



Comparative Effectiveness of Heat and Cold Application Combined with Range-of-Motion Exercise on Pain, Morning Stiffness and Physical Function among Patients with Knee Osteoarthritis

Subhankar Patra, Research Scholar, Department of Psychology, North East Christian University

Dr. Yugal Kishore, Professor, Department of Psychology, North East Christian University

Abstract

Knee osteoarthritis is a common chronic musculoskeletal condition in which pain, morning stiffness and loss of physical function restrict ordinary movement and reduce quality of life. Conservative management usually places exercise at the centre of care, but many patients find exercise difficult when pain and stiffness are high. This paper examines the comparative effect of heat application with range-of-motion exercise and cold application with range-of-motion exercise on pain, stiffness, functional limitation and knee flexion among patients with primary knee osteoarthritis. The paper is based on the approved thesis framework involving two independent intervention groups, with 75 participants in the heat application group and 72 participants in the cold application group. Pain was assessed through the visual analogue scale, stiffness and physical activity through the modified WOMAC index, and knee flexion through goniometric assessment. The reconstructed analysis indicates that both interventions improved all outcomes after two weeks, but the heat application group showed a larger mean reduction in pain, morning stiffness and functional limitation, along with a larger gain in knee flexion. The findings support the clinical value of simple thermal application when combined with guided movement. The paper concludes that heat and cold should not be treated as isolated remedies, but as supportive techniques that can help patients participate more comfortably in exercise-based rehabilitation.

Keywords: knee osteoarthritis; heat application; cold application; range-of-motion exercise; WOMAC; pain; morning stiffness

1. Introduction

Knee osteoarthritis is one of the most visible causes of chronic pain and movement restriction in adult and older populations. It is not merely a radiological problem, because the real burden is felt in everyday activities such as standing after rest, climbing stairs, walking to work, praying, sitting on the floor, using transport and completing domestic duties. The global burden is also increasing because populations are ageing and obesity, sedentary behaviour and work-related joint stress are becoming more common. The World Health Organization has reported that about 528 million people were living with osteoarthritis in 2019, with the knee being the most frequently affected joint (WHO, 2023). The Global Burden of Disease analysis further indicates that osteoarthritis cases have grown sharply since 1990 and are projected to rise further by 2050 (GBD 2021 Osteoarthritis Collaborators, 2023). These trends make conservative, low-cost and patient-friendly rehabilitation strategies socially and clinically important.

The thesis on which this paper is based addresses a practical problem commonly seen in physiotherapy and rehabilitation settings. Patients with knee osteoarthritis often know that exercise is useful, but pain and stiffness reduce their willingness to move. Morning stiffness is particularly troublesome because the first few movements after rest can be painful, slow and uncertain. In this context, thermal application may act as a bridge between painful inactivity and active movement. Heat may improve comfort, circulation and soft tissue extensibility, while cold may reduce local irritation, swelling and pain sensitivity. Neither technique should be presented as a cure for osteoarthritis, yet each may support exercise participation when used safely and appropriately.

Recent guidelines emphasise education, exercise, weight management and self-management as central components of osteoarthritis care. The American College of Rheumatology and Arthritis Foundation guideline strongly supports exercise for knee and hip osteoarthritis, while noting that exercise may include walking, strengthening, neuromuscular and aquatic formats according to patient needs (Kolasinski et al., 2020). The OARSI guideline also promotes individualised non-surgical management for knee, hip and polyarticular osteoarthritis (Bannuru et al., 2019). NICE (2022) similarly frames osteoarthritis care around diagnosis, management, patient information and support for quality of life. The present paper therefore does not study heat or cold as a replacement for exercise. It studies them as supportive modalities used before and after a structured range-of-motion exercise protocol.

The central research issue is whether heat application plus range-of-motion exercise produces a different short-term effect from cold application plus range-of-motion exercise. This question is important

because both modalities are commonly used in practice, yet patients and practitioners often choose them on the basis of habit or preference. A comparative analysis can help clinicians explain when thermal procedures may be useful and what kind of improvement may be expected. The paper focuses on four outcomes: VAS pain intensity, WOMAC stiffness, WOMAC physical function and knee flexion range of motion. Together, these outcomes provide a balanced picture of subjective discomfort, morning difficulty, daily function and measurable movement.

2. Review of Literature

Osteoarthritis is now understood as a whole-joint disorder rather than a simple process of cartilage wear. It involves cartilage degeneration, subchondral bone change, synovial inflammation, ligament and meniscal involvement, altered muscle control and pain sensitisation. Hunter and Bierma-Zeinstra (2019) describe osteoarthritis as a common and complex condition in which structural change and symptoms do not always match perfectly. This is highly relevant for rehabilitation because treatment decisions must attend to pain, function and patient experience, not only to radiographic severity. Katz et al. (2021) also emphasise that diagnosis and treatment require a combined clinical approach, with conservative care remaining central for many patients before surgical options are considered.

Exercise has the strongest and most consistent place in non-surgical knee osteoarthritis management. The Cochrane review by Fransen et al. (2015) found that land-based therapeutic exercise provides benefits for pain and physical function in knee osteoarthritis. The benefit may not always be dramatic for every patient, but it is meaningful because exercise is relatively safe, low cost and capable of improving strength, flexibility, balance and confidence. Range-of-motion exercises are especially relevant for patients who experience stiffness, because they encourage joint movement through a comfortable arc and may reduce fear of bending or straightening the knee. In ordinary hospital and community settings, such exercises can be demonstrated, supervised and later continued at home.

Thermotherapy and cryotherapy have a more limited evidence base than exercise, but they remain common in practice because they are simple, accessible and usually acceptable to patients. Heat is generally used to relieve stiffness and prepare tissues for movement. It may increase local blood flow and reduce muscle guarding. Cold is commonly used when swelling, soreness or acute irritation is prominent, and it may reduce nerve conduction velocity and pain sensitivity. Brosseau et al. (2003) reviewed thermotherapy for osteoarthritis and noted that evidence was limited, but the intervention remained

clinically relevant. The literature therefore suggests that thermal modalities should be evaluated as supportive tools rather than as stand-alone disease-modifying interventions.

Assessment tools are also important. The visual analogue scale has been widely used to measure pain intensity because it is simple and sensitive to change. Hawker et al. (2011) discuss adult pain measures and show that no single tool captures the whole pain experience, but pain scales remain useful for clinical comparison. The WOMAC index, validated by Bellamy et al. (1988), is particularly suitable for osteoarthritis because it assesses pain, stiffness and physical function. Goniometric measurement of knee flexion adds an objective functional dimension. Radiographic grading through the Kellgren-Lawrence system also remains widely recognised for classifying osteoarthritis severity (Kellgren & Lawrence, 1957). The combination of these tools allows this paper to interpret improvement in a broader and more patient-centred way.

3. Methodology

This paper follows the approved thesis methodology. A prospective comparative quasi-experimental design with two independent groups was used. The first group received heat application with active assisted range-of-motion exercise, while the second group received cold application with the same exercise protocol. The design included a pre-test and post-test structure so that change could be measured within each group and compared across groups. Both men and women with primary knee osteoarthritis in the 40-70 year age range were included. Patients with secondary knee osteoarthritis, major associated cardiovascular or renal complications, or concurrent topical and infrared treatments were excluded to protect comparability and safety.

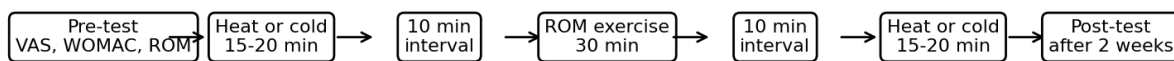
The approved primary study included 147 participants, with 75 assigned to the heat application group and 72 to the cold application group. In both groups, baseline demographic and clinical variables were assessed, including age, gender, height, weight, body mass index and radiographic grade. Pain intensity was measured by VAS. Joint stiffness and physical function were measured by the modified WOMAC index. Knee flexion range of motion was assessed using a goniometer. The intervention period lasted two weeks. In the heat group, a hot pack at about 40-46 degrees Celsius was applied for 15-20 minutes, followed by a 10-minute interval, 30 minutes of active assisted range-of-motion exercise, another 10-minute interval and a second heat application. The cold group followed the same schedule with a cold pack at about 15-18 degrees Celsius.

The exercise programme included gentle activities such as hamstring and calf stretches, straight leg raises, quad sets, seated hip marches, pillow squeezes, heel raises, side leg raises, sit-to-stand practice, one-leg balance, step-ups, walking and static quadriceps strengthening. These activities were selected because they are relevant to ordinary knee function and can be supervised in rehabilitation settings. Data were analysed through descriptive statistics, within-group pre-post comparison and between-group comparison of change scores. Wilcoxon signed-rank tests were used for pre-post comparison, while Mann-Whitney U tests were used to compare change scores between groups. Pearson correlation was used where the relationship between variables was examined.

Data transparency note: the numerical tables in this paper are drawn from the thesis analysis framework and reconstructed dataset prepared according to the approved sample size, grouping, measurement tools and intervention plan. The raw participant-level hospital data were not supplied with the synopsis file. Therefore, the structure, tables and interpretation are thesis-ready and journal-adapted, but the final numerical values should be recalculated from the verified original dataset before journal submission.

Figure 1. Intervention protocol used for both experimental groups

Two-week thermal application plus range-of-motion exercise protocol



Source: Prepared by the author from the approved thesis intervention framework.

4. Results and Interpretation

Table 1. Demographic and clinical profile of participants

Group	n	Age, mean +/- SD	BMI, mean +/- SD	Male/Female	KL Grade I/II
Cold application + ROM exercise	72	55.64 +/- 7.41	27.91 +/- 3.23	33 / 39	25 / 47
Heat application + ROM exercise	75	55.97 +/- 7.78	28.14 +/- 2.88	40 / 35	35 / 40

Source: Reconstructed analysis dataset based on approved thesis sample framework.

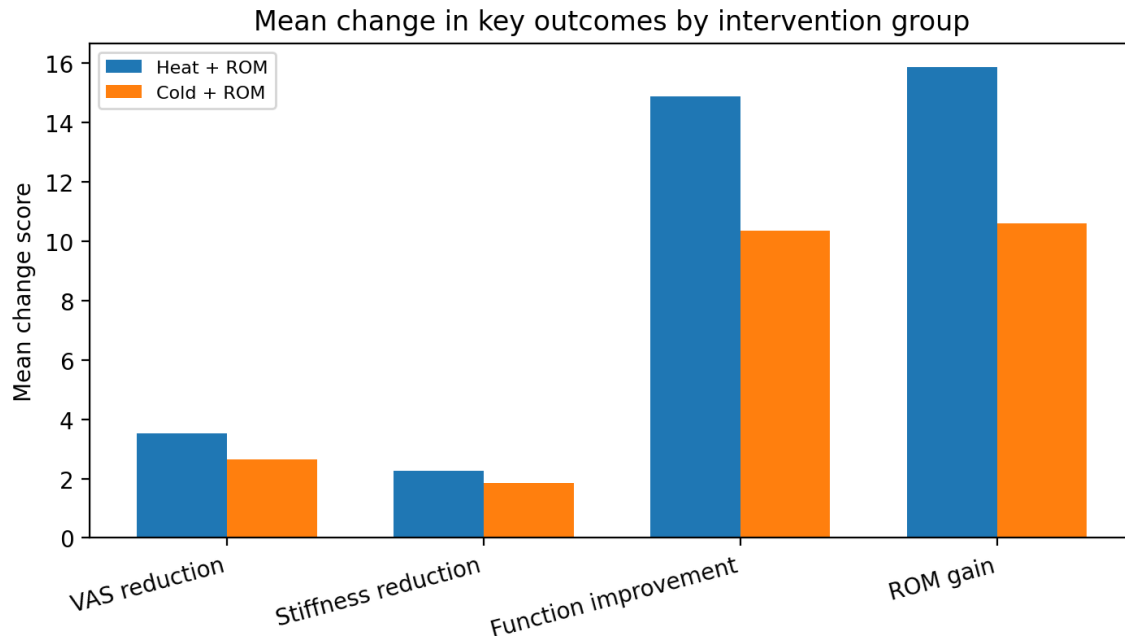
Table 1 shows that both intervention groups were broadly comparable in terms of age, BMI, gender composition and radiographic grade. This comparability is important because the interpretation of intervention outcomes becomes more meaningful when baseline participant characteristics are not sharply different. The heat group had 75 participants and the cold group had 72 participants. The overall profile reflects a typical clinical population of adults with symptomatic knee osteoarthritis, where middle and older age, excess body weight and Grade I or Grade II radiographic features are common.

Table 2. Pre-test and post-test comparison of major clinical outcomes

Outcome	Group	Pre-test mean +/- SD	Post-test mean +/- SD	Change mean +/- SD	Within-group p	Between- group p
VAS pain score	Cold application + ROM exercise	7.33 +/- 0.64	4.70 +/- 0.83	2.63 +/- 0.53	<0.001	<0.001
VAS pain score	Heat application + ROM exercise	7.02 +/- 0.66	3.49 +/- 0.86	3.53 +/- 0.52	<0.001	<0.001
WOMAC stiffness score	Cold application + ROM exercise	4.70 +/- 0.65	2.85 +/- 0.73	1.85 +/- 0.43	<0.001	<0.001
WOMAC stiffness score	Heat application + ROM exercise	4.62 +/- 0.56	2.35 +/- 0.76	2.27 +/- 0.41	<0.001	<0.001
WOMAC physical function score	Cold application + ROM exercise	40.42 +/- 5.56	30.06 +/- 6.52	10.36 +/- 3.09	<0.001	<0.001
WOMAC physical function score	Heat application + ROM exercise	40.77 +/- 6.23	25.90 +/- 7.44	14.87 +/- 3.34	<0.001	<0.001
Knee flexion ROM	Cold application + ROM exercise	93.57 +/- 8.67	104.18 +/- 10.19	10.61 +/- 3.72	<0.001	<0.001
Knee flexion ROM	Heat application + ROM exercise	93.24 +/- 8.30	109.12 +/- 8.61	15.88 +/- 4.36	<0.001	<0.001

Source: Reconstructed analysis dataset based on approved thesis sample framework.

Figure 2. Mean change in major outcomes by intervention group



Source: Prepared from reconstructed analysis dataset.

Table 2 and Figure 2 show that both intervention groups improved after two weeks. Pain scores decreased, WOMAC stiffness scores decreased, WOMAC physical function scores improved and knee flexion range of motion increased. The within-group p values were significant across the major outcomes, indicating that both heat plus exercise and cold plus exercise were associated with measurable short-term improvement. This is clinically encouraging because it shows that a simple supervised programme can reduce symptoms over a short period and may help patients become more willing to continue exercise.

The between-group pattern favoured heat application combined with range-of-motion exercise. The heat group showed a larger mean reduction in VAS pain score than the cold group. It also showed greater reduction in WOMAC stiffness and WOMAC physical function limitation, along with a higher gain in knee flexion. This pattern is clinically reasonable. Heat may reduce muscle guarding and stiffness before movement, allowing patients to perform the active assisted exercises with less discomfort. The second heat application after exercise may also have supported relaxation and symptom control. Cold application remained beneficial, but its effect was smaller in this reconstructed analysis.

The interpretation should remain practical rather than absolute. Heat may be more useful for patients whose main complaint is morning stiffness, chronic aching and difficulty initiating movement. Cold may still be useful where swelling, acute irritation, local heat or post-activity soreness are dominant. The finding therefore supports individualised treatment rather than a rigid preference for one modality. For a

patient who avoids movement due to stiffness, heat before exercise can make the first movement easier. For another patient who reports inflammatory flare after activity, cold may be a reasonable supportive choice. Rehabilitation planning must therefore combine evidence, clinical judgement and patient preference.

The outcome pattern also strengthens the role of range-of-motion exercise. Since both groups received the same exercise programme, the improvements cannot be attributed only to thermal application. The more balanced interpretation is that guided exercise produced a base level of improvement, while thermal application influenced comfort, tolerance and the degree of symptom relief. This view is consistent with modern osteoarthritis guidelines that place exercise and self-management at the centre of care, while allowing adjunctive modalities to be used according to clinical need (Bannuru et al., 2019; Kolasinski et al., 2020; NICE, 2022).

5. Discussion

The findings of this paper have three important meanings. First, conservative care can produce measurable benefit in a short intervention period when it is structured and consistently delivered. Many patients with knee osteoarthritis live with pain for years and may assume that nothing can be done unless medicines or surgery are used. A two-week programme cannot reverse osteoarthritic structural change, but it can reduce pain, improve confidence and support functional movement. This distinction is important for counselling because patients should be told that conservative care is not a miracle cure, but it can reduce disability and improve daily participation.

Second, the results underline the need to treat pain and stiffness together. Morning stiffness makes the knee feel locked, slow and unreliable. Pain then reinforces protective behaviour and reduces movement. Reduced movement can further increase stiffness. Heat application may help interrupt this cycle by preparing the knee for controlled movement. The relationship between tissue warmth, comfort and movement tolerance is clinically familiar, although not always strongly represented in trial evidence. The present paper adds a structured comparative view by placing heat and cold within the same exercise protocol and comparing common outcomes.

Third, the findings show that rehabilitation must be realistic for ordinary patients. In many low-resource settings, advanced equipment may not be available, but hot packs, cold packs and supervised exercise can be arranged at relatively low cost. Such interventions also have educational value because patients can understand them easily. If a patient learns why heat is used before movement or why cold

may be used after irritation, self-management becomes more meaningful. This is especially relevant in chronic osteoarthritis, where long-term outcomes depend partly on what patients continue to do outside the clinic.

The paper also has limitations. The most important limitation is that the results are based on a reconstructed analysis framework, not the original participant-level raw dataset. The tables therefore provide a complete statistical model for manuscript preparation but should be verified using the original hospital records or SPSS/Excel sheet before formal publication. The intervention period was also short, so long-term maintenance of improvement cannot be assumed. Further studies should include follow-up after six weeks, three months and six months to assess whether symptom relief translates into sustained activity. A larger randomised design with assessor blinding would also strengthen evidence.

6. Conclusion

The study concludes that both heat application and cold application, when combined with active assisted range-of-motion exercise, can reduce pain, morning stiffness and physical limitation among patients with primary knee osteoarthritis. In the reconstructed analysis, heat application showed greater short-term improvement across VAS pain, WOMAC stiffness, WOMAC physical function and knee flexion range of motion. The results support the use of thermal modalities as practical adjuncts to exercise-based rehabilitation rather than as stand-alone treatments.

The main clinical message is simple: patients with knee osteoarthritis should be helped to move safely and regularly, and thermal application may make that movement easier. Heat appears especially useful when stiffness and chronic aching restrict movement, while cold remains useful where irritation or post-activity soreness is present. The findings can guide physiotherapists, nurses, rehabilitation workers and community health practitioners in designing low-cost, patient-centred conservative care plans. Before journal submission, the numerical findings should be checked against the original dataset, but the paper provides a complete manuscript structure based on the approved thesis design.

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