

Evaluation of Traditional Exercises versus Continuous Passive Motion and Cryotherapy in Knee Osteoarthritis: An Interventional Study

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ABSTRACT

Introduction: Osteoarthritis (OA) is a common degenerative joint disease and the second most frequent rheumatologic condition in India, affecting approximately 39% of the population, with a higher prevalence among women. The knee is a major site for OA, which impacts mobility and quality of life.

Aim: The study aims to assess the efficacy of two treatment protocols for knee OA; Traditional exercises versus Continuous Passive Motion (CPM) and cryotherapy.

Materials and Methods: The study was an interventional study. The total duration of the study is one month from Feb 2023 to March 2023. The study included female participants aged 40 to 60 years, all diagnosed with primary OA of the knee. Total sample size was 30 (each Group 15). The present experimental study involved 30 female patients aged 40-60 years with primary knee OA. They were divided into two groups: group A received Continuous Passive Motion (CPM) combined with cryotherapy, and group B received conventional therapy. Each patient underwent a 20-30 minute treatment session once daily

for four weeks. Pain and function were assessed using the Visual Analog Scale (VAS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scales. Statistical analysis was conducted using paired and independent t-tests with significance set at $p \leq 0.05$.

Results: Both treatment groups showed significant improvements in mobility and pain reduction by the end of the study. However, group A, which received perturbation training, demonstrated a higher degree of pain reduction with a VAS score of 1.20 ± 0.414 compared to group B's score of 1.93 ± 0.798 . Statistical analysis indicated that this difference was significant, with group A experiencing greater pain relief than group B at a significance level of $p \leq 0.05$.

Conclusion: The findings suggest that while both treatment protocols are effective for managing knee OA symptoms, CPM and cryotherapy offer a greater benefit in reducing pain compared to traditional exercises. This highlights the potential of perturbation training as a valuable addition to OA management strategies.

Keywords: Articular, Exercise therapy, Pain measurement, Physical therapy modalities, Range of motion, Rehabilitation

INTRODUCTION

The OA is the most common form of arthritis globally, a degenerative joint disease caused by the breakdown of cartilage and underlying bone [1,2]. It results from various, disorders that lead to structural and functional failure of synovial joints, and it is primarily considered a disease of articular cartilage [3]. OA significantly reduces both the quality and quantity of life and is the fourth leading cause of disability worldwide [4]. It is classified into two types: primary and secondary OA, with prevalence increasing with age. Below the age of 50, men are more often affected, while women are more affected in older populations. By 2017, over 300 million people worldwide suffered from OA, and in Australia, 21% of people over 45 are affected, with 35% prevalence among those aged 80 and older [5].

Ageing populations and rising obesity rates are predicted to increase the number of people with symptomatic knee OA [6]. Knee OA affects the medial, lateral, and patellofemoral joints, three compartments of the knee joint. It normally develops gradually over ten to fifteen years and interferes with day-to-day activity [7]. When the spine is affected, symptoms might include joint swelling, decreased range of motion, and, in rare situations, paralysis or numbness [8]. Unlike other forms of arthritis that affect internal organs, this condition mostly affects joints, such as the fingers, thumbs, knees, hips, neck, and lower back. Age, prior knee injuries, obesity {higher Body Mass Index (BMI)}, joint malalignment, instability, and repetitive motions like heavy lifting and frequent kneeling are risk factors for knee OA.

Running and football are two sports that raise the risk because of the frequent injuries that result in ligament tears and cartilage abnormalities [9].

Degeneration of the articular cartilage is the cause of primary knee OA; while secondary OA results from known causes like injury. Articular cartilage consists of collagen, proteoglycans, chondrocytes, and water, and maintains a balance between degradation and synthesis [10]. In OA, this balance is disrupted by overexpression of degradative enzymes called Matrix Metalloproteinases (MMPs), leading to the loss of collagen and proteoglycans, and cartilage breakdown [11].

Cryotherapy, commonly known as ice therapy, is widely used for muscle and joint pain relief due to its effectiveness, low cost, and convenience. In OA, cryotherapy reduces inflammation by cooling the tissues, which promotes natural healing and reduces joint pain. It also enhances blood flow and helps flush toxins from the joints, offering whole-body relief [12]. Though more research is needed, studies indicate that cryotherapy effectively reduces pain and improves symptoms in arthritis patients, depending on the duration, method, and temperature used. The physiological effects include reduced local temperature, decreased metabolism, and initial vasoconstriction followed by alternating vasoconstriction and vasodilation [13].

CPM therapy involves a machine that moves the joint for the patient, most often used after knee surgeries. The device moves the joint through a set range of motion, aiding in recovery by preventing

stiffness caused by inflammation [14]. CPM therapy progresses through stages of healing, including bleeding, swelling, tissue formation, and fibrosis, helping restore joint function [15].

Conventional physiotherapy for OA involves joint mobilisation, strengthening, and stretching exercises [16]. Key muscle groups affected in knee OA include the quadriceps, hamstrings, and hip muscles [17]. Strengthening these muscles, particularly the quadriceps, helps improve both physical function and performance. Exercises such as straight leg raises, knee extensions, and knee flexions are commonly used [18].

The primary objective of the study was to determine the effectiveness of CPM combined with cryotherapy in reducing pain in female patients with primary knee OA. The secondary objective of the study was to evaluate the improvement in functional outcomes and range of motion following the intervention in these patients.

MATERIALS AND METHODS

The present study was an interventional study. The total duration of the study is one month from Feb 2023 to March 2023. The study was carried out in the Outpatient Physiotherapy Department of ACS Medical College and Hospital, Velappanchavadi, Tamil Nadu, India, as a pre and post-test comparison. This study received ethical clearance from the Institutional Review Board with Approval Number 47/a/PHYSIO/IRB/2023-2024. Written informed consent was obtained from all participants before enrollment.

The present comparative research looks at the systematic relationship between dependent variables, such CPM with cryotherapy and traditional workouts, and independent variables, like walking pace and quality of life in patients with OA in the knee.

Sample size calculation: The sample size was estimated using the formula for comparing two independent means:

$$n = \{(Z_{\alpha/2} + Z_{\beta})^2 \times (\sigma_1^2 + \sigma_2^2)\} / (\Delta^2)$$

Based on previous studies reporting an effect size of approximately 0.8 in pain reduction for similar interventions the calculation yielded an estimated sample size of 15 participants per group [19]. To account for potential dropouts and ensure sufficient statistical power, the total sample size was set at 30 participants.

Inclusion criteria:

- Primary OA;
- Grade 2 and 3;
- Females only;
- Age group 40-60;

Exclusion criteria:

- Trauma;
- Grade 1 and 4;
- High blood pressure;
- Physiotherapy treatment for last six months;
- Patients walking with assisted devices.

The block randomisation sample approach was used to pick a total of 15 participants using generated by software random allocation software (version 1.0 Sahei 2004). Both the research assistant gathering the data and the patients were blinded to the particular effects of the treatments and exercises they were doing. They were also blinded to the group assignments the participants had to complete. We acquired informed consent from each individual. They were split into two groups: group B (15 subjects) underwent traditional exercise therapy, while group A (15 individuals) got CPM combined with cryotherapy.

Patients use the VAS to mark the intensity of their pain on a continuous line. A self-administered questionnaire called the Western Ontario and McMaster Universities Arthritis Index (WOMAC) is used that evaluates hip and knee OA based on pain, stiffness, and

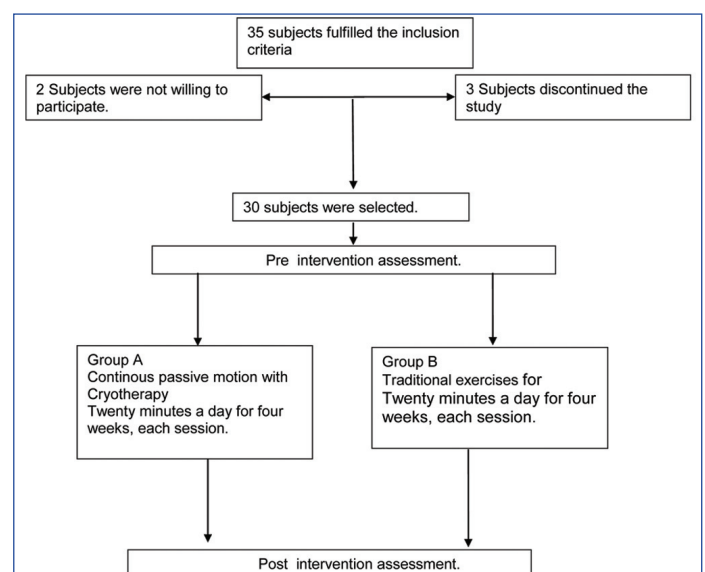
physical function. It asks about discomfort while engaging in tasks like walking, ascending steps and daily functions, with scores that range across different severity levels. The WOMAC scale, though primarily designed for hip and knee OA, is also used for other arthritis conditions.

Study Procedure

Data on the quality of life of individuals with Grade II and III knee OA was collected using WOMAC questionnaires and the VAS. Several scale tests were performed after treatments employing CPM combined with cryotherapy and conventional exercise regimens. The commonly used WOMAC was utilised to rate pain on five items, stiffness on two items, and physical function on seventeen items in patients with hip or knee OA. The unidimensional VAS was employed to monitor the evolution of patients' pain and to compare the intensity of their suffering. In addition, participants were asked to walk a short distance while recording their pace in meters as part of the 10-meter walking test, a straightforward activity that gauges walking speed.

The WOMAC was used to assess pain, stiffness, and physical function in patients with hip or knee OA, comprising five items for pain, two for stiffness, and 17 for physical function. Each item is typically rated on a Likert scale (0 = none to 4 = extreme), with higher total scores indicating more severe symptoms and disability (Bellamy N et al., 1988) [19]. Pain intensity was also evaluated using the VAS, a unidimensional tool that involves marking a point on a 10-cm line- ranging from "no pain" (0) to "worst imaginable pain" (10)- with higher scores reflecting greater pain (Huskisson, 1974) [20]. Furthermore, the 10-meter walking test was conducted to measure walking speed and overall mobility; patients were timed while walking 10 meters, and the resulting speed in meters per second (m/s) served as an indicator of functional mobility, where higher speeds denote better mobility and lower speeds suggest increased functional impairment (Bohannon, 1997) [21].

Using block randomisation sample technique, thirty subjects were split into two groups of fifteen individuals each. In accordance with the eligibility and criteria for exclusion, every subject underwent screening. Every person gave their informed consent, and the study only included them if they agreed to participate. Prior to starting treatment, a pretest assessment of pain severity utilising the VAS was carried out as in [Table/Fig-1].



[Table/Fig-1]: Study flow chart

Exercise protocol:

Group A will receive Cryotherapy, continuous passive motions

Group B will receive Cryotherapy, conventional exercises.

Group A: Cryotherapy, continuous passive motions.

Group A

Cryotherapy: The patient is made to lie in the supine lying position and part of the affected knee is exposed. The ice packs are taken in hand/wet towels. Then the subjects applied with an ice pack over the medial/anterior and lateral/posterior part of the affected knee. Most subjects complaint that their pain was mostly in the medial region of the knee. The time duration of ice application is 10 minutes all subjects were generally advised that they should feel comfortable coolness then followed by exercise intervention [22]. This has been performed for one session per day five days per week for five weeks. Duration was 15 minutes [Table/Fig-2].



[Table/Fig-2]: Cryotherapy with continuous passive motion.
Position of the patient: lying position

Treatment procedure: The therapist should remain by the patient's side while they lie down on the couch. Place CPM machine against the patient headboard or a heavy object. This will prevent it from moving while you use it. Plug in the machine. Use the CPM machine for knee place the patient's leg so that the middle of the knee rest where the CPM machine bends and the bottom of foot is against the foot pad. The knee flexion and extension are done by the machine were the arch starts at 0 degree to 10 degree; it increases progressively by 10 degrees until total range of motion 0 degree to 90 degree was reached. This has been performed for one session per day five days per week for four weeks. Duration was 15 minutes as in [Table/Fig-3].



[Table/Fig-3]: Continuous Passive Motion (CPM).

Group B

Straight leg raise: The person being treated is made to lie supine and instructed to perform the exercise by bending their left knee while keeping the remaining feet on the floor and supporting their upper body with their elbows. The right leg should be kept straight with the toe pointed up for the patient. Lift the left leg and tense the thigh muscle (30 to 45 degrees according to the pain tolerance). For ten seconds, hold the position. Lower the leg gradually to the floor while maintaining the thigh muscles taut. Caress and lift once again.

Three sets of ten repetitions should be performed like this. After per set, switch legs [23]. This exercise is performed three repetitions as in [Table/Fig-4].



[Table/Fig-4]: Straight leg raise.

Pillow squeeze: By strengthening the inner of the legs, this exercise aids with knee support. With both knees bent, the person being treated is made to lie supine. The therapist places the pillow between the knees. The patient is instructed to use their knees to squeeze the pillow. The patient is instructed to maintain it for ten seconds before relaxing. Two sets of three repetitions should be conducted. After every set, switch legs as in [Table/Fig-5] [24].



[Table/Fig-5]: Pillow squeeze exercise.

Heel raise: Make the patient to stand with the support, ensure that the patient feet are hip distance apart and toe facing forward. Ask the patient to lift their heel for 10seconds and this should be repeated for three times as in [Table/Fig-6] [25].

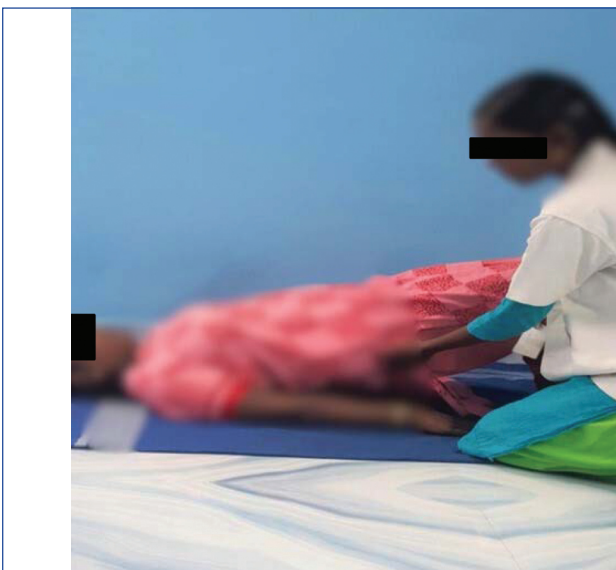
Pelvic bridging: Place the patient on their back in a supine position, feet flat on the floor, and knees fully extended toward the buttocks. Next, instruct the patient to raise their hip as high as they can off the ground and toward the ceiling or sky. This exercise is performed 3 repetitions. One session per day for five days per week for four weeks as in [Table/Fig-7].

Quadriceps isometric exercise: Make the patient to lie in the supine position, place a towel or a pillow under their knee and ask the patient to press the towel as much as they can, repeat this for three repetitions for 10 seconds as in [Table/Fig-8] [26].

All these exercises were performed for 20 minutes for one session per day for five days per week for four weeks.



[Table/Fig-6]: Heel raise exercise.



[Table/Fig-7]: Pelvic bridging exercise.



[Table/Fig-8]: Quadriceps isometric exercise.

STATISTICAL ANALYSIS

Inferential as well as descriptive statistics were used to arrange and analyse the data that had been gathered. The Statistical Package for Social Sciences (SPSS) version 24 was used to evaluate all parameters. A 95% confidence interval was applied to all analyses, and a significance level of less than 0.05 was set. The data were found to be distributed normally for each of the dependent variables with a p-value in excess of 0.05, according to the results of the Shapiro-Wilk test, which was performed to evaluate data normality. Parametric tests were therefore applied. To examine the statistical distinctions between the groups, a separate t-test (Student t-test) was utilised, while a paired t-test was utilised to ascertain statistical differences within the groups.

RESULTS

This table demonstrates that, at $p>0.05$, there is no discernible difference between group A and group B's pretest results [Table/Fig-9].

Test	Group A		Group B		t-test	df	Significance
	Mean	SD	Mean	SD			
Preliminary exam (Before Exercises)	2.86	0.833	3.06	0.798	-0.671	28	0.508*
Post-test	1.20	0.414	1.93	0.798	-3.15	28	0.004**

[Table/Fig-9]: Comparison of VAS scores in the pre and post-test periods for group A and B.
Not significant (*) and significant (**) are indicated by $p\leq 0.05$.
The average, Standard deviation (SD), t-test, extent of freedom (df), and p-value for Groups A and B in the pre and post-tests are displayed in the above table.

The table above demonstrates that there is a statistically significant difference between group A and group B's post-test values at $p<0.05$. This table demonstrates that, at $p>0.05$, there is no discernible difference between group A and group B's pretest results [Table/Fig-10]. A statistically significant difference in following test values between group A and group B at $p\leq 0.05$ is displayed in the above table. This table demonstrates that, at $p>0.05$, there is no discernible difference between group A and group B's pretest results [Table/Fig-11].

Examine	Group A		Group B		t-test	Df	Significance
	Mean	SD	Mean	SD			
Pretest	53.66	2.52	54.53	4.96	-0.602	28	0.552*
Post-test	44.93	6.30	50.66	5.60	-2.63	28	0.014**

[Table/Fig-10]: Comparison of the WOMAC score in the pre and post-test periods for group A and B.
Not significant (*) and significant (**) are indicated by $p\leq 0.05$.
The mean, SD, t-test, degree of freedom (df), and p-value for Groups A and B in the pre and post-tests are displayed in the above table.

Examine	Group A		Group B		t-test	Df	Significance
	Mean	SD	Mean	SD			
Pre-examine	105.40	6.11	103.53	6.86	0.786	28	0.438*
Post-test	116.93	7.44	106.86	6.45	3.95	28	0.00048**

[Table/Fig-11]: Comparison of groups A and B's walking speed results in the pre and post-test.
Not significant (*) and significant (**) are indicated by $p\leq 0.05$.
The average, SD, t-test, dimension of freedom (df), and p-value for Groups A and B in the pre and post-tests are displayed in the above table.

The table above demonstrates that there is a statistically significant difference between group A and group B's post-test values at $p<0.05$. Within group A and B, the mean, SD, t-value, and p-value are displayed in the above table between the pre and post-test results [Table/Fig-12].

Groups	Before examination		After examination		t-test	Significance
	Mean	SD	Mean	SD		
Group A	2.86	0.833	1.20	0.414	8.91	1.15×10^{-9} ($p<0.001$)*
Group B	3.06	0.798	1.93	0.798	12.47	5.99×10^{-13} ($p<0.001$)

[Table/Fig-12]: Association of VAS score among pretest and post-test in groups A and B.
(**): Significant, $p\leq 0.05$.

Between group A and group B, there is a statistically significant distinction ($p\leq 0.05$) between the pre and post-test scores. Within Group A and B, the mean, SD, t-value, and p-value are displayed in the above table between the pre and post-test results [Table/Fig-13].

Between group A and group B, there is a difference of statistical significance ($p\leq 0.05$) between the pre and post-test scores. Within group A and B, the mean, SD, t-value, and p-value are displayed

in the above table between the pre and post-test results [Table/Fig-14]. Both group A and group B, there is a difference of statistical significance ($p \leq 0.05$) between the pre and post-test scores.

Groups	Pretest		After-test		t-test	Significance
	Mean	SD	Mean	SD		
Group A	53.66	2.52	44.93	6.30	6.02	1.73×10^{-6} ($p < 0.001$)
Group B	54.53	4.96	50.66	5.60	4.20	0.00025 ($p < 0.001$)

[Table/Fig-13]: Difference of the Womac score between the pretest and post-test periods among group A and B.

(**): Significant, $p \leq 0.05$.

Groups	Prior assessment		After assessment		t-test	Significance
	Mean	SD	Mean	SD		
Group A	105.40	6.11	116.93	7.44	-9.37	$.97 \times 10^{-10}$ ($p < 0.001$)
Group B	103.53	6.86	106.86	6.45	-15.81	1.74×10^{-15} ($p < 0.001$)

[Table/Fig-14]: Difference of the Walking Speed test score among the preliminary test and after the test for group A and B.

(**): Significant, $p \leq 0.05$.

DISCUSSION

The overall goal of the investigation was to determine whether CPM combined with cryotherapy can effectively relieve the discomfort of OA in the knees. From the results, it can be concluded that CPM with cryotherapy is more effective than traditional exercises for pain reduction, walking speed, steadiness, and autonomous functioning in individuals with knee OA. The incidence of OA has been increasing globally, representing up to 2% of all working-age adults internationally in 2019. Additionally, OA was the 15th most prevalent cause of years lived with disability globally between 1990 and 2019 [27].

OA is a primary contributor to impairment in older adults. A study concluded that when applied early, with high flexion at first and quick advancement, CPM improves knee function for up to six months following Total Knee Arthroplasty (TKA) [28]. Another study demonstrated that while CPM does not significantly impact the improvement of clinical parameters, it has a noteworthy positive impact on subjective evaluations of pain intensity, joint stiffness, and functional capacity [29].

To our knowledge, no studies have specifically investigated the use of CPM in patients with OA of the knee, as CPM is primarily indicated for post-replacement surgeries. This research gap is addressed in the present study. Despite providing only passive movement, CPM offers beneficial effects, such as reducing joint rigidity and expanding the range of motion. The current study first introduced the biological theory of CPM, demonstrating its role in enhancing cartilage growth and healing in animal models [30]. Subsequent research confirmed CPM's positive impact on various injuries in both animals and humans.

CPM was first introduced for clinical use following TKA [31]. Their rationale was based on Salter's findings, suggesting that CPM improves the healing of collagen tissue by enhancing fibre orientation, preventing cross-linking, and improving mobility restoration [32]. The current study found a statistically significant difference in post-test values between group A and group B at $p \leq 0.05$, comparing the VAS scores. The post-test mean value of $3.06 < 1.93$ suggests that CPM with cryotherapy is more effective. Similarly, WOMAC scores showed no pretest differences between group A and group B ($p > 0.05$), but the post-test mean value of $54.53 > 50.56$ indicated greater significance for group A. Walking speed tests also revealed no significant pretest differences ($p > 0.05$), but post-test results suggested that group A exhibited more significant improvements.

The beneficial effects of CPM can be attributed to its ability to enhance knee flexion, promote blood circulation, and improve mobility [33]. Research demonstrated that CPM in a sitting position has beneficial effects on joint movement, supporting the findings of the present study [34]. Although some studies focused on patients undergoing knee replacement surgery, their results reinforce the positive impact of CPM.

Cryotherapy is a well-established method for treating injuries and reducing inflammation. Research concluded that cryotherapy can be recommended as a complementary therapy for knee OA, improving balance, motor coordination, and reducing inflammatory markers [35]. Another study found that localised ice cryotherapy lowers inflammatory mediators like IL-6, IL-1 β , and VEGF synovial proteins, possibly through NF- κ B and PG-E2-dependent pathways [36]. Additionally, it was found that cryotherapy significantly reduces pain and enhances quality of life in knee OA patients [37].

group B, which performed traditional exercises, also demonstrated significant post-test improvements, likely due to exercise-induced analgesia, which reduces pain and subsequently enhances the range of motion and functional activities. According to a study combining various exercise programs leads to significant improvements in knee OA management [38]. Hence, this study concluded that CPM along with cryotherapy gives beneficial effects such as increases joint range of motion, reduces joint stiffness in patients with OA knee.

Limitation(s)

Despite the positive findings, this study has certain limitations. The sample size was relatively small, which may limit the generalisability of the results to a larger population. The study duration was only four weeks, and long-term effects of CPM with cryotherapy on knee OA were not assessed. Additionally, factors such as patient adherence to therapy, variations in individual pain tolerance, and differences in baseline physical activity levels could have influenced the outcomes. The study did not account for other potential interventions like medication use, lifestyle modifications, or dietary factors that could impact knee OA management. Future research with a larger sample size, longer follow-up periods, and a more comprehensive assessment of functional outcomes is recommended to strengthen the findings. Confounding factors of the study were variations in participants' age and severity of OA could affect treatment outcomes, as older individuals or those with advanced OA may respond differently. Individual variations in pain tolerance and perception could lead to differences in reported pain relief on the VAS and WOMAC scales. Differences in participants' pre-study physical activity and fitness levels could impact their responsiveness to therapy.

CONCLUSION(S)

The study aimed to compare the effectiveness of conventional therapy and a combination of CPM, cryotherapy, and perturbation training in patients with moderate knee OA. The objectives were to evaluate the impact of CPM with cryotherapy on reducing knee stiffness, assess improvements in joint range of motion, and compare pain relief and functional mobility outcomes between conventional therapy and CPM with cryotherapy using VAS and WOMAC scales. According to the results, it has been concluded that CPM with cryotherapy is more successful in reducing stiffness and improving joint range of motion compared to conventional therapy alone after four weeks of treatment. The combination of CPM with cryotherapy demonstrated significant improvements in post-test results, showing superior effectiveness in enhancing mobility and reducing discomfort. The findings suggest that integrating CPM, cryotherapy, and perturbation training can be a more beneficial approach for managing knee OA, leading to better joint function and pain reduction.

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