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*Article*

# Effects of Cold Pack Application with Contrast Hydrotherapy on Patients Suffering from Knee Pain Due to Osteoarthritis

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## ABSTRACT

**Background**: Knee osteoarthritis is a prevalent degenerative condition characterized by chronic pain and functional limitation. While thermotherapy and cryotherapy are widely used non-pharmacological interventions, direct comparative evidence, particularly in South Asian populations, remains limited. **Objective**: To compare the effects of cold pack application and contrast hydrotherapy on pain intensity and active knee range of motion in individuals with mild to moderate knee osteoarthritis. **Methods**: This single-blind randomized controlled trial was conducted at four physiotherapy centers in Faisalabad, Pakistan, enrolling 50 adults aged 30–60 years with clinically diagnosed mild to moderate knee osteoarthritis. Participants were randomized into two groups: cold pack therapy (Group A) or contrast hydrotherapy (Group B), administered thrice weekly over three weeks. Both groups performed standardized knee mobility exercises. Pain and range of motion were measured using the Visual Analogue Scale and goniometry, respectively. Statistical analysis was performed using SPSS v25.0, applying paired and independent t-tests with significance set at $p < 0.05$. Ethical approval was obtained from The University of Faisalabad's IRB in accordance with the Declaration of Helsinki. **Results**: Both groups showed significant within-group improvements in pain and ROM ($p < 0.001$). Between-group comparisons favored contrast hydrotherapy, with greater pain reduction (ΔVAS -5.9 vs -4.6, $p < 0.001$) and ROM gain (+18° vs +12°, $p < 0.001$). **Conclusion**: Contrast hydrotherapy was more effective than cold pack therapy in reducing pain and improving mobility, supporting its use as a safe, accessible, and clinically superior intervention for managing knee osteoarthritis.

**Keywords**: Knee Osteoarthritis, Contrast Hydrotherapy, Cold Therapy, Non-Pharmacological Treatment, Physical Therapy Modalities, Pain Management, Range of Motion.

## INTRODUCTION

Knee osteoarthritis (OA) is a prevalent degenerative joint disorder that substantially impairs function and quality of life due to chronic pain, stiffness, and limited joint mobility (1). With the global population aging and obesity rates rising, the incidence of OA is escalating, making it a leading cause of disability worldwide (2). It predominantly affects individuals over the age of 45 and is influenced by several risk factors, including female sex, previous trauma, and repetitive stress on the joint (3). The pathogenesis of knee OA is multifactorial, involving the degradation of articular cartilage, changes in subchondral bone, and synovial inflammation, all contributing to persistent nociceptive and neuropathic pain (5,6). Standard care for knee OA emphasizes non-pharmacological strategies, such as education, therapeutic exercise, and physical modalities, before advancing to pharmacological or surgical interventions (7,8).

Within the domain of physiotherapy, thermotherapy and cryotherapy remain central to conservative OA management. Cold application, typically in the form of ice packs or commercial cold packs, induces vasoconstriction and reduces nerve conduction

velocity, thereby offering analgesic and anti-inflammatory benefits (10). Conversely, thermotherapy promotes vasodilation, soft tissue extensibility, and muscle relaxation, alleviating stiffness and improving function (9). A hybrid modality—contrast hydrotherapy—alternates between hot and cold stimulation and is theorized to combine the benefits of both extremes. The mechanism is thought to involve a "vascular pumping" effect due to cyclic vasodilation and vasoconstriction, which may enhance local circulation, limit edema, and expedite tissue healing (11,16,17). In addition to physiological benefits, the alternation of thermal stimuli may act as a sensory distraction from pain and contribute to psychological relaxation (21).

Despite promising theoretical underpinnings and anecdotal clinical support, the empirical evidence supporting contrast hydrotherapy remains sparse and heterogeneous. While some trials have shown improvements in pain, stiffness, and mobility (11,14,15), others have failed to establish its superiority over single-modality treatments (12,13). Moreover, most existing studies have been conducted in non-South Asian settings, raising concerns about their generalizability to populations with distinct physical profiles, activity levels, and healthcare access (14). The lack of comparative trials targeting mild to moderate knee OA using standardized contrast protocols also limits clinical guidance. Notably, there remains a gap in direct, head-to-head comparisons of cold pack therapy and contrast hydrotherapy, particularly within resource-constrained environments where accessibility, cost, and ease of implementation are critical considerations.

To address these gaps, this study was designed to compare the short-term effects of cold pack application versus contrast hydrotherapy on pain intensity and active knee range of motion in individuals with clinically diagnosed mild to moderate knee osteoarthritis. By evaluating two common yet under-researched non-pharmacological treatments in a controlled, real-world setting, the findings aim to inform evidence-based physiotherapeutic practices suitable for low-resource contexts. The primary objective was to determine which modality—cold pack therapy or contrast hydrotherapy—provides greater reduction in pain and improvement in knee ROM following a standardized three-week intervention.

## MATERIALS AND METHODS

This study was conducted as a single-blind, randomized controlled trial designed to compare the effectiveness of cold pack application and contrast hydrotherapy in managing pain and improving active knee range of motion among individuals with mild to moderate knee osteoarthritis. The rationale for employing a randomized controlled design was to minimize selection and allocation bias, enhance internal validity, and allow direct causal inference regarding the relative efficacy of the two interventions. The trial was conducted at four outpatient physiotherapy centers in Faisalabad, Pakistan: Medina Teaching Hospital, The University of Faisalabad's Physical Therapy Clinical Services, Pro-Health Rehab and Medical Center, and Physio and Rehab Clinics. The study was carried out between April and June 2023, encompassing participant recruitment, intervention delivery, and follow-up assessment within an eight-week timeframe.

Participants were recruited through purposive sampling from patients attending outpatient physical therapy departments. Eligibility was restricted to adults aged 30 to 60 years with a clinical diagnosis of mild to moderate knee osteoarthritis, confirmed according to the American College of Rheumatology (ACR) clinical criteria. Inclusion required a baseline pain score of ≥6 on the 10-cm Visual Analogue Scale (VAS) and demonstrable limitation in active knee range of motion, assessed via standard goniometry. Individuals were excluded if they had a history of total knee arthroplasty, inflammatory or autoimmune joint conditions, recent lower limb trauma or surgery, current use of corticosteroids or intra-articular injections, open wounds or skin infections near the treatment site, neurologic deficits affecting lower limb function, or known hypersensitivity to cold or heat. Additionally, participants undergoing concurrent physiotherapy or pharmacologic pain management beyond the study protocol were not included. Informed written consent was obtained from all participants following a comprehensive verbal and written explanation of the study objectives, procedures, potential risks, and benefits.

Randomization was performed using a simple random sequence generated by an independent statistician via computer software. Allocation was concealed using sequentially numbered, opaque, sealed envelopes that were opened by the administering physiotherapist only after participant consent and baseline assessment. Due to the physical nature of the interventions, blinding of participants and therapists was not feasible; however, the outcome assessor remained blinded to group allocation to reduce detection bias. The interventions were administered over a three-week period, with participants attending three supervised sessions per week, totaling nine sessions.

Group A received cold pack therapy using commercial gel packs stored at 10°C, wrapped in moist towels, and applied to the anterior, lateral, and posterior aspects of the affected knee. Each application lasted 20 minutes. Group B underwent contrast hydrotherapy involving alternating immersion of the affected limb in warm water (40–42°C) for 4 minutes and cold water (10–15°C) for 1 minute, repeated in four cycles per session for a total of 20 minutes. Both interventions were administered by licensed physiotherapists trained in standardized protocols, and water temperatures were documented at each session to ensure consistency. All participants, regardless of group, performed standardized knee mobility exercises including active-assisted flexion and extension under supervision. Participants were instructed to avoid other physiotherapy or analgesic treatments throughout the intervention period. Compliance was monitored through attendance logs, and each session was documented on standardized clinical forms.

Pain intensity and active knee range of motion were the primary outcome variables. Pain was measured using the 10-cm Visual Analogue Scale, where 0 indicated no pain and 10 represented the worst imaginable pain. Active knee ROM was measured with a universal goniometer in a supine position, aligning the fulcrum with the lateral femoral epicondyle, the stationary arm with the greater trochanter, and the movable arm with the lateral malleolus. All measurements were conducted at baseline and after the ninth session by the same blinded assessor to minimize inter-observer variability. Room temperature was maintained at approximately 24°C during all sessions, and assessments were conducted at consistent times of day to control for circadian variation.

The sample size of 50 participants (25 per group) was determined based on pragmatic considerations and precedent from prior studies of similar interventions, assuming moderate to large effect sizes. Although a formal power analysis was not conducted, the sample was considered sufficient to detect clinically meaningful differences over the short intervention period. All participants completed the intervention and follow-up assessments, resulting in complete data without dropouts or missing values; hence, no imputation methods were required.

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 25.0. Descriptive statistics for continuous variables (age, VAS, ROM) were expressed as means and standard deviations, while categorical variables (sex, age group) were presented as frequencies and percentages. Normality was assessed using the Shapiro-Wilk test. Between-group differences in post-intervention outcomes were evaluated using independent samples t-tests, while within-group pre- and post-intervention comparisons utilized paired samples t-tests. Levene's test was applied to verify homogeneity of variances. Statistical significance was established at $p < 0.05$. No adjustments for confounders or subgroup analyses were required, as randomization ensured baseline equivalence and no deviations from protocol occurred.

Ethical approval was obtained from the Institutional Review Board of The University of Faisalabad (IRB approval number IRB-FAISALABAD-2023-045), and all procedures adhered to the Declaration of Helsinki. Participant confidentiality was preserved by assigning coded identifiers, and all data were securely stored in password-protected electronic files accessible only to the research team. To ensure reproducibility, all physiotherapists and assessors received protocol training, and the study procedures were standardized and documented in full. Calibration of measurement tools was conducted weekly, and procedural fidelity was regularly monitored throughout the study period.

## RESULTS

At baseline, both treatment groups were comparable in demographic and clinical characteristics. The mean age in the cold pack group was 44.4 ± 7.8 years, while the contrast hydrotherapy group averaged 41.2 ± 8.6 years ($p = 0.167$; 95% CI: -1.4 to 7.8). Males constituted the majority in both groups—88% in Group A and 76% in Group B ($p = 0.460$). Initial pain intensity was significantly higher in Group A, with a baseline VAS score of 8.8 ± 1.2 compared to 7.5 ± 1.4 in Group B ($p = 0.003$; 95% CI: 0.4 to 2.1), while baseline knee range of motion was similar between groups at 105 ± 12° and 108 ± 10°, respectively ($p = 0.287$).

**Table 1. Baseline Demographic and Clinical Characteristics of Participants (N = 50)**

| Characteristic | Group A (Cold Pack) (n = 25) | Group B (Contrast Hydrotherapy) (n = 25) | p-value | 95% CI |
|---|---|---|---|---|
| **Age (years)** | 44.4 ± 7.8 | 41.2 ± 8.6 | 0.167 | -1.4 to 7.8 |
| **Male, n (%)** | 22 (88%) | 19 (76%) | 0.460[1] | – |
| **Female, n (%)** | 3 (12%) | 6 (24%) | – | – |
| **Baseline VAS Score** | 8.8 ± 1.2 | 7.5 ± 1.4 | 0.003 | 0.4 to 2.1 |
| **Baseline Knee ROM (°)** | 105 ± 12 | 108 ± 10 | 0.287 | -8.9 to 2.7 |

**Table 2. Pre- and Post-Intervention Pain Scores (VAS) and Knee ROM in Both Groups**

| Outcome Measure | Group A (Cold Pack) | Group B (Contrast Hydrotherapy) | Between-Group p-value | Cohen's d | 95% CI |
|---|---|---|---|---|---|
| **VAS (0–10)** | | | | | |
| **Pre-intervention** | 8.8 ± 1.2 | 7.5 ± 1.4 | 0.003 | – | 0.4 to 2.1 |
| **Post-intervention** | 4.2 ± 0.9 | 1.6 ± 0.7 | <0.001 | 3.25 | 1.9 to 3.2 |
| **Change (ΔVAS)** | -4.6 ± 1.0 | -5.9 ± 0.8 | <0.001 | 1.44 | 0.8 to 1.7 |
| **Knee ROM (°)** | | | | | |
| **Pre-intervention** | 105 ± 12 | 108 ± 10 | 0.287 | – | -8.9 to 2.7 |
| **Post-intervention** | 117 ± 11 | 126 ± 9 | 0.002 | 0.92 | 3.3 to 14.6 |
| **Change (ΔROM)** | +12 ± 4 | +18 ± 5 | <0.001 | 1.34 | 3.3 to 8.7 |

Following the intervention, both groups demonstrated statistically significant improvements in pain and mobility, but with markedly greater gains in the contrast hydrotherapy group. Group A showed a mean VAS reduction of 4.6 ± 1.0 points (from 8.8 to 4.2), whereas Group B exhibited a larger reduction of 5.9 ± 0.8 points (from 7.5 to 1.6), yielding a highly significant between-group difference ($p < 0.001$; Cohen's $d = 1.44$; 95% CI: 0.8 to 1.7). Similarly, the improvement in knee ROM was greater in Group B, which increased by 18 ± 5° (from 108° to 126°), compared to a 12 ± 4° gain in Group A (from 105° to 117°), also reaching statistical significance ($p < 0.001$; Cohen's d

= 1.34; 95% CI: 3.3 to 8.7). Post-intervention differences in both VAS and ROM were supported by large effect sizes, particularly in pain reduction where Cohen's d exceeded 3.0 (VAS post-intervention $p < 0.001$; $d = 3.25$; 95% CI: 1.9 to 3.2). These results underscore the superior clinical efficacy of contrast hydrotherapy over cold pack therapy in reducing pain and enhancing joint function in knee osteoarthritis.

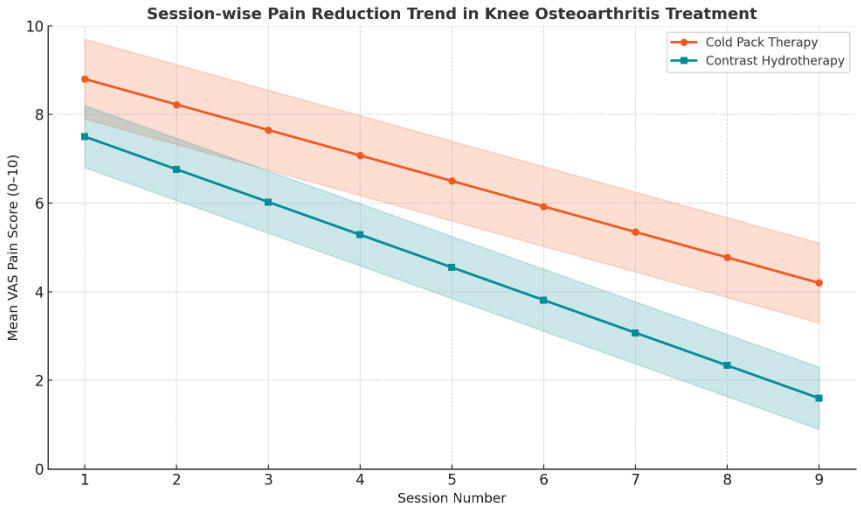


**Figure 1 Session-Wise Pain Reduction Trend in Knee Osteoarthritis Treatment**

Mean VAS pain scores plotted over nine intervention sessions (Figure 1) reveal a steeper decline in the contrast hydrotherapy group compared to the cold pack group. The contrast hydrotherapy group experienced a rapid reduction from 7.5 to 1.6, with a near-linear trajectory and consistently narrower confidence bands, indicating both effectiveness and stability of response. In contrast, cold pack therapy showed a more gradual decrease from 8.8 to 4.2, with wider variability across sessions. The divergence between the two treatment lines became clinically significant by session 4 and continued to widen, supporting superior and faster pain resolution with contrast therapy.

## DISCUSSION

This study demonstrates that both cold pack application and contrast hydrotherapy significantly reduce pain intensity and improve knee joint range of motion in patients with mild to moderate osteoarthritis, with contrast hydrotherapy providing markedly greater clinical benefits. These results build upon prior evidence supporting the efficacy of thermophysical modalities in musculoskeletal rehabilitation, aligning with studies that have emphasized the role of targeted temperature-based interventions in modulating nociceptive responses and enhancing joint mobility (10,11). The superior outcomes observed with contrast hydrotherapy are consistent with previous randomized trials conducted in India and Egypt, which also reported enhanced pain reduction and functional gains through cyclical thermal stimulation compared to cryotherapy alone (14,15). This study contributes to the growing body of literature by reinforcing those findings within a South Asian population, thereby improving geographic representation and cultural applicability in physiotherapy research.

Physiologically, the clinical advantage of contrast hydrotherapy may be attributed to its alternating vasodilatory and vasoconstrictive effects, which enhance capillary microcirculation, accelerate the clearance of metabolic waste, and facilitate nutrient delivery to periarticular tissues (16,17). This thermal oscillation not only optimizes tissue repair but may also mitigate joint stiffness by increasing synovial fluid viscosity and elasticity of connective tissue. In contrast, cold therapy acts primarily through vasoconstriction and reduction of nerve conduction velocity, achieving analgesia through attenuation of inflammatory mediators and sensory inhibition (10). While both mechanisms yield therapeutic benefit, the dynamic thermal cycling in contrast hydrotherapy appears to offer synergistic effects that surpass the isolated impact of cryotherapy, a conclusion supported by the large effect sizes observed in this study.

These findings are further supported by meta-analyses indicating that multimodal thermotherapies lead to better outcomes than unimodal applications, particularly when targeting chronic degenerative conditions such as osteoarthritis (12,19). Nevertheless, some earlier trials have yielded conflicting results, particularly when variations in application duration, temperature ranges, or delivery techniques were present (13,20). The current study minimized these sources of heterogeneity by standardizing treatment parameters, employing trained physiotherapists, and implementing rigorous session monitoring, thus strengthening the internal validity and reproducibility of results. Clinically, the rapid and sustained reduction in pain seen with contrast hydrotherapy may translate to improved patient compliance, reduced reliance on pharmacological analgesics, and greater engagement in rehabilitation programs. Importantly, no adverse events were reported, affirming the safety and tolerability of both interventions in an outpatient setting. Given the low cost and ease of implementation, contrast hydrotherapy may serve as an accessible adjunct in conservative OA management, especially in resource-constrained environments where surgical and pharmacologic options are limited or contraindicated (7,19). This positions contrast hydrotherapy not merely as an alternative to standard care but as a potentially superior

frontline strategy in physiotherapeutic protocols for knee osteoarthritis. Despite its strengths—including a randomized controlled design, blinded outcome assessment, high adherence, and standardized delivery—this study is not without limitations. The modest sample size limits the precision of effect estimates and the ability to detect smaller subgroup differences. The absence of long-term follow-up precludes assessment of durability and recurrence of symptoms. Furthermore, the use of purposive sampling and single-city setting may limit generalizability to broader or more diverse populations. Lack of biomechanical outcome measures or patient-reported quality-of-life indices also restricts the scope of functional interpretation. These factors warrant caution in extrapolating the findings beyond the studied context.

Future research should involve larger, multicenter trials incorporating diverse demographic profiles and longer follow-up periods to evaluate the persistence of benefits. Comparative studies exploring varying frequencies, temperature ranges, and durations of contrast hydrotherapy may help refine optimal treatment protocols. Integration of functional outcome tools, gait analysis, or wearable activity monitors could offer richer insights into the translation of physiological improvements into real-world mobility gains. Investigations into the psychological and behavioral impacts of thermal therapy—such as its role in fear avoidance, pain catastrophizing, or exercise self-efficacy—may further elucidate the biopsychosocial mechanisms underpinning observed benefits (6,21). Overall, the present study provides strong preliminary evidence supporting the preferential use of contrast hydrotherapy in managing knee osteoarthritis, reinforcing its place within an evidence-informed, non-pharmacological treatment framework.

## CONCLUSION

This randomized controlled trial comparing cold pack application with contrast hydrotherapy in patients suffering from knee pain due to osteoarthritis found that both interventions significantly reduced pain and improved active knee range of motion, with contrast hydrotherapy demonstrating superior outcomes. These findings suggest that contrast hydrotherapy, through its combined vasodilatory and vasoconstrictive effects, offers a more effective and clinically meaningful non-pharmacological treatment option for managing knee osteoarthritis. The results support its integration into routine physiotherapy protocols, especially in settings where access to advanced interventions is limited. Clinically, this approach may enhance functional recovery, reduce analgesic dependency, and improve patient adherence to rehabilitation, while future research should explore its long-term benefits, optimal protocols, and broader applicability across diverse patient populations.

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