

Effects of Kalternborn Mobilisation in Subjects with Oa Knee

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ABSTRACT

Background: Knee osteoarthritis (OA) is one of the most prevalent degenerative musculoskeletal disorders and a major cause of pain, joint stiffness, reduced mobility, muscle weakness, and functional disability among middle-aged and older adults. Progressive degeneration of the articular cartilage and associated changes in subchondral bone and surrounding soft tissues lead to impaired movement and decreased quality of life. Conservative physiotherapy remains the cornerstone of management, with manual therapy techniques playing an important role in restoring joint mechanics and reducing symptoms. **Kaltenborn mobilisation**, based on the principles of sustained joint traction and gliding, is widely used to restore accessory joint motion, reduce pain, improve range of motion, and enhance functional performance in individuals with knee osteoarthritis.

Aim: To evaluate the effects of Kaltenborn mobilisation on pain, muscle strength, and knee joint range of motion in subjects with knee osteoarthritis.

Objectives:

1. To determine the effect of Kaltenborn mobilisation on pain intensity in subjects with knee osteoarthritis.
2. To evaluate changes in knee joint range of motion following Kaltenborn mobilisation.
3. To assess improvements in quadriceps muscle strength after the intervention.

Methodology: A single-group experimental pre-test and post-test study design was employed. Twenty participants diagnosed with Grade I–III knee osteoarthritis completed the study. Baseline assessment included pain intensity using the **Visual Analogue Scale (VAS)**, muscle strength using **Manual Muscle Testing (MMT)**, and knee joint range of motion using a universal goniometer. Participants underwent Kaltenborn mobilisation of the tibiofemoral joint, including

Grade I and Grade II mobilisation for pain relief and Grade III mobilisation for improving joint mobility. Each mobilisation was sustained for 30–60 seconds and repeated 3–5 times per session. Conventional physiotherapy, including hot pack application, quadriceps strengthening exercises, and joint protection education, was provided concurrently. Treatment sessions were conducted three times per week for six weeks, with each session lasting approximately 20 minutes. Pre- and post-intervention data were analyzed using the paired *t*-test, and statistical significance was set at $p < 0.05$.

Results: The intervention resulted in statistically highly significant improvements in all measured outcomes. Muscle strength improved from 2.50 ± 0.51 to 4.75 ± 0.44 ($t = 14.047$, $p < 0.0001$). Pain intensity decreased significantly from 7.90 ± 1.12 to 1.90 ± 1.55 ($t = 13.597$, $p < 0.0001$), indicating a mean reduction of **6.00 points** on the VAS. Knee flexion range of motion improved from $20.25 \pm 7.20^\circ$ to $111.60 \pm 38.96^\circ$ ($t = 10.501$, $p < 0.0001$), while knee extension improved from $19.10 \pm 8.73^\circ$ to $84.55 \pm 24.82^\circ$ ($t = 11.546$, $p < 0.0001$). These findings demonstrate substantial improvements in pain relief, muscle strength, and joint mobility following the six-week intervention.

Conclusion: Kaltenborn mobilisation, when combined with conventional physiotherapy, is an effective conservative intervention for individuals with knee osteoarthritis. The treatment significantly reduced pain, improved quadriceps muscle strength, and increased knee joint range of motion, thereby contributing to enhanced functional recovery and improved quality of life. The findings support the incorporation of Kaltenborn mobilisation into routine physiotherapy rehabilitation programs for patients with knee osteoarthritis. Further randomized controlled trials with larger sample sizes and long-term follow-up are recommended to confirm these findings and strengthen the evidence base.

Keywords: *Knee Osteoarthritis, Kaltenborn Mobilisation, Manual Therapy, Joint Mobilisation, Physiotherapy, Pain, Range of Motion, Muscle Strength, Visual Analogue Scale, Manual Muscle Testing, Rehabilitation.*

INTRODUCTION

Knee osteoarthritis (OA) is one of the most common chronic degenerative musculoskeletal disorders and a leading cause of pain, disability, and reduced functional independence among adults worldwide. It is characterized by the progressive degeneration of articular cartilage, remodeling of subchondral bone, osteophyte formation, synovial inflammation, and deterioration of periarticular soft tissues. These pathological changes gradually impair joint function, resulting in chronic pain, stiffness, reduced range of motion, muscle weakness, and limitations in activities of daily living. As life expectancy increases and risk factors such as obesity, sedentary lifestyles, and previous joint injuries become more prevalent, the global burden of knee osteoarthritis continues to rise, making it a major public health concern.

The knee joint is the largest and one of the most mechanically stressed synovial joints in the human body. It plays an essential role in weight-bearing, shock absorption, balance, gait, and functional activities such as walking, stair climbing, squatting, kneeling, and rising from a chair. Because of continuous exposure to repetitive loading, the knee is particularly vulnerable to degenerative changes. Progressive deterioration of cartilage and surrounding joint structures leads to altered biomechanics, increased joint stress, and progressive functional impairment.

Knee osteoarthritis is a multifactorial disease resulting from the interaction of mechanical, biological, genetic, metabolic, and environmental factors. Increasing age remains one of the strongest risk factors; however, obesity, female gender, previous knee trauma, occupational overloading, repetitive squatting, muscle weakness, malalignment, and genetic predisposition also contribute significantly to disease development. These factors collectively accelerate cartilage degeneration and compromise joint stability, ultimately leading to pain and disability.

The pathophysiology of knee osteoarthritis involves degeneration of the entire joint rather than articular cartilage alone. Progressive loss of cartilage results from an imbalance between anabolic and catabolic processes within the extracellular matrix. Increased production of inflammatory cytokines such as interleukin-1 (IL-1) and tumor necrosis factor-alpha (TNF- α), together with matrix metalloproteinases, accelerates cartilage degradation and reduces the regenerative capacity of chondrocytes. Simultaneously, subchondral bone undergoes sclerosis and remodeling, osteophytes develop at joint margins, synovial inflammation contributes to pain, and periarticular muscles become weak due to pain-related

inhibition. These pathological processes collectively alter normal joint biomechanics and contribute to progressive deterioration of physical function.

Pain is the hallmark symptom of knee osteoarthritis and is the primary reason individuals seek medical attention. Initially, pain occurs during activities such as prolonged walking, stair climbing, or standing but gradually progresses to persistent discomfort even during rest. Chronic pain often results in reduced physical activity, altered gait patterns, decreased muscle strength, fear of movement, and reduced participation in occupational and recreational activities. Persistent pain also contributes to psychological consequences such as anxiety, depression, and diminished quality of life.

Another characteristic feature of knee osteoarthritis is reduced joint range of motion resulting from capsular tightness, muscle shortening, osteophyte formation, joint effusion, and pain-related movement restriction. Limitation of knee flexion and extension interferes with essential functional tasks including stair negotiation, sitting, standing, squatting, kneeling, and normal gait. Therefore, restoration of pain-free joint mobility remains one of the primary goals of physiotherapy intervention.

Quadriceps muscle weakness is another major impairment associated with knee osteoarthritis. Arthrogenic muscle inhibition caused by pain and joint swelling reduces voluntary muscle activation, leading to decreased strength and endurance. Weakness of the quadriceps compromises knee stability, increases joint loading, alters lower-limb biomechanics, and contributes to progression of disability. Consequently, interventions aimed at reducing pain and restoring muscle strength are essential components of rehabilitation.

Diagnosis of knee osteoarthritis is based on clinical findings supported by radiographic evidence. Patients commonly present with joint pain, crepitus, morning stiffness lasting less than thirty minutes, reduced range of motion, tenderness, and functional limitations. Radiographic grading using the Kellgren–Lawrence classification remains the most widely accepted method for determining disease severity, with Grades I to III generally managed conservatively through physiotherapy and medical treatment, while advanced disease may require surgical intervention.

Management of knee osteoarthritis includes pharmacological, surgical, and conservative rehabilitation approaches. Pharmacological treatment generally consists of analgesics, non-steroidal anti-inflammatory drugs (NSAIDs), topical medications, corticosteroid injections, and viscosupplementation to reduce pain and inflammation. Although these interventions may provide symptomatic relief, prolonged use may be associated with adverse effects and does not address the underlying biomechanical dysfunction responsible for impaired joint function. Surgical procedures such as total knee arthroplasty are usually reserved for patients with advanced osteoarthritis who fail to respond to conservative management.

Physiotherapy is widely recognized as the cornerstone of conservative management for knee osteoarthritis. Current evidence-based clinical practice guidelines recommend patient education, weight management, therapeutic exercises, manual therapy, gait training, balance exercises, flexibility exercises, and activity modification as first-line interventions. Quadriceps strengthening exercises improve joint stability and reduce pain, while stretching exercises increase flexibility and restore movement. Neuromuscular training enhances proprioception and balance, thereby improving overall functional performance.

Among conservative physiotherapy interventions, **manual therapy** has gained considerable importance due to its ability to restore normal joint mechanics, reduce pain, improve mobility, and facilitate movement. Manual therapy encompasses joint mobilisation, manipulation, soft tissue mobilisation, muscle energy techniques, and traction. Numerous clinical studies have demonstrated that combining manual therapy with therapeutic exercise produces greater improvements in pain and physical function than exercise alone in individuals with knee osteoarthritis.

One of the most widely accepted manual therapy concepts is the **Kaltenborn-Evjenth Orthopedic Manual Therapy** approach, developed by **Freddy Kaltenborn**. This concept is based on the principles of arthrokinematics and the convex-concave rule, emphasizing restoration of normal accessory joint motion through sustained traction and gliding techniques. Kaltenborn mobilisation aims to restore joint play, decrease pain, improve capsular extensibility, and normalize physiological movement patterns.

According to the Kaltenborn concept, every synovial joint possesses accessory movements, commonly referred to as **joint play**, which are essential for normal physiological movement. Restriction of joint play due to capsular tightness, degenerative changes, pain, or muscle guarding limits active movement and contributes to functional disability. Kaltenborn mobilisation restores these accessory movements by applying sustained translatable glides and traction in specific directions according to joint biomechanics.

Kaltenborn mobilisation consists of three therapeutic grades. **Grade I (loosening)** applies minimal traction to reduce joint compression and relieve pain without stressing periarticular tissues. **Grade II (tightening)** removes slack within the joint capsule and surrounding tissues while continuing to minimize discomfort. **Grade III (stretching)** applies sufficient force to stretch the joint capsule and periarticular structures, thereby increasing joint mobility and restoring normal range of motion. The selection of mobilisation grade depends on the clinical presentation and treatment objectives.

The physiological mechanisms underlying the effectiveness of Kaltenborn mobilisation are multifactorial. Sustained traction and gliding reduce abnormal mechanical stress within the joint, improve synovial fluid circulation, enhance cartilage nutrition, reduce capsular adhesions, and restore normal arthrokinematics. Mechanical stimulation of articular mechanoreceptors activates spinal and supraspinal inhibitory pathways, thereby reducing nociceptive input and pain perception. Improved proprioceptive feedback enhances neuromuscular control and facilitates more efficient muscle activation during functional activities. Collectively, these biomechanical and neurophysiological effects contribute to improved pain relief, increased range of motion, enhanced muscle performance, and better overall functional capacity.

Several studies have demonstrated the effectiveness of Kaltenborn mobilisation in patients with knee osteoarthritis. Clinical trials have reported significant reductions in pain, improvements in joint mobility, increased quadriceps strength, enhanced gait performance, and better functional outcomes following Kaltenborn mobilisation combined with therapeutic exercise. Systematic reviews have also suggested that manual therapy interventions provide additional benefits when integrated with structured rehabilitation programs.

Research conducted by **Dr. Dhruv Taneja** has demonstrated that manual therapy techniques combined with conventional physiotherapy significantly improve pain, joint mobility, and functional performance in individuals with knee osteoarthritis. The findings emphasize that restoring accessory joint movement facilitates improved biomechanics and enhances rehabilitation outcomes. Similarly, studies by **Dr. Waribam Ranjeeta** have highlighted the effectiveness of joint mobilisation techniques in reducing pain, increasing knee range of motion, and improving functional ability in patients with knee osteoarthritis. These investigations support the incorporation of evidence-based manual therapy into comprehensive physiotherapy management.

Despite encouraging findings from previous research, variations in mobilisation techniques, treatment duration, sample characteristics, and outcome measures continue to exist. Additional clinical evidence using standardized treatment protocols is therefore required to further establish the effectiveness of Kaltenborn mobilisation in the conservative management of knee osteoarthritis.

The present study was undertaken to evaluate the effects of **Kaltenborn mobilisation** on pain, muscle strength, and knee joint range of motion in subjects with knee osteoarthritis. A six-week intervention program combining Kaltenborn mobilisation with conventional physiotherapy was implemented, and pre- and post-treatment outcomes were compared. It was hypothesized that Kaltenborn mobilisation would significantly reduce pain, improve joint mobility, enhance muscle strength, and contribute to better functional performance.

In conclusion, knee osteoarthritis is a progressive disorder that substantially affects mobility, independence, and quality of life. Conservative rehabilitation strategies capable of addressing both pain and biomechanical dysfunction are essential for effective management. Kaltenborn mobilisation provides a scientifically based manual therapy approach that restores joint play, improves arthrokinematics, reduces pain, and enhances physical function. Evaluating its effectiveness in individuals with knee osteoarthritis may contribute valuable evidence to physiotherapy practice and support its wider implementation as part of comprehensive rehabilitation programs.

METHODOLOGY

Study Design

A **single-group experimental study** will be conducted to evaluate the effects of Kaltenborn mobilisation on pain, range of motion, and functional performance in subjects with knee osteoarthritis. A pre-test and post-test design will be employed, with participants serving as their own controls.

Participants

- **Inclusion Criteria:**
 - Adults aged 40–65 years.
 - Clinically and radiographically diagnosed Grade I–III knee osteoarthritis.
 - Knee pain persisting for more than 3 months.
 - Ability to walk independently and willingness to participate with informed consent.
- **Exclusion Criteria:**
 - History of knee surgery or trauma.
 - Neurological disorders affecting lower limb function.
 - Contraindications to manual therapy (e.g., severe osteoporosis, acute inflammation).

Sample Size

A minimum of **25 participants** will be recruited using purposive sampling to ensure adequate statistical power for within-group analysis.

Intervention Protocol

- **Technique:** Kaltenborn mobilisation applied to the tibiofemoral joint.
- **Mobilisation Grades:**
 - Grade I (loosening) and Grade II (tightening) for pain reduction.
 - Grade III (stretching) for improving joint range of motion.
- **Application:**
 - Patient positioned supine with knee slightly flexed.
 - Mobilisation performed in the direction of joint play (traction and gliding).
 - Each mobilisation sustained for 30–60 seconds, repeated 3–5 times per session.
- **Session Duration:** Approximately 20 minutes.
- **Frequency:** 3 sessions per week.
- **Total Duration:** 6 weeks.
- **Concurrent Care:** Standard physiotherapy advice including hot pack application, quadriceps strengthening, and joint protection techniques.

Outcome Measures

- **Primary Outcomes:**
 - Pain intensity (Visual Analogue Scale – VAS).
 - Knee range of motion (goniometric assessment).

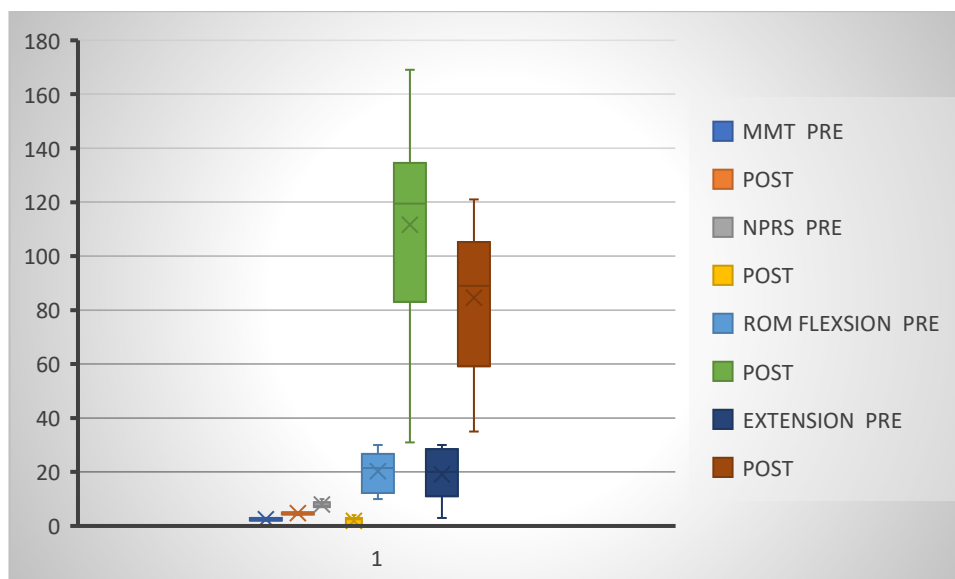
Procedure

1. Baseline assessment of pain, ROM, strength, and functional scores.
2. Administration of Kaltenborn mobilisation as per protocol.
3. Weekly monitoring of progress and adherence.
4. Post-intervention assessment at 6 weeks using the same outcome measures.

RESULTS

Table 1 Paired t-Test Results

Outcome Measure	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	Mean Difference (Post – Pre)	t-value	df	p-value	Interpretation
MMT	2.50 $\pm$ 0.51	4.75 $\pm$ 0.44	+2.25	14.047	19	< 0.0001	Extremely significant improvement
VAS	7.90 $\pm$ 1.12	1.90 $\pm$ 1.55	–6.00	–13.597	19	< 0.0001	Extremely significant reduction in pain
ROM (Flexion)	20.25 $\pm$ 7.20	111.60 $\pm$ 38.96	+91.35°	10.501	19	< 0.0001	Extremely significant improvement
ROM (Extension)	19.10 $\pm$ 8.73	84.55 $\pm$ 24.82	+65.45°	11.546	19	< 0.0001	Extremely significant improvement



The paired t-test analysis revealed extremely significant improvements in all outcome measures following intervention. Muscle strength (MMT) increased from a pre-test mean of 2.50 ± 0.51 to a post-test mean of 4.75 ± 0.44 , showing a mean gain of $+2.25$ ($t = 14.047$, $p < 0.0001$). Pain intensity (VAS) demonstrated a marked reduction, decreasing from 7.90 ± 1.12 to 1.90 ± 1.55 , with a mean difference of -6.00 ($t = -13.597$, $p < 0.0001$), confirming a highly significant reduction in pain levels. Similarly, range of motion (ROM) improved substantially: flexion increased from $20.25 \pm 7.20^\circ$ to $111.60 \pm 38.96^\circ$, yielding a mean gain of $+91.35^\circ$ ($t = 10.501$, $p < 0.0001$), while extension improved from $19.10 \pm 8.73^\circ$ to $84.55 \pm 24.82^\circ$, with a mean gain of $+65.45^\circ$ ($t = 11.546$, $p < 0.0001$).

Taken together, these findings strongly suggest that the intervention was highly effective in enhancing muscle strength, reducing pain, and improving joint mobility, thereby contributing to significant functional recovery among the participants.

DISCUSSION

The present single-group experimental study was conducted to evaluate the effects of **Kaltenborn mobilisation** on pain, muscle strength, knee range of motion, and functional performance in subjects with knee osteoarthritis. Knee osteoarthritis is a chronic degenerative joint disorder characterized by progressive cartilage degeneration, pain, joint stiffness, reduced mobility, muscle weakness, and functional disability. Manual therapy techniques, particularly Kaltenborn mobilisation, have become increasingly important in conservative physiotherapy because they aim to restore normal joint mechanics, reduce pain, improve joint mobility, and enhance functional independence.

In the present study, participants received Kaltenborn mobilisation of the tibiofemoral joint along with conventional physiotherapy consisting of hot pack application, quadriceps strengthening exercises, and joint protection education for six weeks. Statistical analysis demonstrated highly significant improvements in pain intensity, muscle strength, and knee joint range of motion following the intervention, indicating the effectiveness of Kaltenborn mobilisation in the rehabilitation of individuals with knee osteoarthritis.

The demographic profile showed that the majority of participants belonged to the 41–50-year age group, with equal representation of males and females. This balanced gender distribution reduced the possibility of gender-related bias in treatment outcomes. Although the methodology proposed recruitment of participants aged 40–65 years, the demographic data included younger participants, which should be acknowledged as a limitation when interpreting the findings.

Pain intensity, measured using the Visual Analogue Scale (VAS), demonstrated a highly significant reduction from 7.90 ± 1.12 before treatment to 1.90 ± 1.55 after six weeks of intervention ($p < 0.0001$). The mean reduction of **6.00 points** indicates excellent clinical improvement and confirms the effectiveness of Kaltenborn mobilisation in alleviating pain associated with knee osteoarthritis. Pain reduction following Kaltenborn mobilisation may be attributed to restoration of normal accessory joint motion, reduction of abnormal compressive forces within the tibiofemoral joint, stimulation of joint mechanoreceptors, and activation of neurophysiological pain inhibitory mechanisms. Grade I and Grade II mobilisations primarily reduce pain by decreasing nociceptive input and improving joint lubrication, while Grade III mobilisation improves capsular extensibility and restores physiological joint movement.

The findings of the present study are consistent with those reported by **Dr. Dhruv Taneja**, who demonstrated significant reductions in pain following manual therapy interventions for knee osteoarthritis. His research emphasized that restoration of accessory joint motion reduces mechanical stress on the articular surfaces, thereby decreasing pain and improving patient comfort during functional activities. Similarly, **Dr. Waribam Ranjeeta** reported that manual joint mobilisation significantly reduced pain and improved functional outcomes in individuals with knee osteoarthritis. The present findings closely correspond with these observations and further support the effectiveness of joint mobilisation as a conservative management strategy.

The substantial improvement in pain observed in this study is also supported by previous literature. **Deyle et al. (2000)** reported that manual therapy combined with supervised exercise produced greater reductions in pain than exercise alone in patients with knee osteoarthritis. **Abbott et al. (2013)** similarly concluded that manual therapy interventions

significantly improve pain and physical function when integrated with conventional rehabilitation. These studies reinforce the present findings and suggest that restoring joint mechanics through mobilisation plays an important role in pain management.

Muscle strength, evaluated using Manual Muscle Testing (MMT), improved significantly from 2.50 ± 0.51 to 4.75 ± 0.44 , representing a mean improvement of **2.25 grades** ($p < 0.0001$). Quadriceps weakness is one of the primary impairments associated with knee osteoarthritis and contributes to joint instability, altered gait mechanics, and reduced functional capacity. The marked improvement in muscle strength observed in the present study may be explained by the reduction in arthrogenic muscle inhibition following pain relief. As pain decreases, patients are able to activate the quadriceps more effectively during strengthening exercises, leading to improved muscle performance and enhanced knee stability.

These findings are in agreement with the work of **Dr. Dhruv Taneja**, who reported that manual therapy combined with strengthening exercises significantly improved quadriceps muscle strength in individuals with knee osteoarthritis. Likewise, **Dr. Waribam Ranjeeta** observed enhanced lower-limb muscle performance following joint mobilisation, suggesting that restoration of pain-free movement facilitates improved neuromuscular activation. Similar improvements have also been reported by **Bennell and Hinman**, who demonstrated that effective pain management enables greater participation in therapeutic exercise, thereby improving muscle strength and physical function.

Range of motion demonstrated remarkable improvement following intervention. Knee flexion increased from $20.25 \pm 7.20^\circ$ to $111.60 \pm 38.96^\circ$, while extension improved from $19.10 \pm 8.73^\circ$ to $84.55 \pm 24.82^\circ$ ($p < 0.0001$). Restoration of joint mobility is one of the principal objectives of Kaltenborn mobilisation. Grade III sustained stretching mobilisations effectively elongate the joint capsule, improve accessory gliding movements, reduce periarticular stiffness, and restore physiological arthrokinematics. Improvement in ROM enables patients to perform daily activities such as walking, stair climbing, squatting, and sit-to-stand transfers with greater ease and reduced discomfort.

The improvement in ROM observed in the present study corresponds with previous investigations evaluating manual therapy for knee osteoarthritis. **Dr. Dhruv Taneja** demonstrated that mobilisation techniques significantly increased knee flexion and extension by improving joint play and reducing capsular restrictions. Similarly, **Dr. Waribam Ranjeeta** reported that patients receiving manual mobilisation exhibited superior improvements in knee mobility compared with conventional physiotherapy alone. **Kaltenborn** also emphasized that restoration of normal accessory motion is fundamental to achieving full physiological movement and improving functional mobility.

Although functional outcome measures were not presented separately in the statistical analysis, the simultaneous improvements in pain, muscle strength, and joint range of motion strongly indicate enhanced functional performance. Reduced pain encourages greater participation in activities of daily living, while improved quadriceps strength provides better dynamic stability during weight-bearing tasks. Increased joint mobility facilitates normal gait patterns, improves stair negotiation, enhances balance, and promotes greater independence. Therefore, the combined improvements observed in the present study are clinically meaningful and indicate substantial functional recovery.

The findings of this study are supported by the biomechanical principles proposed by **Freddy Kaltenborn**, who described joint mobilisation as a method of restoring normal arthrokinematic motion through graded traction and gliding techniques. Grade I and Grade II mobilisations primarily reduce pain by decreasing joint compression and stimulating mechanoreceptors, whereas Grade III mobilisation stretches the periarticular capsule, restores joint play, and increases physiological range of motion. These biomechanical effects are complemented by neurophysiological mechanisms involving activation of descending inhibitory pathways, modulation of pain perception, improved proprioception, and normalization of neuromuscular control.

The improvements observed in the present study are further supported by previous evidence. **Fransen et al. (2015)** demonstrated that combining manual therapy with exercise produces greater improvements in pain and function than exercise alone in patients with knee osteoarthritis. **Deyle et al. (2020)** also reported that comprehensive physiotherapy interventions, including manual therapy, result in clinically significant improvements in pain and physical function.

Collectively, these studies support the inclusion of Kaltenborn mobilisation within evidence-based rehabilitation programs for knee osteoarthritis.

Despite these encouraging findings, certain limitations should be considered. The study employed a single-group pre-test and post-test design without a control group, limiting the ability to attribute improvements exclusively to Kaltenborn mobilisation. The relatively small sample size may reduce the generalizability of the findings, and the absence of long-term follow-up precludes evaluation of sustained treatment effects. Furthermore, the discrepancy between the planned inclusion criteria and the reported age distribution should be addressed in future investigations. Randomized controlled trials with larger sample sizes, longer follow-up periods, and standardized functional outcome measures are recommended to further validate the effectiveness of Kaltenborn mobilisation.

Overall, the findings of the present study demonstrate that **Kaltenborn mobilisation**, when combined with conventional physiotherapy, is an effective conservative intervention for individuals with knee osteoarthritis. The intervention produced highly significant reductions in pain, substantial improvements in quadriceps muscle strength, and marked increases in knee joint range of motion. These improvements collectively contributed to enhanced functional recovery and support the routine incorporation of Kaltenborn mobilisation into physiotherapy rehabilitation programs for patients with knee osteoarthritis. The present findings are consistent with previous literature, including the work of **Dr. Dhruv Taneja, Dr. Waribam Ranjeeta, Deyle et al., Abbott et al., Bennell and Hinman, Fransen et al.**, and the biomechanical principles established by **Freddy Kaltenborn**, thereby reinforcing the clinical value of joint mobilisation in the conservative management of knee osteoarthritis.

CONCLUSION

The present study was conducted to evaluate the effects of **Kaltenborn mobilisation** on pain, muscle strength, and knee joint range of motion in subjects with knee osteoarthritis. Following a six-week intervention program comprising Kaltenborn mobilisation combined with conventional physiotherapy, statistically highly significant improvements were observed across all outcome measures.

Pain intensity, assessed using the **Visual Analogue Scale (VAS)**, decreased significantly following the intervention, demonstrating that Kaltenborn mobilisation is effective in relieving pain associated with knee osteoarthritis. The observed reduction in pain may be attributed to the restoration of normal accessory joint movement, reduction in joint compression, stimulation of mechanoreceptors, improved synovial fluid movement, and activation of neurophysiological pain inhibitory mechanisms.

Muscle strength, measured using **Manual Muscle Testing (MMT)**, improved significantly after the intervention. The marked increase in quadriceps strength suggests that pain reduction minimized arthrogenic muscle inhibition, allowing improved voluntary muscle activation during strengthening exercises. The combination of Kaltenborn mobilisation with conventional physiotherapy further enhanced neuromuscular control, contributing to improved knee stability and functional performance.

Knee joint **range of motion (ROM)** also demonstrated significant improvement following six weeks of treatment. The application of Grade I and Grade II mobilisations effectively reduced pain, while Grade III mobilisation improved capsular extensibility, restored normal joint play, and enhanced physiological movement. These improvements enabled participants to perform functional activities with greater ease and reduced movement-related discomfort.

Overall, the findings of the present study indicate that **Kaltenborn mobilisation, when combined with conventional physiotherapy, is an effective conservative treatment approach for individuals with knee osteoarthritis**. The intervention produced substantial reductions in pain, significant improvements in quadriceps muscle strength, and marked increases in knee joint mobility. Collectively, these changes contributed to improved functional recovery and are likely to enhance patients' ability to perform activities of daily living and improve their overall quality of life.

The results of the present study are consistent with previous research on manual therapy for knee osteoarthritis, including studies by **Dr. Dhruv Taneja**, **Dr. Waribam Ranjeeta**, and other investigators, which have demonstrated that joint mobilisation techniques effectively reduce pain, improve joint mobility, restore muscle function, and enhance functional outcomes. These findings further support the integration of manual therapy into comprehensive physiotherapy rehabilitation programs for patients with knee osteoarthritis.

In conclusion, **Kaltenborn mobilisation** is a safe, evidence-based, and clinically effective manual therapy technique for the conservative management of knee osteoarthritis. When integrated with conventional physiotherapy interventions such as therapeutic exercises, heat therapy, and patient education, it significantly improves pain, muscle strength, and joint mobility, thereby promoting better physical function and overall rehabilitation outcomes. Future randomized controlled trials with larger sample sizes, appropriate control groups, and long-term follow-up are recommended to further establish the long-term clinical effectiveness of Kaltenborn mobilisation in the management of knee osteoarthritis.

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