## DISCUSSION

The greater pain reduction with cryotherapy is consistent with cold-induced reduction in nerve conduction velocity and local analgesia<sup>3</sup>, and with Hocutt et al. and Bleakley et al., who reported favourable pain outcomes with early and frequent cryotherapy application<sup>7,8</sup>. The comparable improvement in dorsiflexion range of motion between groups likely reflects distinct but equally effective mechanisms — reduced pain-related guarding with cold, and increased tissue extensibility with heat<sup>3</sup> — illustrating the value of assessing multiple outcome domains rather than relying on range of motion alone.

The most striking finding was the divergent effect on swelling: cryotherapy significantly reduced swelling while thermotherapy significantly increased it. This directly reflects the opposing effects of cold-induced vasoconstriction and heat-induced vasodilation on capillary permeability and fluid extravasation<sup>3</sup>, and is directly consistent with the theoretical concern raised by the PEACE and LOVE framework regarding heat-based modalities in the acute inflammatory phase<sup>9</sup>. The reliability of the figure-of-eight method used to detect this divergence is well established<sup>6,10,11</sup>, supporting confidence that this finding reflects genuine physiological change.

This pattern of domain-specific rather than uniform benefit — cryotherapy favoured for pain and swelling, comparable effect on range of motion — provides the most clinically actionable finding: cryotherapy should be preferred over thermotherapy in the first 24–72 hours after acute Grade I lateral ankle sprain, particularly when limiting swelling is a treatment priority.

These findings should be interpreted in light of certain limitations. Only the immediate, single-session effect was evaluated; participant blinding was not feasible since ice and heat are readily distinguishable; and the sample was drawn from a single outpatient centre. Future trials with longer follow-up, multiple centres, and sham-controlled comparisons would further strengthen this evidence base.

## CONCLUSION

Cryotherapy produced significantly greater immediate reduction in pain and swelling than thermotherapy in adults with acute Grade I lateral ankle sprain, while both modalities produced comparable immediate improvement in active ankle dorsiflexion range of motion. Cryotherapy should be preferred as the initial thermal modality in the first 24–72 hours after injury, particularly when pain and swelling control are primary treatment goals.

## DECLARATIONS

### Ethical Approval

Ethical approval for this study was obtained from the Institutional Ethics Committee of the Institute of Applied Medicines and Research (IAMR), Ghaziabad, prior to commencement of the study. Written informed consent was obtained from all participants.

#### **Conflict of Interest**

The authors declare that they have no conflict of interest.

#### **Source of Funding**

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

#### **Author Contributions**

All authors contributed to the study design, data collection, analysis, interpretation, and preparation of the manuscript, and approved the final version for submission.

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