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## Efficacy of open and closed kinetic chain exercises in knee Osteoarthritis: A comparative analysis

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### Abstract

**Background:** Knee Osteoarthritis (OA) is a prevalent condition that often leads to debilitating pain and disability, especially after the age of 40. It is one of the leading causes of sick leave and disability. Open Kinetic Chain (OKC) exercises may offer more effective outcomes in reducing pain and disability compared to Closed Kinetic Chain (CKC) exercises when combined with hot packs, posterior capsular stretching, basic knee stretching exercises, and Transcutaneous Electrical Nerve Stimulation (TENS).

**Objective:** This study aimed to compare the effectiveness of OKC and CKC exercises when both were added to hot packs, posterior capsular stretching, basic knee stretching exercises, and TENS in patients with knee OA.

**Methods:** This four-week study involved 60 participants with knee OA, divided into three groups of 20. Group A received hot packs, OKC exercises, posterior capsular stretching, basic knee stretching exercises, and TENS. Group B received hot packs, CKC exercises, posterior capsular stretching, basic knee stretching exercises, and TENS. Group C received hot packs, posterior capsular stretching, basic knee stretching exercises, and TENS. Pain and disability levels were measured before and after the intervention.

**Results:** Both Group A (OKC exercises) and Group B (CKC exercises) demonstrated significant reductions in pain and disability ( $p \leq 0.0001$ ). Intergroup comparisons showed that Group A had significantly lower pain and disability scores than Group B ( $p \leq 0.0001$ ). The ANOVA analysis also revealed significant differences in pain ( $f = 43.84, p \leq 0.05$ ) and disability ( $f = 25.57, p \leq 0.05$ ) between the groups, with Group A showing more significant improvements.

**Conclusion:** The addition of OKC exercises to standard treatments (hot packs, posterior capsular stretching, basic knee stretching exercises, and TENS) resulted in a more significant reduction in pain and disability in individuals with knee OA compared to CKC exercises. Both interventions showed effectiveness, but OKC exercises provided superior outcomes over the 4-weeks period.

**Keywords:** Osteoarthritis, transcutaneous electrical nerve stimulation, open kinetic chain, closed kinetic chain, interferential current.

### Introductions

Osteoarthritis (OA) is the fourth leading cause of disability worldwide, significantly affecting quality of life, especially in the aging population. Among the various types of OA, knee osteoarthritis is the most common cause of chronic disability in the elderly, as the knee joint plays a critical role in weight-bearing and ambulation. Functional limitations arising from knee OA often impair activities of daily living (ADLs) [1].

OA is a progressive, degenerative, non-inflammatory joint disease characterized by metabolic, structural, and biochemical changes in articular cartilage, leading to its deterioration [2]. These changes are often accompanied by reactive new bone formation at the joint surfaces and margins, affecting the subchondral bone, joint capsule, synovial membrane, and surrounding muscles. Common symptoms of OA include joint pain, stiffness, reduced range of motion, impaired muscle strength, altered proprioception, instability, crepitus, and loss of function [3].

The etiology of OA is multifactorial, with a strong association with aging and repetitive mechanical loads. Studies categorize risk factors into three primary subgroups: Sex, anatomy, and body mass. Obesity is a notable contributor to the onset and progression of knee OA [4].

Approximately 60% of individuals over 50 years of age are affected, with prevalence increasing with age. Women are disproportionately affected compared to men. According to Davies *et al.*, OA affects 9% of men and 18% of women over 65 years, resulting in significant absenteeism and early retirement due to disability [5].

Radiographic evidence of OA is present in 80% of adults aged 65 and older, with symptomatic knee OA affecting 10% of adults. Such symptoms often lead to difficulty in climbing stairs, standing, walking, and performing ADLs. For instance, Ettinger *et al.* reported that 50-71% of individuals with knee OA experience ambulatory challenges, while 44-67% face difficulty in transfers [6].

Treatment strategies for knee OA include both pharmacological and non-pharmacological interventions. While non-steroidal anti-inflammatory drugs (NSAIDs) are commonly prescribed, recent studies highlight their potential negative effects on cartilage metabolism. Physiotherapy, a widely recommended non-pharmacological approach, offers pain relief and functional improvement through modalities such as exercises, Transcutaneous Electrical Nerve Stimulation (TENS), interferential current therapy, low-energy laser therapy, manual therapy, thermotherapy, and cryotherapy [7-10].

Exercise therapy for knee OA can be broadly classified into weight-bearing (closed kinetic chain) and non-weight-bearing (open kinetic chain) exercises. Closed kinetic chain exercises involve movements where the joint moves while the distal segment is fixed, whereas open kinetic chain exercises allow the distal segment to move freely. A meta-analysis by the Philadelphia Expert Panel concluded that therapeutic exercises provide significant pain relief and functional improvement in knee OA [6].

Additionally, TENS has been shown to effectively manage arthritic pain, with strong evidence supporting its use for pain relief and improved patient outcomes in knee OA.

This study aims to evaluate the efficacy of different intervention strategies for reducing disability associated with knee OA. Participants were divided into three groups:

- **Group A:** Open kinetic chain exercises,
- **Group B:** Closed kinetic chain exercises,
- **Group C:** (Control): Hot packs and TENS.

Both experimental groups (A and B) received hot packs before exercises and TENS after exercises for four weeks. Posterior capsular stretching and basic stretching exercises were administered across all groups to further enhance functional outcomes. Outcome measures included chronic knee pain and disability, assessed using categorical scales.

## Materials and Methodology

### Source of Data

The subjects were selected from the out-patient department of physiotherapy of a tertiary care hospital of Odisha.

### Sample Size

Sixty subjects were selected for the study.

### Sampling Method

A convenient sampling method was adopted for the study. The subjects were then randomly allocated into one of the study groups:

- **Group A:** Hot packs + Open Kinetic Chain (OKC) Exercises + Posterior Capsular Stretching + Basic

Stretching Exercises for knee OA + TENS.

- **Group B:** Hot packs + Closed Kinetic Chain (CKC) Exercises + Posterior Capsular Stretching + Basic Stretching Exercises for knee OA + TENS.
- **Group C:** Hot packs + Posterior Capsular Stretching + Basic Stretching Exercises for knee OA + TENS (control group).

**Study Design:** Experimental study, comparative in nature.

### Inclusion Criteria

Both male and female subjects characterized by chronic knee pain ( $\geq 6$  weeks duration) and fulfilling at least three of the following six criteria (based on the American Rheumatology Criteria for classification of idiopathic OA of the knee joint, 1986).

1. Age  $> 50$  years
2. Morning stiffness (knee)  $\leq 30$  minutes
3. Crepitus
4. Bony tenderness
5. Bony enlargement
6. No palpable warmth

These criteria were selected as they have 95% sensitivity and 69% specificity in clinically diagnosing knee OA.

### Exclusion Criteria

**Subjects were excluded if they:**

- Had no pain on the WOMAC pain score.
- Experienced referred pain from the back or hip.
- Had undergone previous knee replacement or surgery of the knee.
- Had any medical conditions preventing exercise.
- Had a severe traumatic injury of the knee within 6 months.
- Had used intra-articular steroid therapy in the affected knee.

### Instrumentations Used

- Visual Analog Scale (VAS) for pain.
- WOMAC (Western Ontario & McMaster Universities) Index of Osteoarthritis.
- Hot packs.
- TENS (Transcutaneous Electrical Nerve Stimulation).
- Treatment couch.
- Weight cuffs, Thera Bands, and bolster.

### Intervention protocol

The subjects (N=60) were divided into three groups with 20 subjects in each group. Each group followed a specific intervention protocol as described below

#### Group A (Experimental Group 1)

- Hot packs for 15 minutes (with a towel wrapped over them).
- OKC Exercises: Strengthening and range of motion (ROM) exercises.
- Posterior Capsular Stretching.
- Basic Stretching Exercises for knee OA.
- TENS after exercises.

#### Group B (Experimental Group 2)

- Hot packs for 15 minutes (with a towel wrapped over them).

- CKC Exercises: Strengthening and functional exercises designed to improve joint stability.
- Posterior Capsular Stretching.
- Basic Stretching Exercises for knee OA.
- TENS after exercises.

#### Group C (Control Group)

- Hot packs for 15 minutes (with a towel wrapped over them).
- Posterior Capsular Stretching.
- Basic Stretching Exercises for knee OA.
- TENS after exercises.

Each subject was treated three times a week, once daily, for a total duration of four weeks. The overall study duration was six months.

#### Strengthening exercises

For Groups A and B, 1 Repetition Maximum (1RM) was calculated, and subjects started exercises with 55-60% of their 1RM.

#### OKC Exercises (Group A)

- Seated knee extensions.
- Straight leg raises.
- Ankle pumps.
- Hamstring curls.

#### CKC Exercises (Group B)

- Mini squats.
- Step-ups and step-downs.
- Partial lunges.
- Wall sits.

#### Duration and Frequency

- Hot packs: 15 minutes per session.
- TENS: Administered after exercises for 15 minutes.
- Total duration of intervention: 4 weeks.
- Frequency: 3 sessions per week.

#### Strengthening Exercises

##### 1. Static Quadriceps Sets in Knee Extension

- **Patient Position:** Supine-lying or supine supported on elbows with the knee in full extension.
- **Exercise:** Isometric contraction of the quadriceps femoris by pushing the knee down while maintaining the foot in full dorsiflexion.
- **Repetitions:** 1 set = 10 reps, with a 6-seconds hold for each contraction and a 10-seconds rest between repetitions.

##### 2. Hamstring Curls

- **Patient Position:** Prone-lying.
- **Setup:** A towel roll placed under the femur (proximal to the patella) to avoid patella compression.
- **Exercise:** With weight cuffs around the ankle, flex the knee to 90°.
- **Repetitions:** 3 sets, with 1 set = 6 reps; hold for 3 seconds at the end range; 10 seconds rest between sets.

##### 3. Supine Straight Leg Raise (SLR):

- **Patient Position:** Supine-lying, with the knee extended.

- **Setup:** Opposite hip and knee flexed, with the foot flat on the treatment couch to stabilize the pelvis and lower back.
- **Exercise:** Activated the quadriceps muscle, then lifted the leg to about 45° of hip flexion while keeping the knee extended. Held for a count of 10, then lowered it. Progressed by reducing the lift angle to 30° and eventually 15°. Added ankle weight cuffs for increased resistance as needed.
- **Repetitions:** 3 sets, with 1 set = 6 reps; 10-second hold at the end range; 10 seconds rest between sets.

#### 4. Short-Arc Knee Extension

- **Patient Position:** Supine-lying or long-sitting.
- **Setup:** A rolled towel or bolster was placed under the knee to support it in flexion.
- **Exercise:** Started with the knee in a few degrees of flexion and progressed the flexion as tolerated. Extended the knee against gravity initially, adding ankle weights later for resistance.
- **Repetitions:** 3 sets, with 1 set = 6 reps; 10-second hold at the end range; 10 seconds rest between sets.

#### Range of Motion (ROM) Exercises

##### 1. Knee in Mid-Flexion to Full Extension

- **Patient Position:** Supine-lying or supine supported on elbows.
- **Exercise:** With the knee flexed to 45°, slid the foot on the surface until the knee was fully extended. Engaged the quadriceps against any limitation to full extension.
- **Repetitions:** 2 bouts of 30 seconds each, with a 3-seconds hold at the end range.

##### 2. Knee in Mid-Flexion to Full Flexion

- **Patient Position:** Supine-lying or supine supported on elbows.
- **Exercise:** Flexed the knee fully with assistance from the upper extremities or a strap.
- **Repetitions:** 2 bouts of 30 seconds each, with a 3-seconds hold at the end range.

##### 3. Posterior Capsular Stretching

- **Patient Position:** Supine-lying with the knee extended as much as possible.
- **Setup:** The physiotherapist lifted the patient's heel off the couch with one hand and pressed down on the knee (just above the patella) with the other hand.
- **Technique:** Performed a quick jerk to break adhesion.
- **Repetitions:** Held each stretch for 30 seconds, repeating 3 times per session.

#### Stretching Exercises

##### 1. Supine Hamstring Stretch

- **Patient Position:** Supine-lying.
- **Exercise:** Kept the contralateral leg straight. Flexed the ipsilateral hip to 90°, straightened the knee, and supported the proximal lower leg with hands until a moderate stretch was felt in the posterior thigh and calf.
- **Repetitions:** 3 reps with a 30-second hold.

##### 2. Prone Quadriceps Stretch

- **Patient Position:** Prone-lying.
- **Setup:** Hips and knees were extended. A strap was

placed around the ipsilateral ankle, pulling posteriorly and superiorly over the ipsilateral shoulder.

- **Exercise:** Grasped the strap and flexed the knee passively until a gentle stretch was felt in the anterior thigh. Avoided lumbar discomfort by maintaining a gentle stretch.
- **Repetitions:** 3 reps with a 30-second hold. *Note: Use the strap to prevent active hamstring contraction and cramping.*

### 3. Supine Ankle Plantar flexors Stretch

- **Patient Position:** Supine-lying.
- **Setup:** The therapist grasped the plantar aspect of the patient's foot with one hand while stabilizing the knee with the other.
- **Exercise:** Gently dorsiflexed the foot and maintained the position to stretch the plantarflexors.
- **Repetitions:** 3 reps with a 30-second hold at the end range.

### Group-A Protocol

Subjects in Group-A received high-rate surged TENS for 40 minutes, with a frequency of 100 Hz and a pulse width of 0.2 ms. A dual-channel device using 4 electrodes or large-sized electrodes was used for pain covering large areas, such as the knee joint.

### Electrode Placement

Electrodes were applied so that currents permeated the site of pain. This was usually achieved by placing the electrodes to straddle the injury or painful area. Electrodes were always applied to healthy, innervated skin.

If it was not possible to deliver currents within the site of pain due to a skin lesion or altered skin sensitivity, indifferent electrodes were applied proximally over the main nerve trunk arising from the site of pain. Alternatively, the indifferent electrodes were applied over the spinal cord at the spinal segments related to the origin of pain [11-13].

The active electrode was held in the therapist's hand, using the index finger to probe the skin of the patient to locate the best site for electrode placement. When the TENS device was switched on and the amplitude was slowly increased, the patient or therapist felt TENS paraesthesia when the circuit was completed by touching the patient's skin. As the therapist probed the skin with the index finger, the intensity of TENS paraesthesia increased whenever nerves on the patient's skin ran superficially [14-16]. This helped target an effective electrode site.

### Group-B Protocol

This group received hot packs, CKC exercises, posterior capsular stretching, basic stretching exercises for knee OA, and TENS.

Hot packs were applied for 15 minutes with a towel wrapped around it.

### CKC Exercises (Strengthening and ROM exercises)

#### 1. Standing Terminal Knee Extension

- The patient stood with a resistive band/cuff from a weighted pulley mechanism behind a slightly flexed knee.
- The patient contracted the gluteal and quadriceps femoris muscles to fully straighten the hip and knee.

- Repetitions: 1 bout of 30 seconds (10 reps), with a 3-second hold at the end range. Resistance was increased as tolerated.

### 2. Partial Squats or Dips (Weight-lesened with arm support)

- The patient stood with arm support as needed.
- The patient performed a partial squat, keeping the knees centered over the feet.
- The patient flexed both knees up to 45-60 degrees.
- The patient returned to standing by contracting the quadriceps femoris and gluteal muscles.
- Repetitions: 1 bout of 30 seconds (1-second concentric phase; 2-second eccentric phase), with a 3-second hold at the end range.

### 3. Step-ups

- The patient stood in front of a low step.
- The patient placed the foot of the involved leg on the step and brought the body over the foot to stand on the step.
- Push-off assistance was used (as little as possible) from the contralateral foot, and the patient stepped down with the contralateral foot.
- Repetitions: 1 bout of 30 seconds (repeated slowly for 30 seconds). Step height and additional bouts were progressed as tolerated. Legs were alternated if both knees were involved.

### 4. Lunges

- The patient stepped forward into a stance.
- The patient rocked body weight forward.
- The knee was allowed to flex slightly.
- The patient rocked backward and controlled knee extension.
- Repetitions: 1 bout of 30 seconds, with a 3-second hold at the end range.

### 5. Wall Slides

- The patient stood with their back supported against the wall.
- The patient performed hip and knee flexion, sliding back down and then up the wall.
- Knee flexion was up to 60°.
- Repetitions: 1 bout of 30 seconds, with a 3-second hold at the end range.

### Range of Motion (ROM) Exercises

#### 1. Stationary Bike Exercise

- The knee was at nearly full extension at the bottom of the pedal stroke.
- Repetitions: 5 minutes, time was increased as tolerated. Clinical judgment was required to continue the activity for patients who were intolerant of the stationary bicycle.

### Posterior Capsular Stretching

- Patient Position: Supine-lying, with knee extension as much as possible.
- The physiotherapist stood by the patient's side, level with the leg.
- The therapist lifted the patient's heel off the couch with

one hand and pressed down on the knee just above the patella with the other hand.

- Since an adhesion needed to be broken, the movement was a quick jerk.
- Each stretch was held for 30 seconds and repeated 3 times per session.

### Stretching Exercises

#### 1. Standing Calf Stretch

- The patient stood with the heel of the foot on the ground and toes in contact with the wall.
- The patient gently pressed their toes against the wall.
- Repetitions: 3 reps with a 30-second hold.

#### 2. Standing Hamstring Stretch

- Patient Position: Standing, with the heel of the test leg placed at the edge of the treatment couch.
- The patient leaned the trunk forward toward the thigh, keeping the back extended, so that there was motion only at the hip joint.
- Repetitions: 3 reps with a 30-second hold.

#### 3. Standing Quadriceps Stretch

- Patient Position: Standing, with the hip extended and knee flexed.
- The patient grasped the ankle with their hand and maintained a posterior pelvic tilt without letting the back arch or side bend during the stretch.
- Repetitions: 3 reps with a 30-second hold.

### TENS Protocol

Subjects in Group-B received high-rate surged TENS for 40 minutes with a frequency of 100 Hz and a pulse width of 0.2 ms.

Dual-channel devices using 4 electrodes or large-sized electrodes were used for pain covering large areas (such as the knee joint).

### Group-C Protocol

This group received hot packs, posterior capsular stretching, basic stretching exercises for knee OA, and TENS.

Hot packs were applied for 15 minutes with a towel wrapped around it.

### Posterior Capsular Stretching:

- Patient Position: The patient was positioned supine-lying, with knee extension as much as possible.
- The physiotherapist stood by the patient's side, level with the leg.
- The therapist lifted the patient's heel off the couch with one hand and pressed down on the knee just above the patella with the other hand.
- Since an adhesion needed to be broken, the movement was performed with a quick jerk.
- Each stretch was held for 30 seconds and repeated 3 times per session.

### Stretching Exercises

#### 1. Supine Hamstrings Stretch:

- Patient position: The patient was positioned supine lying.
- The contralateral lower extremity was maintained as straight as possible.

- The ipsilateral hip was flexed to 90°.
- The knee was straightened, and the proximal lower leg was supported with hands until a moderate pull was felt in the posterior thigh and calf.
- Repetitions: 3 reps were performed with a 30-second hold.

#### 2. Prone Quadriceps Stretch

- Patient position: The patient was positioned prone lying.
- Both hips and knees were extended.
- A strap was placed around the ipsilateral ankle and brought posteriorly and superiorly over the ipsilateral shoulder.
- The patient grasped the strap with the ipsilateral hand and bent the knee by straightening the elbow and pulling on the strap.
- The knee was progressively flexed until a gentle stretch was felt in the anterior thigh.
- Repetitions: 3 reps were performed with a 30-second hold.

**Clinical Observation:** Hamstring muscle cramping may occur if the patient attempts to actively bend the knee. To reduce this possibility, the strap was always used to passively flex the knee. A gentle stretch and a comfortable position for the lumbar spine were maintained. Intense stretching often caused lumbar symptoms in this population.

#### 1. Supine Ankle Plantar flexors stretching

- Patient position: The patient was positioned supine lying.
- The therapist grasped the plantar aspect of the patient's foot with one hand and stabilized the knee joint with the other.
- The therapist gently moved the foot into dorsiflexion and maintained it, thereby stretching the plantar flexors of the ankle.
- Repetitions: 3 reps were performed with a 30-second hold at the end range.

• **Subjects in Group C:** The patient received high-rate surged TENS for 40 minutes with a frequency of 100 Hz and a pulse width of 0.2 ms. Dual-channel devices using 4 electrodes or large-sized electrodes were used for pain covering large areas, such as the knee joint.

• **Electrode Placement:** Electrodes were applied so that currents targeted the site of pain, usually achieved by applying electrodes to straddle the injury or painful area. Electrodes were always applied to healthy, innervated skin. If it was not possible to deliver currents to the site of pain due to a skin lesion or altered skin sensitivity, indifferent electrodes were applied proximally over the main nerve trunk arising from the site of pain. Alternatively, the indifferent electrodes were applied over the spinal cord at the spinal segments related to the origin of pain [18, 21].

• The active electrode was held in the therapist's hand, using the index finger to probe the patient's skin to locate the best site for electrode placement. When the TENS device was switched on and the amplitude was gradually increased, both the patient and therapist felt TENS paraesthesia when the circuit was completed by

touching the patient’s skin. As the therapist probed the patient’s skin, the intensity of TENS paraesthesia increased whenever nerves were superficial. This helped target an effective electrode site [22].

- **Method of Data Collection:** After consent was obtained from the subjects to participate in the study, the required data were collected. Differences in outcomes were assessed using the Visual Analog Scale (VAS) and the Western Ontario and McMaster Universities (WOMAC) Index of Osteoarthritis.
- **Selection of Tools:** VAS and the WOMAC Index of Osteoarthritis were internationally standardized and highly reliable tools for quantifying pain and disability. A Visual Analog Scale (VAS) was a measurement instrument used to assess characteristics or attitudes believed to range across a continuum of values that could not be easily measured directly. For example, the amount of pain a patient felt ranged across a continuum from none to extreme pain. From the patient's perspective, this spectrum appeared continuous, as their pain did not experience discrete jumps as it would with a categorization of none, mild, moderate, or severe. The VAS was designed to capture this continuum [23-25].
- The Western Ontario and McMaster Universities (WOMAC) Index of Osteoarthritis provided information about how osteoarthritis had affected the patient's ability to manage in everyday life. It consisted of three sections: pain, stiffness, and physical function. The index used 24 parameters: 5 parameters assessed pain, 2 assessed stiffness, and 17 assessed physical function.

**Results**

Statistical analyses were performed by using the Microsoft Excel. Results are calculated by using 0.05 levels of significance

**Intragroup analysis**

**Table 1:** Mean, standard deviation of age for the subjects of group-A, group-B and group-C

Demographic Data	Group-A		Group-B		Group-C	
	Mean	S D	Mean	S D	Mean	S D
Age	52.05	3.93	51.35	3.91	52.35	4.04

It describes the mean and standard deviation of age for the subjects of group-A, group-B and group-C which comes out to be 52.05±3.93, 51.35±3.91 & 52.35±4.04 respectively.

**Table 2:** Mean, standard deviation of pain for the subjects of group-A, group-B and group-C

Pain	Group-A		Group-B		Group-C	
	Mean	S D	Mean	S D	Mean	S D
Pre-Intervention	6.795	0.42	6.045	0.55	7.195	0.26
Post-Intervention	2.925	0.42	3.45	0.93	5.29	0.83

It describes the mean and standard deviation of pain for the subjects of group-A, group-B and group-C at pre-intervention and post-intervention levels For group of group-A group-8 6.795±0.42, 2.925±0.42, for group-B, it comes out to be 6.045±0.55, 3.45±0.93 and for group-C, 7.195±0.26. 5.29±0.83 respectively.

It describes paired t-test done between pre & post

intervention for pain values within group-A, group-B & group-C. The t-values are 60.7, 14.28101 respectively.

**Table 3:** Comparison of mean values for pain at pre and post-intervention within subjects of group-A, group-B and group-C

Pain	Group-A		Group-B		Group-C	
	T-Value	P-Value	T-Value	P-Value	T-Value	P-Value
Pre vs Post	52.05	3.93	51.35	3.91	52.35	4.04

**Table 4:** Mean, standard deviation of disability index for the subjects of group-A, group-B and group-C.

Disability Index	Group-A		Group-B		Group-C	
	Mean	S D	Mean	S D	Mean	S D
Pre-Intervention	42.15	2.79	35.6	4.9	52.2	2.52
Post-Intervention	22.6	2.26	21.4	5.7	41.9	4.75

It describes the mean and standard deviation of disability index for the subjects of group-A group-B and group-C at pre-intervention and post-intervention levels For group-A it comes out to be 42.15±2.79.22 6+2.26 for group-B it comes out to be 35.6±4.9.21 4+5.7 and for group-C 52.2±2.52. 41.914.75 respectively.

**Table 5:** Comparison of mean values for disability index at pre and post-intervention within subjects of group-A, group-B and group-C

Disability Index	Group-A		Group-B		Group-C	
	T-Value	P-Value	T-Value	P-Value	T-Value	P-Value
Pre vs Post	50.5	p<0.0001	10.2	p<0.0001	9.12	p<0.0001

It describes paired t-test done between pre and post intervention for disability index values for subjects within group-A, group-B and group-C. The t-values are 50.5, 12.72 and 9.12 respectively.

**Intergroup analysis**

**Table 6:** Comparison of mean values of differences in pain between Group-A & B, Group-B & C and Group-A & C.

Mean values of difference between groups	Group-A		Group-B		Group-C	
	T-Value	P-Value	T-Value	P-Value	T-Value	P-Value
Pain	6.62	p<0.0001	2.6	p<0.0132	9.86	p<0.0001

It describes un-paired t-test done between group-A&B, group-B&C and group-A&C for mean values of differences in pain which are 6.62, 2.6 and 9.86 respectively.

**Table 7:** comparison of mean values of differences in disability index between group-A&B, group-B&C and group-A & C

Mean values of difference between groups	Group-A		Group-B		Group-C	
	T-Value	P-Value	T-Value	P-Value	T-Value	P-Value
Disability index	4.52	p<0.0001	2.45	p<0.019	7.75	p<0.0001

It describes un-paired t-test done between group-A&B, group-B&C and group-A&C for mean values of differences in disability index which are 4.52, 2.45 and 7.75 respectively.

It describes analysis of variance (ANOVA) for mean values of pain and disability index at pre-intervention levels to check for changes between group-A & group-B. The values

are 21.94( $p \leq 0.05$ ), 20.51 ( $p \leq 0.05$ ) respectively.

**Table 8:** Comparison of mean values of pain and disability index at pre-intervention levels between group-A & group-B.

Pre-Intervention	T-Value	P-Value
Pain	21.94	$p \leq 0.05$
Disability index	20.51	$p \leq 0.05$

**Table 9:** Comparison of mean of differences (pre vs post) of pain & disability index between group-A & group-B.

Mean difference	T-Value	P-Value
Pain	43.84	$p \leq 0.05$
Disability index	25.57	$p \leq 0.05$

It describes ANOVA for mean differences of pain and disability index to check for changes between group-A & group-B. The values are 43.84 ( $p \leq 0.05$ ) and 25.57 ( $p \leq 0.05$ ) respectively.

### Discussion

Intragroup analysis, using paired t-tests, revealed significant differences between pre- and post-intervention levels for pain and disability in Group-A and Group-B, with t-values of 60.7 ( $p \leq 0.0001$ ) and 14.2 ( $p \leq 0.0001$ ) for pain, and 50.5 ( $p \leq 0.0001$ ) and 12.72 ( $p \leq 0.0001$ ) for disability. Group-C also showed significant changes in pain ( $t=10.1$ ,  $p \leq 0.0001$ ) and disability ( $t=9.12$ ,  $p \leq 0.0001$ ).

For intergroup comparisons, unpaired t-tests indicated significant differences in pain between Group-A & B ( $t=6.62$ ,  $p \leq 0.0001$ ), Group-B & C ( $t=2.6$ ,  $p \leq 0.0132$ ), and Group-A & C ( $t=9.86$ ,  $p \leq 0.0001$ ). Differences in disability between groups showed similar significance with t-values of 4.52 ( $p \leq 0.0001$ ), 2.45 ( $p \leq 0.019$ ), and 7.75 ( $p \leq 0.0001$ ), respectively.

ANOVA results also demonstrated significant differences in pain ( $F=43.84$ ,  $p \leq 0.05$ ) and disability ( $F=25.57$ ,  $p \leq 0.05$ ) between Group-A and Group-B.

The WOMAC index, which assesses knee OA disability, is influenced by factors like pain, functional performance, and psychological status. Thus, a reduction in pain alone does not fully explain improvements in disability.

### Intervention Effects

TENS, posterior capsular stretching, basic knee OA exercises, and hot packs likely contributed to pain reduction. TENS works through pain modulation via the gate control theory and descending pain suppression systems, inhibiting pain pathways and promoting pain relief.

Posterior capsular stretching helps alleviate adhesions, improving knee function, while basic stretching exercises targeting the hamstrings, quadriceps, and Achilles tendon reduce tightness and enhance mobility. These interventions can improve function by addressing restricted soft tissue, which may otherwise limit movement and contribute to disability.<sup>[26]</sup>

Hot packs, by promoting vasodilation and increasing blood flow, assist in removing pain-inducing chemicals from damaged tissues, further contributing to pain relief.

Strengthening exercises (OKC and CKC) were beneficial in Groups-A and B, as muscle strengthening combats the atrophy-pain cycle, enhancing function. Group-A (OKC) may have shown better results than Group-B (CKC), as weight-bearing exercises can provoke symptoms in weight-bearing joints like the knee, delaying symptom reduction.

### Related Studies

- found that manual therapy combined with exercise yields functional benefits for knee OA patients.
- Concluded that exercise therapy is beneficial for OA patients.
- Showed that combining TENS with hot packs and exercise is effective for reducing knee pain and disability.
- Reported improvements in physical function and pain reduction through exercise in knee OA patients.
- Indicated that moderate exercise improves knee cartilage health in OA patients.
- Supported the efficacy of TENS and exercise in managing knee OA.
- Found no additional benefit of TENS over exercise alone.

### Conclusion

This study demonstrated that after four weeks of intervention, significant reductions in pain and disability were observed in individuals with knee OA who underwent both common interventions hot packs, posterior capsular stretching, basic stretching exercises for knee OA, and TENS along with either OKC or CKC exercises. The OKC exercise group experienced more substantial improvements in both pain and disability than the CKC exercise group, although both groups showed significant post-intervention improvements when compared to pre-intervention levels.

**Ethical Approval:** Approved

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