RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 3, Issue 5, 2025

COMPARATIVE EFFICACY OF LOW-FREQUENCY CURRENT WITH AND WITHOUT HEAT IN THE MANAGEMENT OF CHRONIC LOW BACK PAIN

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DOI: https://doi.org/10.5281/zenodo.17221764

Received	Accepted	Published
07 July 2025	15 September 2025	29 September 2025

ABSTRACT

Background: *Chronic low back pain is a major cause of disability. Electrotherapy using low-frequency current is often used in physiotherapy; heat is frequently added with the assumption it enhances therapeutic effects. However, evidence comparing low-frequency current with heat versus without heat in back pain is limited.*

Methodology: *This randomized controlled trial was conducted at Health & Wellness Physio Rehab Center from January 2024 to April 2025. Sixty adults with chronic non-specific low back pain (duration ≥ 3 months) were randomized into two groups: the experimental group (n = 30) receiving low-frequency current plus superficial heat, and the control group (n = 30) receiving low-frequency current without added heat. Treatment sessions were delivered three times per week for 12 weeks, with baseline, 6-week, and 12-week assessments. Primary outcomes were pain measured by VAS (0-10) and disability by Oswestry Disability Index (ODI %). Secondary outcomes were lumbar range of motion (flexion / extension in degrees) and functional test (sit-to-stand time). Data were analyzed using SPSS version 26, using repeated-measures ANOVA (group × time), post hoc pairwise comparisons, effect sizes (Cohen's d), and checking assumptions of normality (Shapiro-Wilk) and sphericity (Mauchly's test).*

Results: *Fifty-six participants completed the study (experimental n = 28; control n = 28). There were no baseline differences between groups ($p > 0.05$). Repeated measures ANOVA showed significant group × time interaction for VAS ($F(2,108) = 7.42$, $p = 0.001$) and ODI ($F(2,108) = 9.15$, $p < 0.001$). At 12 weeks, mean VAS reduction was 3.5 (SD 1.1) in the experimental group vs 2.1 (SD 1.0) in the control (between-group $p = 0.002$, Cohen's $d = 1.33$). Mean ODI reduction was 15.6% (SD 6.0) vs 8.3% (SD 5.5) ($p = 0.001$, $d = 1.27$). Range of motion and sit-to-stand also improved more in the experimental group ($p < 0.05$). No serious adverse effects reported.*

Conclusion: *Adding superficial heat to low-frequency current therapy provides greater improvements in pain, disability, and function over 12 weeks than low-frequency current alone in patients with chronic low back pain. Physiotherapists should consider combining heat with low-frequency electrotherapy for better outcomes.*

Keywords: *chronic low back pain; low-frequency current; superficial heat; randomized controlled trial; VAS; Oswestry Disability Index*.

INTRODUCTION

Back pain, particularly chronic non-specific low back pain, is one of the most prevalent musculoskeletal complaints worldwide and contributes substantially to disability, healthcare

costs, and reduced quality of life. Many physiotherapy protocols include electrotherapy modalities, including low-frequency currents, intended to modulate pain, stimulate circulation, and reduce muscle spasm. Meanwhile, heat therapy has also been used extensively, under the premise that increased tissue temperature improves blood flow, reduces stiffness, and may amplify analgesic effects of other interventions (3, 6, 8). Some prior studies have tested combinations of transcutaneous electrical nerve stimulation (TENS) with heat and found improvements in pressure pain thresholds, though not always in self-reported pain or functional measures (0,2). Superficial heat alone has been shown to yield small short-term reductions in pain and disability especially in acute or mild low back pain (10), but evidence for chronic low back pain and in combination with low-frequency current is less robust. The mechanisms proposed for combined therapy suggest that heat may increase tissue extensibility, lower pain threshold, and allow low-frequency current to penetrate more comfortably or effectively, thus enhancing neuromodulation. Given the gaps in literature especially long-term (≥12-week) trials comparing low-frequency current with vs without heat in chronic low back pain, this study was designed to compare the two, hypothesizing that the combination would produce significantly greater improvements in pain, disability, and function.

Several studies have explored the effects of superficial heat, low-frequency currents, or electrical modalities in low back pain, though direct comparisons are sparse. A randomized clinical trial combined heat and TENS in participants with chronic low back pain and found significant improvements in pressure pain thresholds, but no significant change in average pain scores compared to controls over four weeks. Superficial heat therapy alone has been reviewed narratively, showing that continuous low-level heat can improve pain intensity, flexibility, and muscle strength in mild to moderate low back pain (9). The Cochrane Review on superficial heat or cold therapy found that heat wrap therapy provides a small short-term benefit on pain and function, particularly in acute or subacute cases, but evidence in chronic low back pain (for durations longer than three months) is limited and effect sizes are modest (10). Studies of continuous ultrasound (which provides mild heating) also suggest improvements in functional status and pain, though methodological differences (frequency, intensity, duration) make comparisons difficult (11). Few studies match our proposed design combining low-frequency electrical stimulation plus heat in a longer-duration protocol, with repeated measurement and functional outcomes. This supports the need for the present study to provide higher quality evidence over 12 weeks in chronic cases.

METHODOLOGY

This randomized controlled trial was conducted at Health & Wellness Physio Rehab Center from January 2024 to April 2025 (15 months). Ethical approval was obtained from the Center's Institutional Review Board. Participants were recruited consecutively from referrals for chronic low back pain (duration ≥ 3 months), aged 25-60, with pain intensity ≥ 4/10 on the Visual Analog Scale, and able to attend thrice-weekly sessions. Exclusion criteria included radiculopathy with neurological deficit, prior lumbar surgery, systemic inflammatory disease, pregnancy, or inability to tolerate electrical current or heat.

Sixty participants who met the criteria and gave informed consent were randomized (sealed envelope method) into two groups: Experimental (low-frequency current + superficial heat) and Control (low-frequency current without heat), each with 30 participants. Randomization was stratified by baseline pain severity (VAS high vs moderate) to ensure balance.

Interventions

Both groups received low-frequency current therapy delivered via surface electrodes placed over lumbar paravertebral muscles. Frequency was set at 10 Hz (a typical low-frequency analgesic current), pulse duration 200 µs, intensity strong but comfortable (just below motor contraction threshold), for 20 minutes per session, three times per week for 12 weeks (total = 36 sessions).

The experimental group, in addition, received superficial heat application immediately before the low-frequency current in each session: a hot pack (maintained at approx. 40-42°C) applied to lumbar region for 15 minutes. The control group got no heat; everything else was identical.

Additionally, both groups performed the same lumbar mobilization/stretching and core stabilization exercise program, twice a week during

sessions (after electrotherapy / heat or current), including: 3 sets × 12 reps of bird-dog, side-plank holds (timed holds of 30 seconds × 3), pelvic bridges 3 × 15, hamstring and hip flexor stretching 3 × 30 seconds each. This ensures that baseline exercise therapy is equal.

Outcomes & Assessment

Assessments were at baseline (Week 0), midpoint (Week 6), and post-intervention (Week 12) by an assessor blinded to group allocation.

- **Primary outcomes:** Pain via VAS (0-10 scale), Disability via Oswestry Disability Index (ODI, %).
- **Secondary outcomes:** Lumbar range of motion: flexion and extension measured in degrees using inclinometer; functional test: sit-to-stand time (number of seconds to complete 5 repetitions). Also recorded adherence (% sessions attended), adverse events.

Sample Size & Statistical Analysis

Sample size was calculated to detect a between-group difference of 2.0 points on VAS (assumed SD = 2.0), with $\alpha = 0.05$, power 0.80, requiring ~25 per group; with anticipated drop-out of 20%, target was 30 per group. Data were analysed using **SPSS version 26**. Normality tested by Shapiro-Wilk. If data met parametric criteria, repeated measures ANOVA (2 groups × 3 times) was used for each outcome. Mauchly's test for sphericity; Greenhouse-Geisser correction if violated. Post-hoc pairwise comparisons using Bonferroni adjustment. Between-group differences at each timepoint analysed by independent samples t-test (or Mann-Whitney U if non-normal). Effect sizes (Cohen's d) calculated. Significance set at $p < 0.05$. Missing data handled via last observation carried forward (LOCF).

RESULTS

A total of 60 participants were randomized; 4 dropped out before week 6 (2 from experimental, 2 from control) due to scheduling conflicts or relocation, leaving n = 28 in each group for analysis (total N = 56). Baseline characteristics (age, gender distribution, baseline VAS, ODI, ROM, sit-to-stand) showed no significant differences (all $p > 0.05$). Both groups showed good adherence: experimental group attended 91% of scheduled sessions (mean ± SD: 32.8 ± 2.4 out of 36), control group 89% (32.0 ± 2.9). No serious adverse events; some mild transient warmth or skin redness in experimental group.

SPSS repeated measures ANOVA results are summarized in (Table 1). For pain (VAS) there was a significant group × time interaction ($F(2,108) = 7.42$, $p = 0.001$), showing the experimental group improved more over time. Post-hoc pairwise comparisons: in the experimental group, VAS decreased from baseline mean 7.2 ± 1.0 to 4.7 ± 1.2 at week 6 ($p < 0.001$), and to 3.7 ± 1.1 at week 12 ($p < 0.001$). In the control group, VAS decreased from 7.1 ± 1.2 to 5.8 ± 1.3 at week 6 ($p < 0.01$), and to 5.0 ± 1.2 at week 12 ($p < 0.01$). Between groups at week 12, the mean difference in VAS was 1.3 (95% CI 0.6 to 2.0), $p = 0.002$, with Cohen's $d = 1.33$.

For disability (ODI), the group × time interaction was also significant ($F(2,108) = 9.15$, $p < 0.001$). The experimental group's ODI dropped from baseline mean 48.0% ± 7.5 to 35.2% ± 7.0 at week 6 ($p < 0.001$), and to 32.4% ± 6.3 at week 12 ($p < 0.001$). Control dropped from 47.5% ± 8.0 to 41.0% ± 7.8 at week 6 ($p < 0.05$), and to 39.2% ± 7.5 at week 12 ($p < 0.01$). Between groups at week 12 difference ≈ 7.2% (95% CI 3.5 to 10.9%), $p = 0.001$, Cohen's $d = 1.27$.

Secondary outcomes: Lumbar flexion ROM improved more in experimental group (baseline 45.5° ± 6.0 → week 12 58.2° ± 5.7) vs control (46.0° ± 6.3 → 52.3° ± 6.0), interaction $F(2,108) = 5.82$, $p = 0.004$. Sit-to-stand time improved (decreased) more in experimental (from 12.8 ± 2.5 s to 8.4 ± 1.9 s) vs control (12.5 ± 2.8 s to 10.5 ± 2.4 s); interaction $F(2,108) = 6.10$, $p = 0.003$. Effect sizes for secondary outcomes ranged from $d = 0.9$ to 1.1, indicating large effects. Full results and SPSS output are shown in **Tables 1 and 2**.

Table 1. Pain (VAS) and Disability (ODI) Over Time (Mean ± SD)

Outcome	Timepoint	Experimental Group	Control Group
VAS Pain	Baseline (Week 0)	7.2 ± 1.0	7.1 ± 1.2
	Week 6	4.7 ± 1.2	5.8 ± 1.3
	Week 12	3.7 ± 1.1	5.0 ± 1.2

Outcome	Timepoint	Experimental Group	Control Group
ODI (%)	Baseline	48.0 ± 7.5	47.5 ± 8.0
	Week 6	35.2 ± 7.0	41.0 ± 7.8
	Week 12	32.4 ± 6.3	39.2 ± 7.5

Table 2. Secondary Outcomes: Range of Motion and Sit-to-Stand Time (Mean ± SD)

Outcome	Timepoint	Experimental Group	Control Group
Flexion ROM	Baseline	45.5 ± 6.0	46.0 ± 6.3
	Week 12	58.2 ± 5.7	52.3 ± 6.0
Sit-to-Stand (5 reps)	Baseline	12.8 ± 2.5	12.5 ± 2.8
	Week 12	8.4 ± 1.9	10.5 ± 2.4

DISCUSSION

The results indicate that combining low-frequency current with superficial heat produces significantly greater improvements in pain, disability, lumbar flexion, and functional transfer tasks than low-frequency current alone over a 12-week treatment course. The group × time interactions for primary outcomes (VAS and ODI) are robust ($p \leq 0.002$), with large effect sizes, suggesting clinically meaningful benefits. These improvements suggest that heat may enhance the efficacy of low-frequency current by raising tissue temperature, improving circulation, reducing stiffness, and possibly improving current conduction or tolerance, thus allowing more effective neuromodulation.

The present study demonstrated that the application of low-frequency current combined with superficial heat produced greater reductions in pain intensity and functional disability in patients with chronic low back pain compared with low-frequency current alone. This finding is consistent with previous research showing that the synergistic effect of thermal therapy and electrical stimulation enhances tissue perfusion, reduces muscle spasm, and modulates pain perception through both peripheral and central mechanisms (12, 13). In contrast, patients who received only low-frequency current showed improvement but to a lesser extent, suggesting that heat may potentiate the analgesic and neuromodulatory effects of electrotherapy. These results support incorporating combined modalities into rehabilitation protocols for chronic low back pain while acknowledging the need for larger and longer-term trials to confirm durability of benefits and to explore optimal treatment parameters (14, 15)

Our findings align partially with earlier studies which combined TENS and heat, showing improvements in pressure pain thresholds though not always in subjective pain scores (0,2). The magnitude of benefit in our study for self-reported pain and function appears greater, likely due to longer duration (12 weeks vs 4 weeks in many prior studies), consistent session frequency, and inclusion of functional outcomes. Heat therapy alone in narrative reviews has been deemed safe, cost-effective, and helpful especially in mild/moderate LBP (16), but our study demonstrates that its use in combination with electrical modalities may be particularly valuable in chronic cases.

There are limitations. First, heat-tolerance and temperature control are concerns; some participants may perceive heat differently, potentially introducing variability. Second, the sample size is moderate and derived from a single clinic; external validity may be limited. Third, outcomes beyond 12 weeks (e.g. 6- or 12-month follow-ups) are unknown. Fourth, participant blinding is not feasible for heat application. Also, we applied superficial heat only; deeper heating modalities may have different effects (17, 18).

For clinical practice, the data support integrating superficial heat along with low-frequency current and exercise protocols, especially for chronic low back pain patients. Future research should test longer-term outcomes, cost-effectiveness, and perhaps compare different heat intensities or durations, or compare superficial vs deep heating in similar protocols.

CONCLUSION

Adding superficial heat to low-frequency current therapy delivers significantly greater reductions in pain and disability, and improves functional measures, compared to low-frequency current alone in chronic low back pain over a 12-week course. The results suggest that heat potentiates the benefits of low-frequency current, possibly via improved tissue perfusion, reduced discomfort, and enhanced neuromodulators effects. Given the large effect sizes and high adherence, this combined approach is feasible and clinically relevant. Physiotherapists should consider incorporating superficial heat in electrotherapy protocols for chronic low back pain, and further studies with longer follow-up and larger, multicentre samples are warranted to confirm these findings and guide optimized treatment parameters.

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