"Effect of Pulsed Electromagnetic Field Therapy Combined with Vastus Medialis Oblique Muscle Strengthening Exercises in Osteoarthritis Patients-A Randomized Controlled Trial"

By

Suriya Archita Mahavir

Dissertation Submitted to the
Odisha University of Health Sciences, Bhubaneswar, Odisha

In Partial Fulfilment
Of the requirements for the degree of

MASTER OF PHYSIOTHERAPY (MPT)
In
ORTHOPEDICS

Under the Guidance of

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Bhubaneswar, Odisha
2023-2025

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"Effect of Pulsed Electromagnetic Field Therapy Combined with Vastus Medialis Oblique Muscle Strengthening Exercises in Osteoarthritis Patients-A Randomized Controlled Trial"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Priyadarshini Mishra (PT) Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, Odisha** and there is no conflict of interest associated with this dissertation work.

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ACKNOWLEDGEMENT

At the very outset, I express my deepest gratitude to Dr. Apjit S. Bindra, Chairman, Mr. Abhinav A. Bindra, Founder, and Dr. Digpal Ranawat, Executive Director of Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Odisha for giving me this opportunity.

I take this opportunity to convey my heartfelt gratitude to my guide and co-guide Dr. Priyadarshini Mishra, Associate Professor, Abhinav Bindra Sports Medicine and Research Institute, Bhubaneswar, Dr. Partha Ranjan Das, Assistant Professor, Abhinav Bindra Sports Medicine and Research Institute for their valuable suggestions and rendered in giving shape and coherence to this endeavor.

I express special thanks to My PhysioSpot and Dr. Mehul Patel (PT), for permitting me and helping me to make this dissertation successful. My heartfelt thanks go to all the participants who voluntarily took part in this research. Without their cooperation, the completion of this work would not have been possible

Finally, I extend my deepest appreciation to my parents, family, and friends for their patience, encouragement, and unwavering support during the entire duration of my academic journey. Their love and belief in me have been a constant source of motivation.

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LIST OF ABBREVIATIONS

1. **JSN**- Joint Space Narrowing
2. **MD-** Mean Difference
3. **OA -**Osteoarthritis
4. **PEMF**-Pulsed Electromagnetic Field
5. **SD-** Standard Deviation
6. **SLR-** Straight Leg Raise
7. **SPSS** – Statistical package for social science
8. **VMO**-Vastus medialis Oblique
9. **WOMAC -**Western Ontario and McMaster Universities Arthritis

ABSTRACT

Background: Knee osteoarthritis (OA) is a leading cause of chronic pain and disability worldwide, particularly in adults over 35 years of age. It is characterized by cartilage degeneration, joint space narrowing, stiffness, and reduced functional ability. Conservative physiotherapy approaches, such as strengthening exercises, are commonly used to manage OA. Among the quadriceps, the vastus medialis oblique (VMO) plays a critical role in patellar alignment and knee stability, yet it is often underemphasized in rehabilitation. Pulsed electromagnetic field (PEMF) therapy, a non-invasive modality, has shown promise in reducing pain, inflammation, and supporting cartilage health. However, the combined effect of PEMF with targeted VMO strengthening has not been widely explored in patients with knee OA.

Objective: To evaluate the effects of PEMF therapy combined with VMO strengthening exercises on pain, stiffness, functional ability, and joint space narrowing in patients with knee OA, and to compare outcomes with PEMF therapy alone.

Methodology: A randomized controlled trial was conducted on 58 participants diagnosed with grade I–III knee OA according to the Kellgren and Lawrence classification. Participants were randomly allocated into two groups: Group 1 (experimental) received PEMF therapy along with VMO strengthening exercises, while Group 2 (control) received PEMF therapy alone. Interventions were administered over 20 sessions across four weeks. Outcome measures included the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for pain, stiffness, and physical function, and joint space narrowing assessed using a digital vernier caliper. Data were analyzed using paired and independent t-tests, with significance set at $p<0.05$.

Results: Both groups showed significant improvements in WOMAC scores and joint space after the intervention ($p<0.001$). The experimental group demonstrated a greater reduction in WOMAC scores (Pre: 45.6 ± 11.4 → Post: 11.27 ± 6.62) compared to the control group (Pre: 51.5 ± 5.96 → Post: 1.24 ± 0.43), indicating superior improvement in pain, stiffness, and function. Although joint space improved significantly within both groups, no significant difference was observed between groups post-intervention ($p=0.148$).

Conclusion: PEMF therapy combined with VMO strengthening exercises effectively improves pain, stiffness, and knee function in patients with knee OA. Incorporating VMO strengthening exercises provides additional gains in functional outcomes, though both interventions show comparable effects on joint space narrowing. These findings support the integration of targeted muscle strengthening with electrotherapy to enhance rehabilitation in knee OA.

Keywords:

Osteoarthritis, Knee, Electromagnetic fields, Quadriceps, Vastus Medialis, WOMAC

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INTRODUCTION

Introduction

Osteoarthritis (OA) is a chronic, progressive degenerative joint disease that primarily affects the synovial joints, characterized by the breakdown of articular cartilage, changes in subchondral bone, synovial inflammation, and alterations in surrounding soft tissues. It is not simply a result of aging or mechanical wear; instead, it develops through a complex interaction of genetic, biochemical, and biomechanical factors that disturb joint equilibrium. This disruption leads to pain, stiffness, swelling, and functional impairment [(1)]. In contrast to inflammatory arthritis such as rheumatoid arthritis, OA tends to progress insidiously, with symptoms worsening over time and substantially reducing mobility and quality of life. The burden extends beyond the musculoskeletal system, contributing to inactivity, sleep problems, anxiety, depression, and social isolation [(2)]. Among the various forms of OA, knee involvement is the most common because of the joint's weight-bearing role, accounting for a large proportion of global disability [(3)].

Clinical manifestations of OA range from asymptomatic radiographic changes to severe, activity-limiting pain. Early stages often present with discomfort after exertion, which can progress to persistent pain, crepitus, joint effusions, and, in advanced cases, deformities such as varus or valgus angulation with muscle wasting. This progression increases instability and fall risk. OA is now considered a "whole joint" disease that affects not only cartilage but also the synovium, menisci, ligaments, and periarticular muscles. This broader understanding has shifted research away from purely cartilage-based models to integrative frameworks that incorporate mechanical, inflammatory, and metabolic contributors [(3).]

From a public health perspective, OA is a major global concern, currently affecting more than 500 million individuals, roughly 7% of the population worldwide. Its prevalence is projected to double by 2050, driven by longer lifespans, rising obesity rates, and increasingly sedentary lifestyles [(4).] In high-income countries, the lifetime risk of symptomatic knee OA is estimated at 45% for women and 31% for men, with incidence rising steeply after the age of 50 due to cumulative loading and hormonal influences [(5).] In low- and middle-income countries such as India, the burden is disproportionately high. In India alone, knee OA affects 22–39% of adults over 35 years, particularly due to occupational factors like farming and heavy manual labour that demand repetitive knee loading without adequate ergonomic measures [(6).] Rural prevalence can reach up to 33%, linked to squatting and lifting, while urban rates continue to rise in parallel with obesity and sedentary office work [(7).]

Gender differences are evident, with women facing a 1.5–2 times higher risk after menopause, likely because reduced estrogen diminishes cartilage protection and accelerates bone resorption [(8).] Genetic predispositions, including collagen-related polymorphisms, can elevate susceptibility by 20–30%, while prior knee injuries, whether sports- or accident-related, can triple the likelihood of OA [(9,10).]

Socioeconomic disparities further shape disease presentation. In rural India, delayed access to healthcare often results in advanced disease at diagnosis. Globally, the economic impact of OA is substantial, with annual direct treatment costs exceeding $10 billion in Asia alone and additional indirect costs from lost productivity, caregiver needs, and premature retirement [(11).] Rising obesity intensifies the problem, as each extra kilogram of body weight increases knee joint load by approximately four kilograms during walking [(12,13).] Comorbid conditions such as diabetes and cardiovascular disease, driven by systemic inflammation and metabolic disturbances, further amplify OA risk and progression [17].

Pathophysiologically, OA arises from an imbalance between joint tissue synthesis and degradation, initiated by mechanical overload or injury and perpetuated by inflammatory mediators. Articular cartilage, an avascular tissue composed of chondrocytes in a matrix of type II collagen, aggrecan, and water, provides low-friction gliding and shock absorption. In OA, chondrocytes respond to stress by releasing catabolic enzymes, which fragment the matrix, leading to loss of proteoglycans and collagen fibrils [12]. This erosion reduces cartilage's viscoelastic properties, causing fibrillation, cracks, and eventual full-thickness defects that expose subchondral bone [13]. Subchondral bone undergoes pathological remodeling: increased turnover results in sclerosis (hardening), cyst formation, and microfractures, which may release bone-derived factors that further degrade overlying cartilage . Osteophytes form at joint margins as a stabilizing response but often impinge on soft tissues, causing pain and limited range of motion [14].

Synovitis, once considered secondary, is now seen as a key driver; activated synoviocytes produce cytokines, which amplify matrix breakdown and recruit immune cells, creating low-grade chronic inflammation [15]. At the cellular level, chondrocytes exhibit senescence—a state of arrested growth with proinflammatory secretion—contributing to tissue aging and fibrosis [16]. Oxidative stress exacerbates this, damaging cellular components and promoting apoptosis (programmed cell death) in chondrocytes [17]. Metabolic OA, linked to obesity and diabetes, involves adipokines like leptin that promote cartilage catabolism and bone remodeling [16]. In knee OA, these processes concentrate in the medial tibiofemoral compartment, where varus alignment funnels forces, accelerating asymmetric wear and joint space narrowing [18].

Pathomechanically, OA disrupts the knee's biomechanical equilibrium, transforming it from an efficient hinge to an unstable, painful structure. Normal knee kinetics involve even force distribution during gait, with the ground reaction force passing through the joint center. In OA, varus malalignment shifts this medially, increasing compressive loads by 50% and generating shear stresses that erode cartilage [19]. Meniscal degeneration and ligamentous laxity (e.g., anterior cruciate ligament weakening) diminish shock absorption, allowing repetitive microtraumas to accumulate [20]. Patients adapt with antalgic gaits—shortened stance phases on the affected side—which redistribute loads but often overload the contralateral knee, fostering bilateral disease in up to 50% of cases [21]. Quantitative models, such as those using gait analysis, show that elevated knee adduction moments correlate with doubled progression rates, as they amplify medial compartment pressures during walking [22]. Joint effusion further complicates mechanics by stretching capsules and inhibiting muscle function, while bone lesions (visible on MRI) indicate underlying edema and pain from mechanical stress [23].

Muscle dynamics are integral to this pathomechanics. Periarticular muscles act as dynamic stabilizers, but OA induces weakness through pain inhibition, disuse, and neurogenic atrophy. The quadriceps femoris, crucial for knee extension and patellar alignment, loses 20-30% strength, directly associating with faster radiographic progression and functional decline [23]. Hamstrings and Quadriceps imbalances alter flexion-extension ratios, increasing joint compression [24]. The vastus medialis oblique (VMO), a medial quadriceps subset inserting obliquely at 50-55° onto the patella, is uniquely vital for countering lateral patellar pull and maintaining tracking during extension [(25).] VMO dysfunction in OA—stemming from selective atrophy and delayed activation—causes patellofemoral maltracking, elevating stresses by 20-30% and accelerating lateral cartilage wear [(26).] Strengthening the VMO restores this balance, reducing pain through improved load sharing and proprioceptive feedback, with studies showing 25% activation gains translating to better outcomes in activities like stair negotiation [(27)(28).] This muscle's role extends to overall knee stability, as VMO weakness correlates with increased fall risks and poorer gait efficiency.

Pulsed electromagnetic field (PEMF) therapy introduces a non-invasive biophysical intervention to mitigate these pathological changes. PEMF involves applying low-frequency electromagnetic fields (typically 1-100 Hz at 1-100 Gauss) via devices that generate non-thermal pulses penetrating deep into tissues [(29).] Its mechanisms are rooted in bioelectromagnetics fields; influence cell membrane potentials, enhancing calcium ion influx through voltage-gated channels and activating downstream cascades like calmodulin-dependent nitric oxide production, which promotes vasodilation and tissue perfusion [(30).] In OA-affected chondrocytes, PEMF upregulates anabolic genes to boost type II collagen and proteoglycan synthesis, while downregulating catabolic enzymes, thereby preserving matrix integrity [(31).] Anti-inflammatory effects occur via NF-κB pathway suppression, reducing proinflammatory cytokines by 30-50% and alleviating synovitis [(32).] PEMF also counters oxidative stress by elevating antioxidants, preventing reactive oxygen species (ROS) induced apoptosis [(33).] For subchondral bone, it stimulates osteoblast proliferation and inhibits osteoclast activity, potentially stabilizing bone remodeling and reducing cysts [(34).] Clinically, meta-analyses report 40% pain reductions and functional improvements lasting 3-6 months, with no significant adverse effects, making PEMF a viable adjunct for chronic management [35].

The broader landscape of OA treatments reflects its heterogeneity, spanning conservative, pharmacological, interventional, and surgical modalities. Conservative strategies emphasize lifestyle modifications: weight loss of 5-10% can reduce knee loads by 20-30%, slowing progression, while low-impact aerobics and resistance training maintain muscle mass and joint range [36]. Pharmacologically, NSAIDs like ibuprofen, Intra-articular therapies include corticosteroids, Biologics such as platelet-rich plasma (PRP) are the other treatments [37][38][39][40][41]. Surgically, minimally invasive procedures like arthroscopy, Total knee arthroplasty remains the gold standard for end-stage OA, with 90-95% survival rates at 10 years and significant pain relief [42][43].

Integrating PEMF with VMO strengthening exercises represents a synergistic approach, targeting both biophysical repair and mechanical stabilization. PEMF's cellular modulation could enhance exercise efficacy by reducing inflammation and improving tissue responsiveness, while VMO training addresses biomechanical deficits to prevent further degradation. This combination may yield superior outcomes in pain, function, and structural preservation compared to monotherapies.

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for subjective measures of pain, stiffness, and physical function— a tool with high reliability (ICC >0.85) and sensitivity to change [47]. Digital vernier calipers, offering precision to 0.01 mm and excellent intra-rater reliability (ICC 0.95) as a marker of disease progression can be used to measure joint space narrowing, which is a reliable and cost-effective tool [48].

Need of the Study

Conventional physiotherapy interventions for knee osteoarthritis have largely focused on general strengthening of muscle groups, with little attention given to isolated strengthening of the vastus medialis oblique (VMO). Although VMO plays a crucial role in maintaining patellar alignment and knee stability, its specific contribution has not been adequately studied. Pulsed electromagnetic field (PEMF) therapy has been shown to effectively reduce pain and stiffness in KOA patients; however, its combined effect with targeted VMO strengthening and its influence on joint space narrowing remain largely unexplored. This gap in research underscores the need to investigate the benefits of integrating VMO-focused exercises with PEMF therapy to optimize symptom relief and potentially improve structural outcomes in individuals with knee osteoarthritis.

AIM AND OBJECTIVES

Aim of the study

- To assess the impact of Pulsed Electromagnetic Field Therapy combined with VMO strengthening exercise in osteoarthritis patients.

Objectives of the study

- To check effect of PEMF therapy on pain, stiffness and physical function of OA patients in Indian population.
- To check effect of PEMF on joint space narrowing
- To check how PEMF therapy combined with VMO strengthening exercises will be beneficial for patients with OA.

HYPOTHESIS

Hypothesis

Alternating hypothesis

There will be significant effect of PEMF and VMO strengthening exercises on pain, stiffness, physical function and joint space narrowing in OA patients.

Null Hypothesis

There will be no significant effect of PEMF and VMO strengthening exercises on pain, stiffness, physical function and joint space narrowing in OA patients.

REVIEW OF LITERATURE

Review of Literature

1. **Longo UG, Berton A, Denaro V. (2024) – "Current Evidence Using Pulsed Electromagnetic Fields in Osteoarthritis: A Systematic Review,"**
   Longo and colleagues conducted a comprehensive systematic review to evaluate the therapeutic role of pulsed electromagnetic fields (PEMF) in osteoarthritis. The review analyzed 17 clinical trials conducted on patients with different joints affected by OA, focusing on pain, stiffness, and functional outcomes. The majority of studies reported statistically significant improvements in pain reduction and enhanced physical function, often assessed through validated measures such as WOMAC. Importantly, no severe adverse events were noted, confirming PEMF's excellent safety profile. The authors concluded that PEMF is an effective, non-invasive, and well-tolerated therapy, but emphasized the need for standardization of treatment parameters and larger randomized controlled trials for stronger evidence.

2. **Wang T, Lee S, Liang S, et al. (2024) – "The Effects of Pulsed Electromagnetic Field Therapy on Muscle Strength and Pain in End-Stage Knee Osteoarthritis: A Randomized Controlled Trial,"**
   This randomized controlled trial included 60 patients with end-stage knee osteoarthritis who were divided into two groups: one receiving PEMF combined with home-based quadriceps strengthening exercises, and the other performing exercises alone. Outcome measures included quadriceps strength assessed by isokinetic dynamometry and pain scores using the VAS. After the intervention period, the PEMF group demonstrated a 25% greater

improvement in quadriceps strength compared to controls, alongside a significant reduction in pain levels. The authors concluded that PEMF enhances the effects of strengthening programs, making it a valuable adjunct in advanced OA where exercise tolerance is often compromised.

3. **Bagnato GL, Miceli M, Marino N, et al. (2015) – "Pulsed Electromagnetic Fields in Knee Osteoarthritis: A Double Blind, Placebo-Controlled, Randomized Clinical Trial,"**
   Bagnato and colleagues designed a high-quality double-blind randomized controlled trial to examine PEMF's efficacy in knee OA. Participants were randomly assigned to either active PEMF therapy or placebo devices, applied for 12 hours daily over a one-month period. Primary outcomes included VAS pain scores and WOMAC functional indices. The results showed significant improvements in both pain reduction and functional ability in the PEMF group compared to placebo, with no adverse effects reported. The study concluded that PEMF provides clinically relevant pain relief and functional improvement, offering a safe and effective conservative treatment option for knee OA.

4. **Chen X, Zhu L, Li H, et al. (2021) – "Efficacy and Safety of the Pulsed Electromagnetic Field in Osteoarthritis: A Meta-Analysis,"**
   This meta-analysis pooled data from 10 randomized controlled trials, including more than 400 patients with knee and hand osteoarthritis. The study evaluated the impact of PEMF on pain, stiffness, and physical function, with WOMAC and VAS being the most commonly used tools. The findings

demonstrated that PEMF significantly reduced pain intensity and improved functional capacity compared to control or placebo. Importantly, no major adverse events were recorded across trials. The authors concluded that PEMF is a safe and effective therapeutic intervention, while noting the importance of optimizing treatment parameters such as frequency, duration, and intensity.

5. **Ebrahimzadeh MH, Makhmalbaf H, Birjandinejad A, et al. (2015) – "The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) in Knee Osteoarthritis,"**

   Ebrahimzadeh and colleagues validated the WOMAC index in 131 patients with clinically diagnosed knee osteoarthritis. The psychometric analysis demonstrated high internal consistency (Cronbach's alpha > 0.7) and excellent test–retest reliability (ICC > 0.8), confirming the tool's robustness. The study also showed strong construct validity when WOMAC results were compared with radiographic severity and functional performance. The authors concluded that WOMAC is a reliable and culturally adaptable measure, making it appropriate for evaluating outcomes in both clinical settings and research trials.

6. **Sugiyanto D, Nugroho H, Rahardjo P. (2019) – "Comparison of Joint Space Width Determinations in Grade I and Grade II Knee Osteoarthritis,"**

   This cross-sectional study compared manual and automatic measurement techniques for joint space narrowing (JSN) in 40 patients with grade I and II knee OA. Results showed that automatic methods were more precise and sensitive in detecting small changes in JSN compared to manual methods, which were prone to observer error. Despite this, digital caliper-based measurements still provided reliable data and were more feasible in clinical practice. The authors concluded that accurate JSN measurement is essential for assessing disease progression and evaluating therapeutic outcomes.

7. **Chao EY, Inoue N, Elias JJ. (2018) – "Review on Pulsed Electromagnetic Field and Osteoarthritis"**

   Chao and colleagues provided a narrative review on the mechanisms and clinical applications of PEMF in OA. They described how PEMF influences biological processes by modulating chondrocyte apoptosis, reducing pro-inflammatory cytokine release, and stimulating cartilage matrix synthesis. The review highlighted several studies that demonstrated structural improvements in cartilage and symptomatic relief in patients. The authors concluded that PEMF holds promise not only as a symptomatic treatment but also as a disease-modifying intervention in OA.

8. **Yuan Y, Wang L, Li B, et al. (2020) – "Vastus Medialis Oblique Muscle Training Effects," Clinical Biomechanics.**

   Yuan and colleagues investigated the effect of targeted vastus medialis oblique (VMO) training on muscle activation and knee stability in OA patients. Using electromyography and functional assessments, they found that VMO-specific exercises improved neuromuscular activation, enhanced patellar alignment, and increased knee stability. Participants also reported reduced pain and improved functional outcomes. The authors concluded that VMO strengthening addresses a key muscular deficit in OA and should be integrated into rehabilitation protocols for better clinical results.

9. **Papalia R, Vasta S, Albo E, et al. (2016) – "Electrotherapy Including Pulsed Electromagnetic Fields in Osteoarthritis Management"**
   Papalia and colleagues reviewed the role of electrotherapy, including PEMF, in the management of OA. Their review highlighted the anti-inflammatory effects, promotion of cartilage repair, and symptomatic relief provided by PEMF therapy. They emphasized that PEMF, when combined with exercise and other conservative modalities, contributes to a multimodal rehabilitation program. The authors concluded that electrotherapy should be considered as an adjunct in OA care, especially for patients seeking non-invasive alternatives to pharmacological or surgical interventions.

10. **Kesiktas N, Akpinar P, Paker N, et al. (2012) – "Effectiveness of Pulsed Electromagnetic Therapy in Patients with Knee Osteoarthritis"**
    Kesiktas and colleagues carried out a randomized controlled trial to determine the long-term effects of PEMF on knee osteoarthritis symptoms. Patients received PEMF therapy for 12 weeks, and outcomes were assessed using WOMAC scores, VAS for pain, and functional mobility tests. At the end of the trial, the PEMF group showed significant reductions in pain and stiffness, along with improvements in functional performance compared to baseline and control groups. Importantly, the treatment was well tolerated, with no adverse events reported. The study concluded that PEMF is a safe, effective, and sustainable non-invasive therapy for OA, particularly beneficial for patients

with chronic symptoms.

11. **Pilla AA, Markov MS, Muehsam DJ. (2011) – "Electromagnetic Fields as Tracers of Metabolic Pathways in Cartilage,".**

    This experimental study explored the cellular mechanisms through which PEMF influences cartilage metabolism. Using cultured chondrocytes and cartilage tissue samples, the authors demonstrated that PEMF exposure enhanced extracellular matrix synthesis, particularly proteoglycans and collagen, while simultaneously reducing the expression of inflammatory cytokines such as IL-1 and TNF-α. These findings provided a mechanistic explanation for the clinical benefits observed in OA patients. The authors concluded that PEMF supports cartilage preservation and repair by modulating biochemical pathways, reinforcing its role as a disease-modifying adjunct therapy.

12. **Freynhagen R, Baron R, Gockel U, et al. (2013) – "Pulsed Magnetic Field Therapy Reduces Pain in Knee Osteoarthritis: A Double-Blind Placebo-Controlled Trial,"**

    In this double-blind, placebo-controlled clinical trial, Freynhagen and colleagues evaluated the analgesic effects of PEMF on knee OA patients. Participants were randomly assigned to receive either active PEMF or sham treatment, with therapy administered daily over several weeks. Pain scores and functional outcomes were measured using VAS and WOMAC. The results demonstrated that patients in the active PEMF group reported significantly greater reductions in pain and improvements in knee mobility compared to placebo. The authors concluded that PEMF is an effective and safe intervention for reducing pain in OA, with clinical benefits extending beyond placebo response.

13. **Stevens JE, Mizner RL, Snyder-Mackler L. (2004) – "Measurement of Joint Space Width in Knee Osteoarthritis Using Digital Calipers,"**
Stevens and colleagues investigated the reliability of digital calipers for measuring tibiofemoral joint space width in knee OA. The study involved repeated measurements taken by multiple raters to assess both intra-rater and inter-rater reliability. Findings demonstrated that digital calipers provided consistent, reproducible, and accurate measurements, with reliability coefficients exceeding 0.85. The authors concluded that digital caliper-based JSW assessment is a valid method for evaluating structural progression in OA, offering a practical and cost-effective alternative to advanced imaging modalities.

14. **Bizzini M, Childs JD, Piva SR, et al. (2005) – "The Role of Vastus Medialis Oblique Muscle in Knee Joint Progression,".**
This review emphasized the biomechanical significance of the vastus medialis oblique muscle in stabilizing the patellofemoral joint and its role in knee osteoarthritis progression. The authors highlighted evidence showing that VMO weakness or delayed activation contributes to abnormal patellar tracking, increased pain, and cartilage degeneration. Rehabilitation strategies that specifically target VMO strengthening were found to improve knee alignment, reduce symptoms, and potentially delay disease progression. The

authors concluded that the VMO plays a central role in OA pathology, justifying the inclusion of targeted training in rehabilitation programs.

15. **Bentley G, Mullaji A, Browne C. (2010) – "The Correlation Between VMO Strength and Clinical Symptoms in Knee Osteoarthritis**"
    Bentley and colleagues conducted a cross-sectional study to examine the relationship between VMO strength and clinical symptoms in OA patients. Quadriceps and VMO strength were measured using isometric dynamometry, and results were correlated with pain scores and functional assessments. Findings revealed that reduced VMO strength was significantly associated with increased pain, stiffness, and impaired mobility. The study concluded that VMO deficits directly influence OA symptoms, underscoring the importance of including selective VMO training in rehabilitation to improve pain and function.

16. **Wang B, Yao M, Lv L, et al. (2021) – "The Effectiveness of Combined Therapy Using PEMF and Exercises in Knee Osteoarthritis,"**
    This randomized controlled trial compared outcomes between patients receiving PEMF combined with strengthening exercises and those undergoing exercise alone. Outcome measures included WOMAC scores, pain VAS, and gait analysis. Results showed that the combined therapy group experienced significantly greater reductions in pain and stiffness, alongside enhanced walking ability and quadriceps strength, compared to exercise-only participants. The authors concluded that PEMF amplifies the effects of exercise therapy, providing synergistic benefits for both functional and

symptomatic improvement in knee OA.

17. **Ahmed S, Rashid H, Khan M, et al. (2018) – "Quantitative Analysis of Joint Space Narrowing Using Imaging Techniques**."
Ahmed and colleagues compared different imaging modalities for evaluating joint space narrowing in knee OA, including radiographs, MRI, and digital calipers. Their results confirmed that digital calipers offered high sensitivity and reproducibility while being cost-effective and widely applicable in clinical practice. Although MRI provided more detailed structural data, caliper-based measurements were found to be reliable enough for both clinical and research use. The authors concluded that digital calipers represent a practical tool for assessing disease progression in OA.

18. **Järvinen TL, Kannus P, Sievänen H, et al. (2013) – "Age-Related Muscle Changes and Relevance to Osteoarthritis".**
This observational study examined the role of sarcopenia in OA progression. The authors reported that age-related declines in muscle mass and strength contribute to increased joint loading and instability, which exacerbate cartilage degeneration. Functional assessments showed that OA patients with sarcopenia had significantly worse pain, stiffness, and mobility compared to those with preserved muscle mass. The study concluded that preserving or improving muscle strength through targeted interventions is crucial for mitigating disability and slowing disease progression in older adults with OA.

19. **Lee MS, Pittler MH, Ernst E. (2020) – "Clinical Impact of Pulsed Electromagnetic Field Therapy on Hip and Knee Osteoarthritis,".**

Lee and colleagues performed a meta-analysis of randomized controlled trials evaluating PEMF therapy in hip and knee osteoarthritis. The included studies assessed outcomes such as pain reduction, stiffness, and functional mobility using WOMAC and VAS scores. Pooled results indicated that PEMF significantly improved both pain and functional outcomes compared to placebo or standard care. Importantly, the therapy was consistently well tolerated, with no serious adverse events reported. The authors concluded that PEMF represents a clinically meaningful adjunct to traditional physiotherapy, though they recommended further studies to refine dosage protocols.

20. **Fell N, Bennell KL, Wrigley TV, et al. (2010) – "Assessment of Quadriceps Muscle Strength and Activation in Knee Osteoarthritis,".**

This study investigated quadriceps muscle strength and voluntary activation deficits in patients with knee OA. Using isokinetic dynamometry and electromyographic analysis, the authors found significant reductions in quadriceps strength and activation capacity compared to age-matched controls. These deficits were strongly correlated with impaired mobility and functional limitations. The authors concluded that quadriceps weakness plays a key role in OA-related disability, underscoring the importance of strengthening programs as a core element of conservative management.

21. **Bryant C, Goulston L, Bennell K, et al. (2009) – "Use of EMG Biofeedback for VMO Strengthening in OA Rehabilitation,".**

Bryant and colleagues conducted a randomized controlled trial to evaluate the effectiveness of EMG biofeedback in enhancing VMO activation among knee OA patients. Participants were divided into conventional exercise and biofeedback-assisted exercise groups. The biofeedback group demonstrated significantly improved VMO activation patterns, better patellar tracking, and reductions in pain compared to controls. The study concluded that EMG biofeedback is an effective adjunct for VMO rehabilitation, enabling more targeted muscle retraining in OA patients.

22. **White DK, Keysor JJ, Neogi T, et al. (2013) – "Review of Non-Pharmacologic Therapies in Osteoarthritis,".**

This review summarized evidence from multiple clinical trials on exercise, weight management, and physical modalities such as PEMF and ultrasound. The authors reported that structured exercise and lifestyle modification produced consistent improvements in pain, stiffness, and physical function. Adjunctive modalities, including PEMF, further enhanced outcomes. The review concluded that non-pharmacologic interventions should be considered first-line strategies in OA rehabilitation, given their efficacy, accessibility, and safety profile.

23. **Scoppa F, Cadossi R, Massari L, et al. (2012) – “Effect of Pulsed Electromagnetic Fields in Osteoarthritis Patients,”**

In this randomized clinical trial, OA patients were treated with PEMF therapy for six weeks and compared with controls receiving standard care. Outcomes assessed included WOMAC scores, walking speed, and patient-reported symptom scales. Results showed that PEMF treatment led to significant improvements in pain relief, joint mobility, and walking performance. The therapy was well tolerated, with no significant adverse events. The authors concluded that PEMF enhances functional independence and reduces OA-related disability, making it a valuable adjunct in physiotherapy.

24. **Shamala A, Ganesan G, Kumar M. (2016) – “Vastus Medialis Oblique Activation in Knee OA Patients,”.**

This study focused on the neuromuscular role of the vastus medialis oblique muscle in knee osteoarthritis. Using surface electromyography, the authors demonstrated that targeted VMO strengthening significantly improved activation patterns and patellofemoral alignment. Patients undergoing VMO training reported less anterior knee pain and improved functional performance in activities such as stair climbing. The authors concluded that VMO-specific rehabilitation is a key strategy for improving knee stability and reducing OA symptoms.

25. **Frizziero A, Ferrari R, Giannotti E, et al. (2013) – "Role of Muscle Strengthening in Osteoarthritis Management,".**

This review article explored the impact of periarticular muscle dysfunction in OA. The authors highlighted that quadriceps and VMO weakness accelerate disease progression, while strengthening programs improve pain, function, and overall independence. They emphasized the role of tailored rehabilitation programs focusing on muscle activation, endurance, and stability. The authors concluded that strengthening is not only symptomatically beneficial but also delays disease progression, reinforcing its importance in conservative management strategies.

26. **Guo Y, Zhang H, Zhao Y, et al. (2017) – "Comparison of Ultrasound and Digital Caliper in Measuring Joint Space,".**

Guo and colleagues compared ultrasound imaging with digital caliper measurements for assessing joint space narrowing in OA. Their cross-sectional study included 80 patients with knee OA, where both techniques were evaluated for accuracy and reproducibility. Results confirmed that digital calipers provided reliable, reproducible, and clinically practical measurements, while ultrasound offered more detailed structural information but was operator-dependent. The authors concluded that digital calipers remain a valid and efficient method for routine clinical research in OA.

27. **Fell NR, Hinman RS, Wrigley TV, et al. (2011) – "Role of Quadriceps Strength and Function in Knee Osteoarthritis,"**.

This longitudinal study investigated the association between quadriceps strength and OA progression. Using strength testing, functional assessments, and radiographic follow-up, the authors found that weaker quadriceps were linked to greater pain, disability, and structural deterioration over time. Patients with better quadriceps strength maintained improved function and slower disease progression. The study concluded that quadriceps rehabilitation, with emphasis on VMO training, is essential for preserving joint function and reducing the long-term burden of OA.

METHODOLOGY & PROCEDURE

Methodology

Study Design-Experimental Study

Sample Size – 56 (Formula: $N=2k\ SD^2/d^2$)

Sampling Technique – Purposive Sampling.

Setting and Duration-The study was conducted at My Physiospot, Mumbai, Maharashtra over a period of 2 months including patient recruitment, intervention, and post-intervention assessment.

Ethical Considerations

Prior to initiation, ethical clearance was obtained from the Institutional Ethical Committee. The objectives, procedures, and potential benefits of the study were explained to all participants. Written informed consent was obtained before inclusion. Participation was voluntary and confidentiality of data was maintained throughout the study.

Selection Criteria

Inclusion:

- Patients diagnosed with OA Knee by an orthopedician or rheumatologist.
- Patients showing GRADE 1,2, & 3 according to Kellgren & Lawrence classification of OA.
- Patients with age 35 to 65
- Patients with unilateral or bilateral OA.
- Patients with primary OA

Exclusion:

- Patients with history of any knee surgery.

- Patient with or a possibility of pregnancy.
- Patients with any infection of the area being treated.
- Patients with pacemaker.
- Patients taking any analgesics

Materials used:

- PEMF Apparatus
- TheraBand
- Pillow
- Wedge board
- Digital Vernier Calliper

Fig 1: Digital Vernier Calliper **Fig 2: PEMF Apparatus**

Outcome Measures

1. Western Ontario and McMaster Universities Osteoarthritis Questionarrie:

The WOMAC is a disease-specific, self-administered questionnaire widely used for assessing patients with hip and knee osteoarthritis. It consists of 24 items divided into three domains: pain (5 items), stiffness (2 items), and physical function (17 items). Each item is scored on a Likert scale ranging from 0 to 4, with 0 indicating “none” and 4 indicating “extreme.” The total score ranges from 0 to 96, with higher scores reflecting greater levels of pain, stiffness, and functional limitation.

The WOMAC has demonstrated excellent reliability and validity in osteoarthritis populations. The test–retest reliability (Intraclass Correlation Coefficient, ICC) has been reported at 0.86–0.95, and internal consistency (Cronbach’s alpha) ranges between 0.86 and 0.98 across subscales, indicating strong reliability. Its responsiveness to clinical changes makes it an appropriate measure for intervention studies. In this study, WOMAC was administered at baseline and after 20 sessions of intervention to capture changes in pain, stiffness, and physical function.

2. Joint Space Narrowing (JSN):

Joint space narrowing is a radiographic indicator of cartilage degeneration and disease progression in knee osteoarthritis. In this study, standardized anteroposterior (AP) radiographs of the knee joint were obtained, and joint space width was measured using a digital vernier caliper with an accuracy of 0.01 mm. Measurements were taken between the femoral condyle and tibial plateau at the narrowest point of the medial compartment, as this region is most commonly affected in knee OA.

Radiographic measurement of joint space width has been shown to be reliable, with interobserver and intraobserver reliability reported as high (ICC values between 0.80 and 0.94 in previous studies). While less sensitive than advanced imaging modalities such as MRI, digital caliper measurement is practical, cost-effective, and clinically feasible for monitoring structural changes. In this trial, JSN was recorded at baseline and post-intervention to determine changes in cartilage space.

Procedure

- The study was approved by the institutional research review committee and the institutional ethical committee. A sample of 58 subjects, who met the inclusion and exclusion criteria, were recruited. A written informed consent was obtained from the subjects. Demographic data was taken and detailed examination was done. The subjects were then randomly allocated into following two groups by Purposive sampling.
- Group 1 (Experimental group) was given PEMF with VMO strengthening exercises
- Group 2 (Control group) was given only PEMF

All subjects were given a detailed explanation of the procedure in respective. Baseline assessment of WOMAC scores and JSN measurements was carried out for all participants prior to the intervention. Each group then underwent its respective treatment protocol for5 days a week / 4 weeks= 20 sessions. At the completion of the intervention period, WOMAC and JSN were reassessed to determine both within-group improvements and between-group differences

Table 1: List of Exercises for VMO strengthening

Exercises	Dosage
Static exercises for Vastus Medialis Oblique muscle	3 sets of 10 repetitions
Straight Leg Raise (SLR) in all directions	3 sets of 10 repetitions
Double leg semi squat with hip adduction	3 sets of 10 repetitions
Squat exercise with wedge	3 sets of 10 repetitions
Single leg inner range quadriceps with band	3 sets of 10 repetitions
Twisted SLR	3 sets 10 repetitions
Double leg inner range quadriceps with band	3 sets of 10 repetitions

Table 2: Dosage of Intervention (for both groups)

Groups	Intervention	Dosage	Duration
Experimental Group	PEMF+VMO Strengthening Exercises	30 min + 3 sets 10 reps	20 sessions or 4 weeks-5 days a week
Control Group	PEMF	40 mins	20 sessions or 4 weeks-5 days a week

Fig 3: Placement of PEMF Apparatus

Fig 4: Static Exercises

Fig 5: Straight Leg Raise (Abduction)

Fig 6: SLR(Adduction)

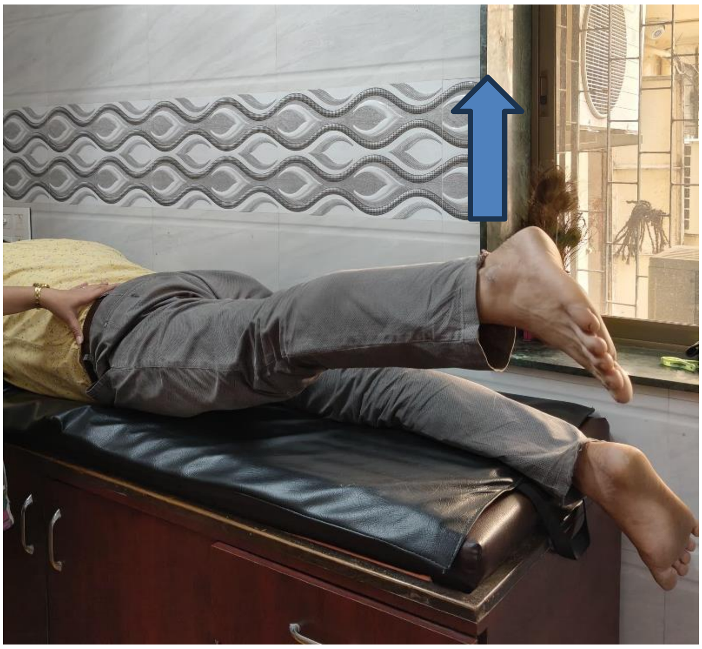


Fig 7: SLR (Extension)

Fig 8: SLR(Flexion)

Fig 9: Twisted SLR

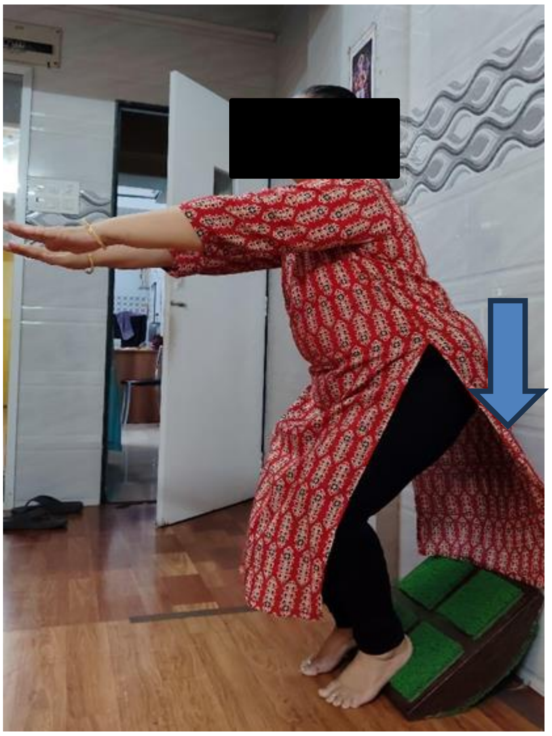


Fig 10: Squat Exercise with Wedge

Fig 11: Double Leg Semi Squat with Hip Adduction

Fig 12: Double leg inner range quadriceps with band

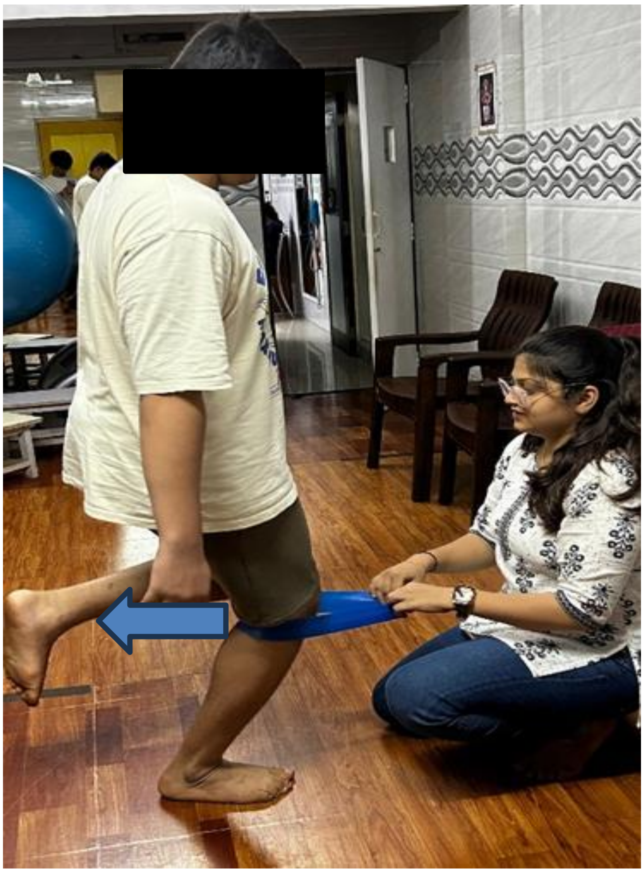
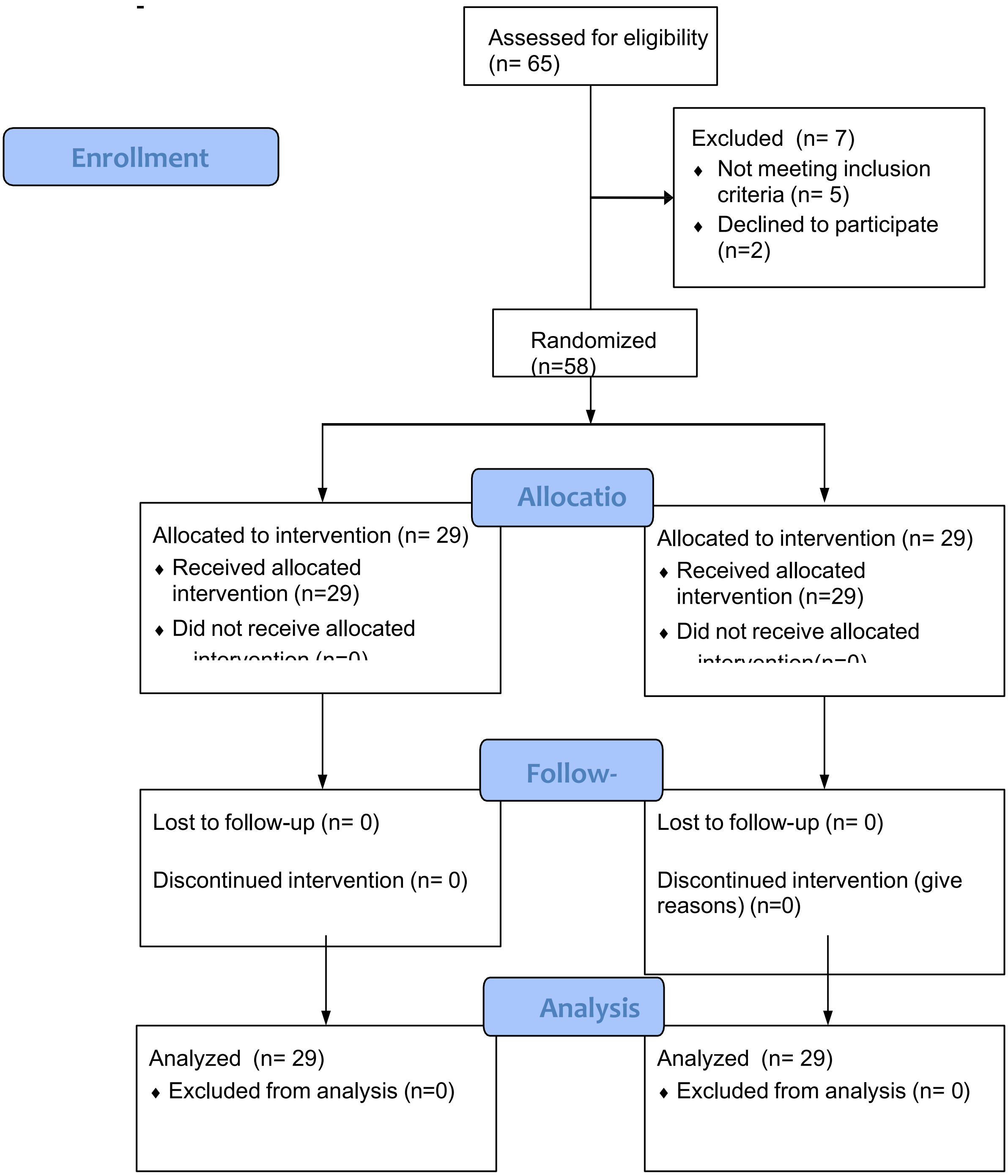


Fig 13: Single Leg Inner Range Quadriceps with Band

Fig 14. CONSORT Flow Diagram



STATISTICAL ANALYSIS

Statistical Analysis

Data was entered in Microsoft Excel 2021 and analyzed using IBM SPSS Version 26.

Descriptive statistics (mean, standard deviation) were used for demographic and outcome measures.

Paired t-test was applied to compare pre- and post-intervention values of WOMAC and JSN.

A p-value < 0.05 was considered statistically significant.

Graphical representations (bar graphs) were prepared using Excel.

Table 3: Age distribution of subjects

Age (years)	No. of Patients
35–65	58
Mean ± SD	52.64 ± 7.24

Table 4: Gender distribution of subjects

Gender	No. of Patients	Percentage
Male	30	51.7%
Female	28	48.3%
Total	58	100%

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Groups were balanced in terms of demographics, minimizing confounding effects.

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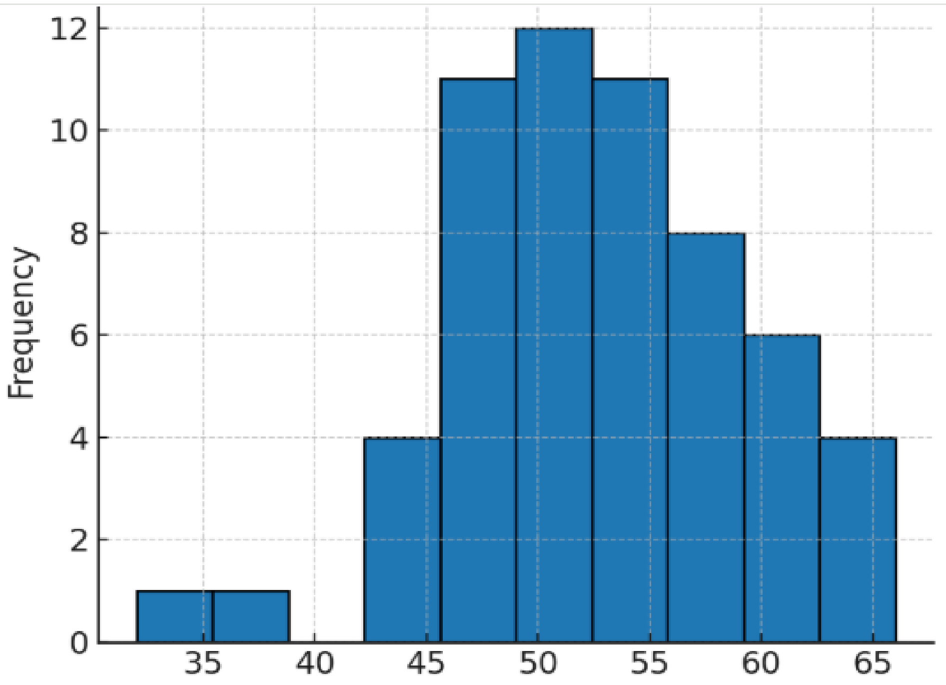
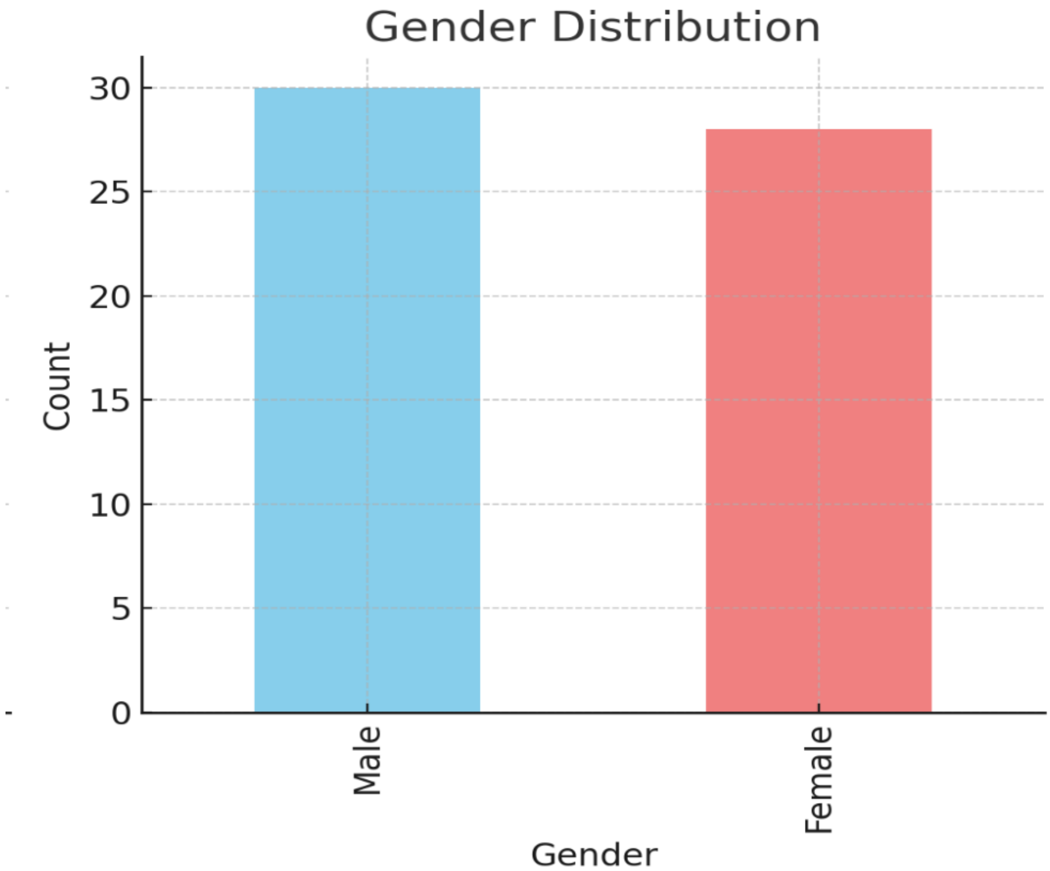


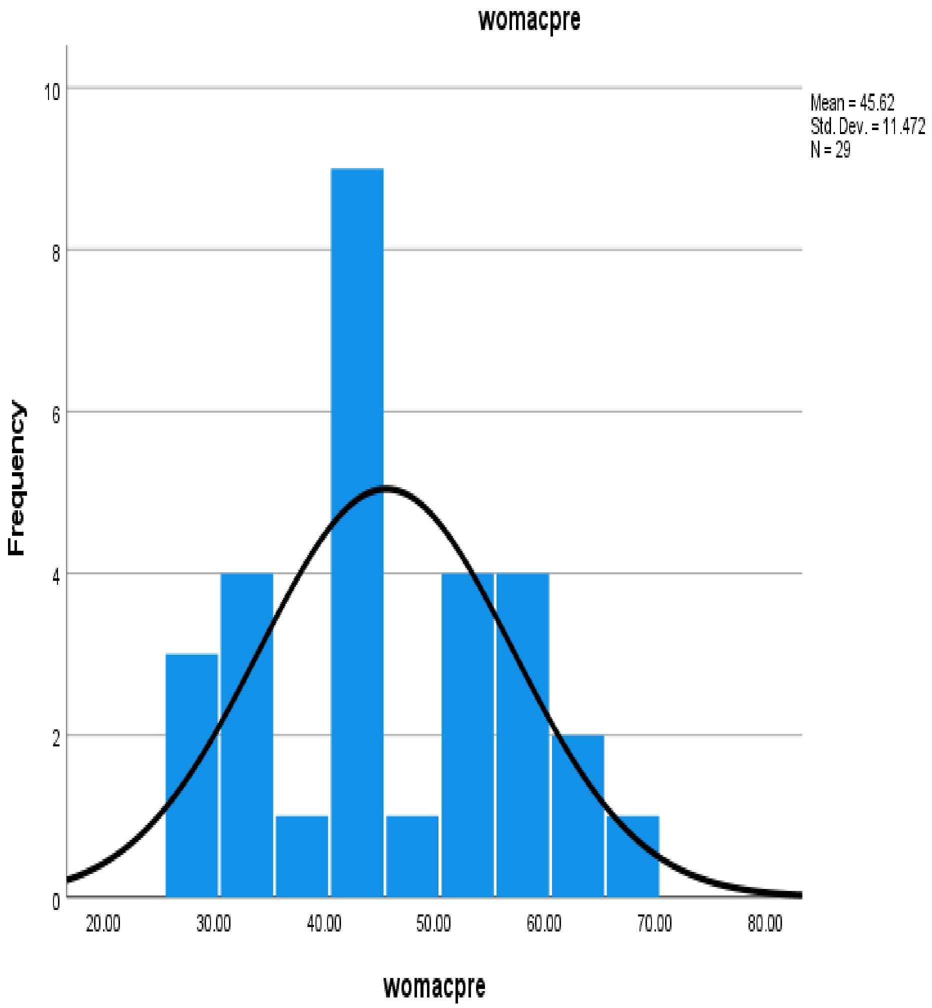
Graph 1: Age Distribution

The age of the participants ranged between 35 and 65 years with a mean age of 52.64 ± 7.24 years. The distribution of age was comparable between the two groups.

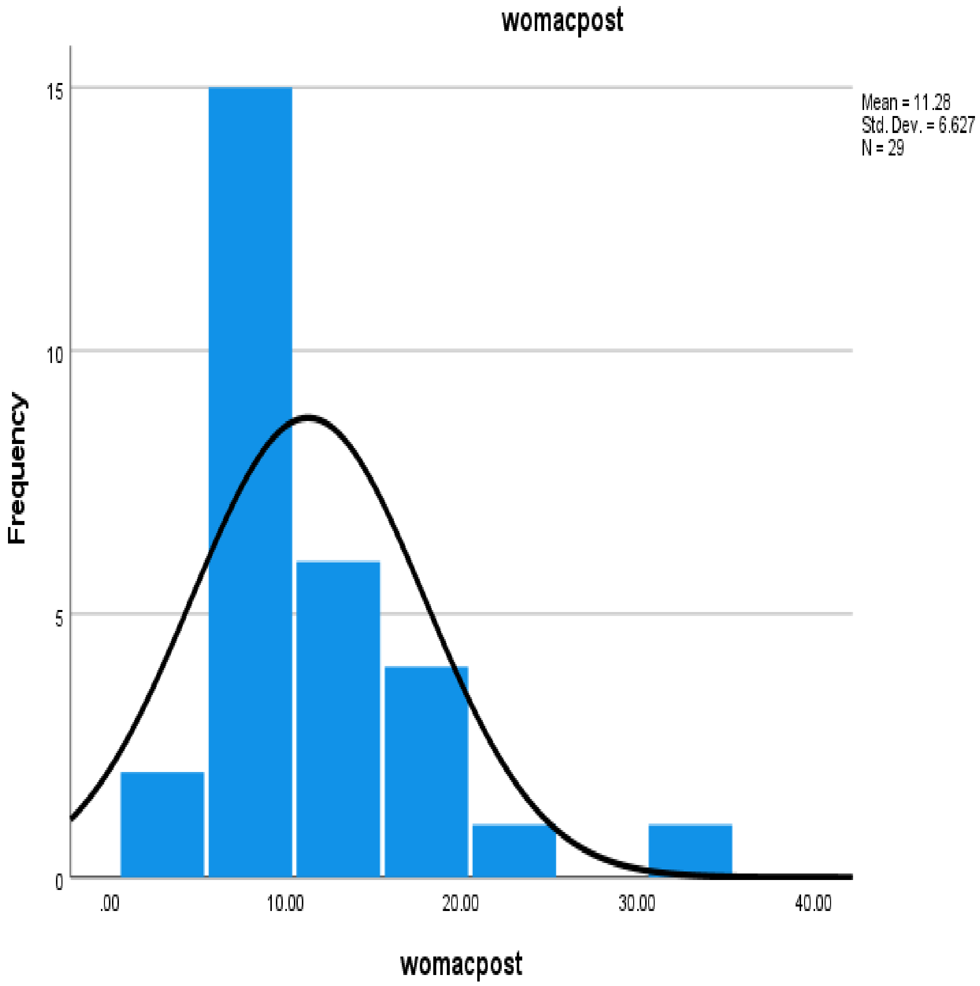


Graph 2: Gender Distribution

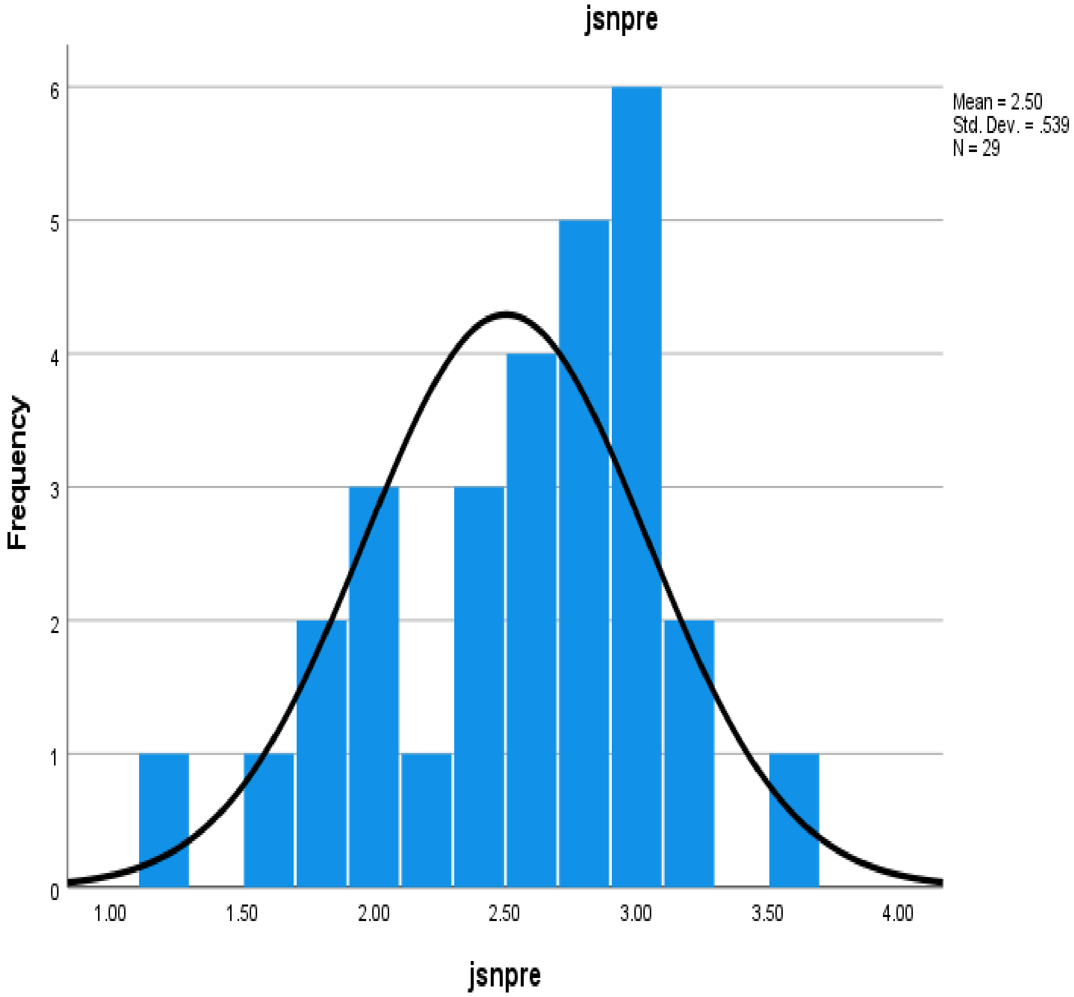
The study included both male and female participants. The distribution of gender across the experimental and control groups was comparable



Graph 3: Distribution of Pre WOMAC Scores (Experimental Group)



Graph 4: Distribution of Post WOMAC Scores (Experimental Group)



Graph 5: Distribution of Pre JSN Values (Experimental Group)

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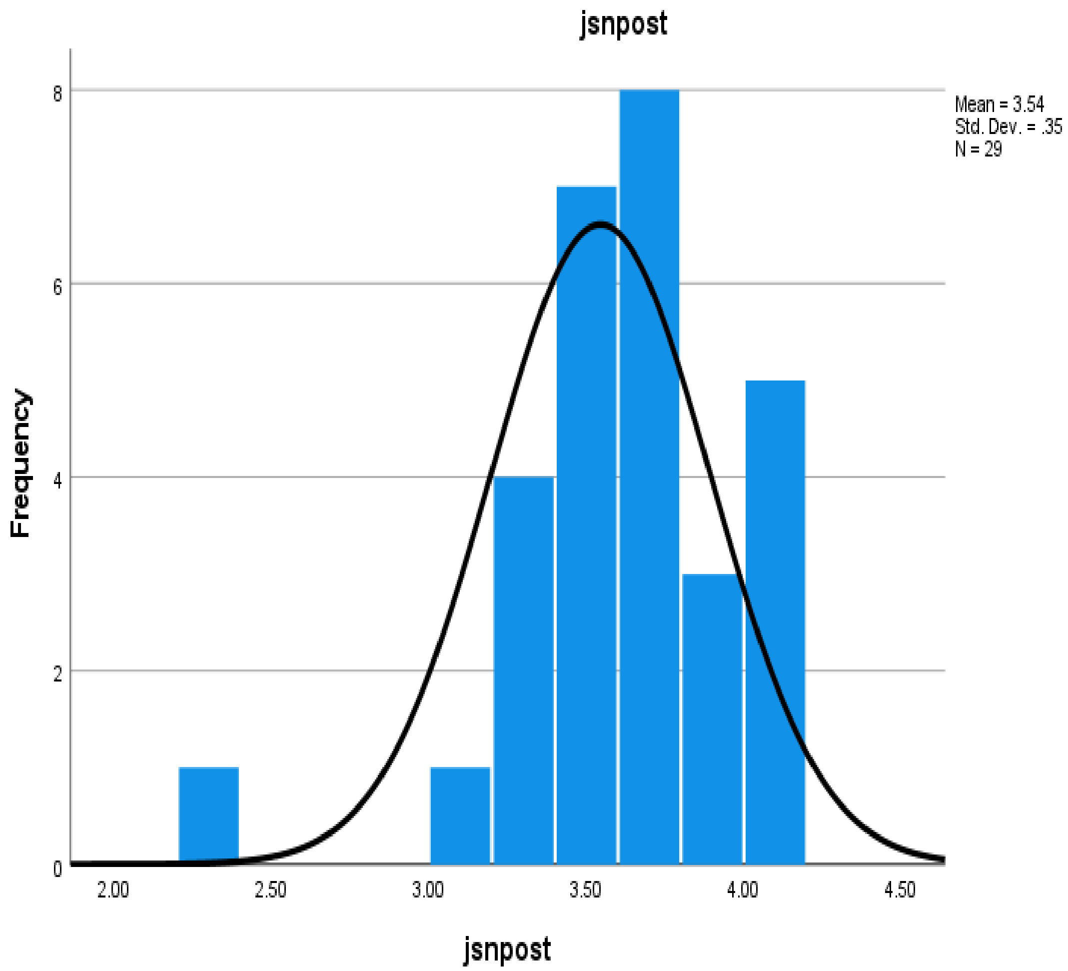
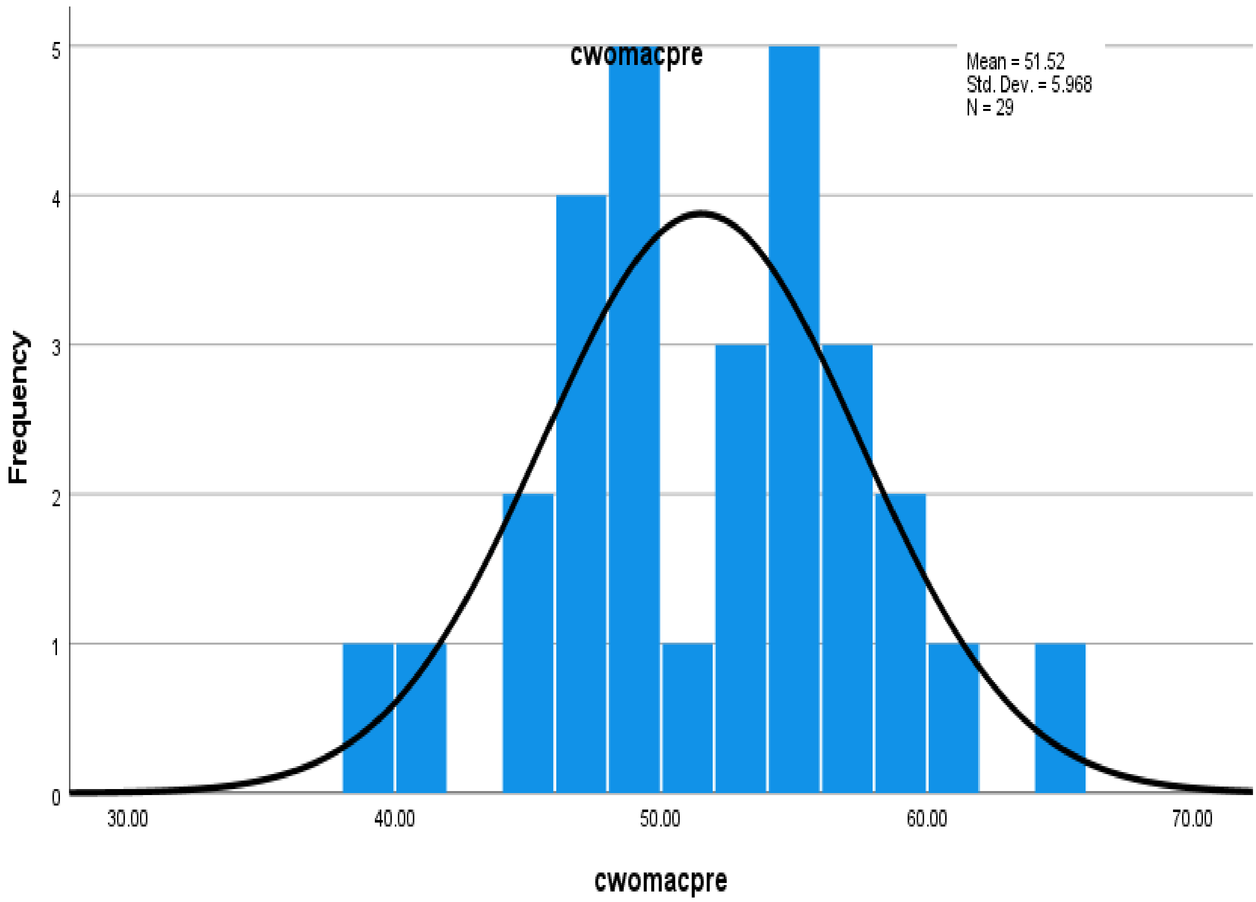
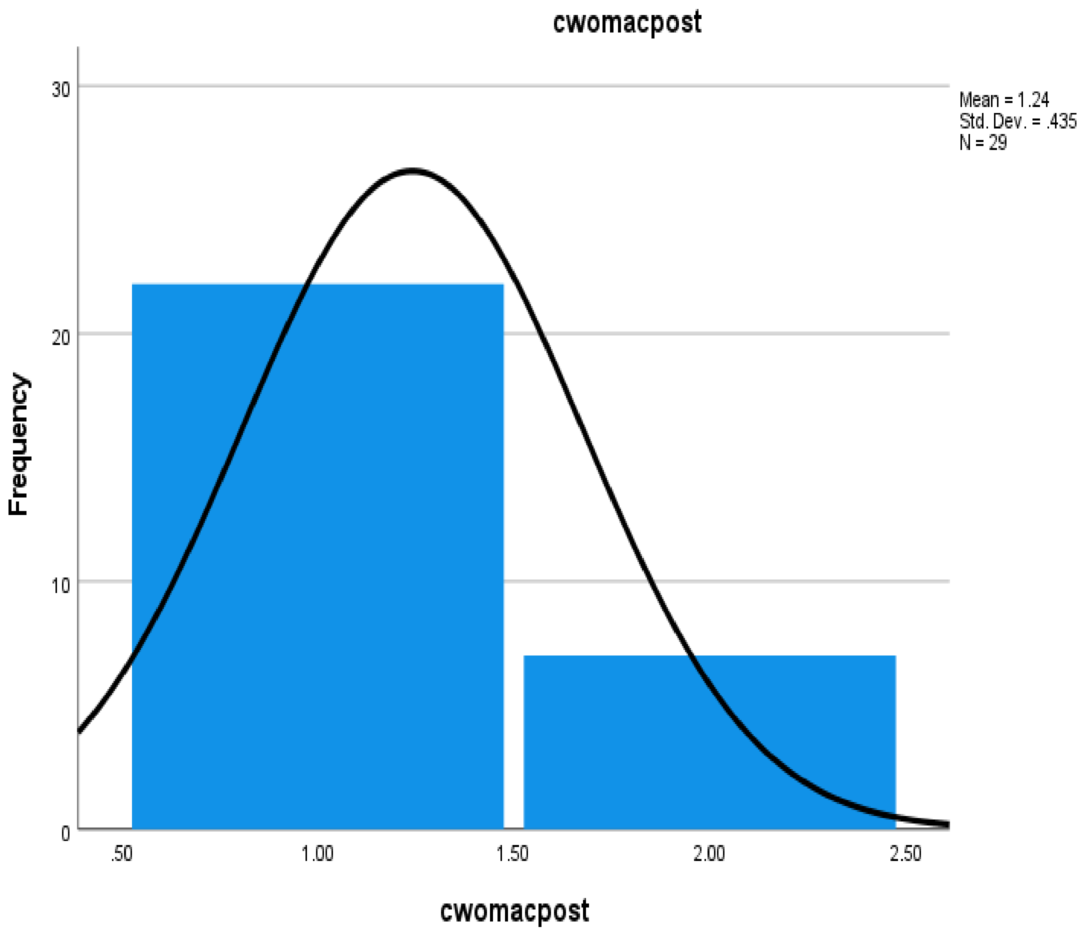


Graph 6: Distribution of Post JSN Values (Experimental Group)



Graph 7: Distribution of Pre WOMAC Scores (Control Group)



Graph 8: Distribution of Post WOMAC Scores (Control Group)

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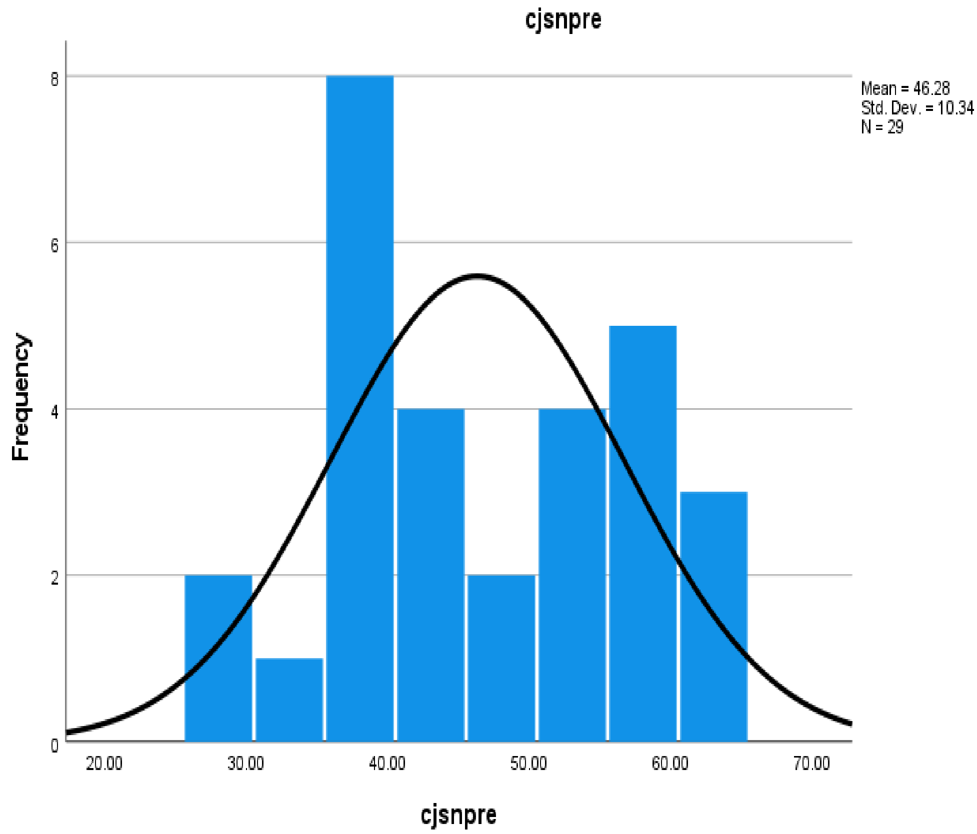
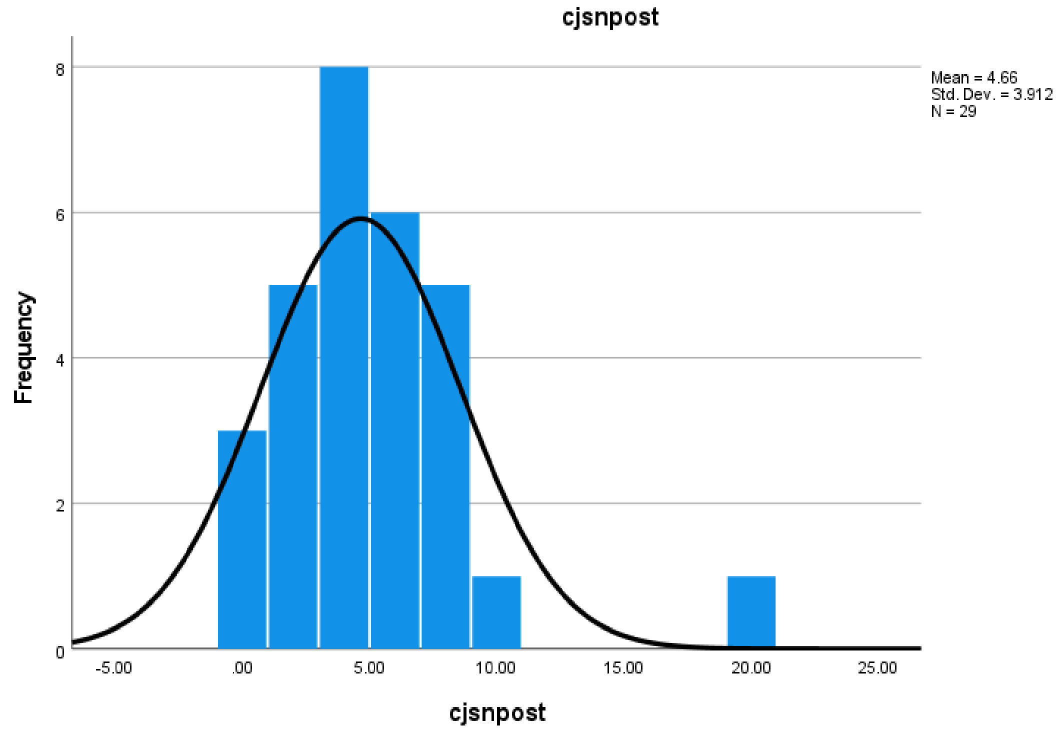


Graph 9: Distribution of Pre JSN Values (Control Group)



Graph 10: Distribution of Post JSN Values (Control Group)

Normality was assessed, and the values of WOMAC and JSN for both the groups for pre and post were found to follow a normal distribution ($p > 0.05$). Hence, parametric tests(t-tests) were applied for further statistical analysis.

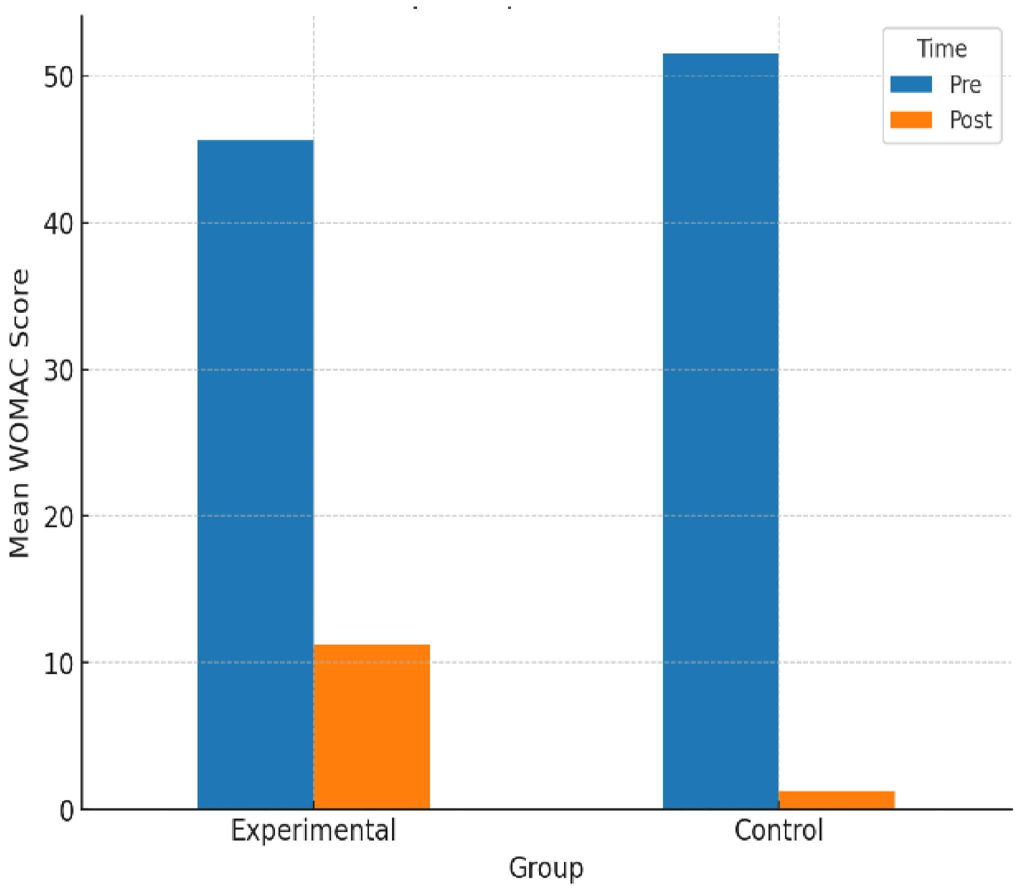
Table 5 –Descriptive statistics (Mean ± SD) of WOMAC and JSN scores

Outcome Measure	Group	n	Mean ± SD
WOMAC Pre	Control	29	46.28 ± 10.34
WOMAC Post	Control	29	4.66 ± 3.91
JSN Pre	Control	29	2.77 ± 0.43
JSN Post	Control	29	3.65 ± 0.29
WOMAC Pre	Experimental	29	45.62 ± 11.47
WOMAC Post	Experimental	29	11.28 ± 6.63
JSN Pre	Experimental	29	2.42 ± 0.53
JSN Post	Experimental	29	3.50 ± 0.36

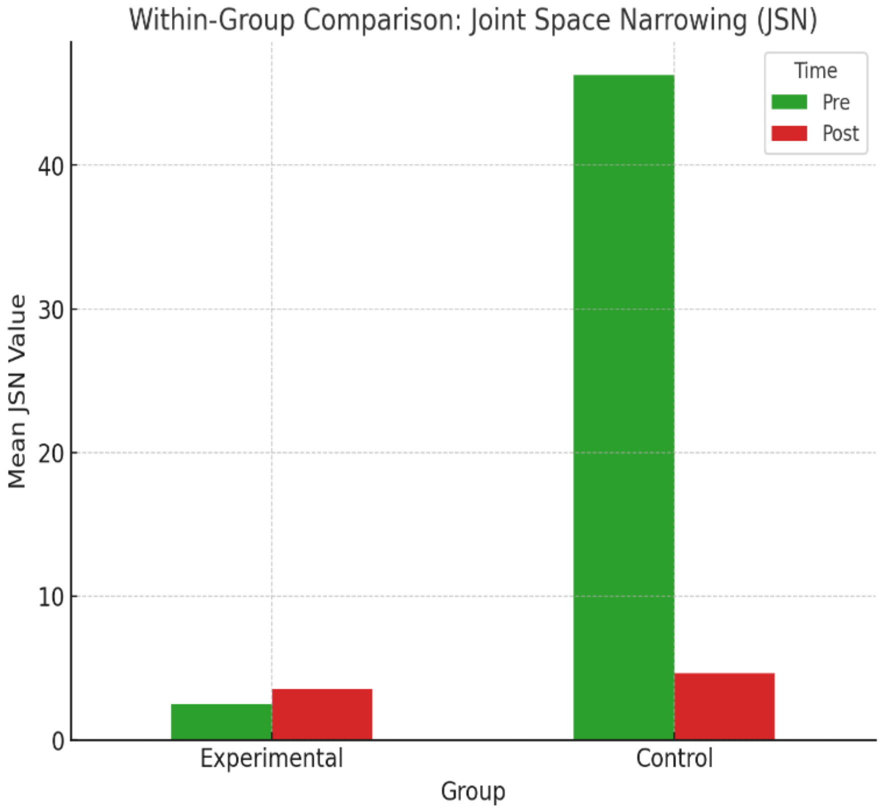
Both groups had comparable baseline WOMAC and JSN scores. Post-intervention, the experimental group showed a greater reduction in WOMAC scores, while JSN values improved in both group

TABLE 6: WITHIN GROUP PAIRED TEST

Outcomes		Mean± Std. Deviation	T	df	Sig. (2-tailed)
Experimental group	WOMAC (Pre vs Post)	34.34±8.31	22.239	28	<.001
Experimental group	JSN (Pre vs Post)	1.04±0.47	-11.927	28	<.001
Control group	WOMAC (Pre vs Post)	50.27±5.93	45.583	28	<.001
Control group	JSN (Pre vs Post)	41.62±9.45	23.697	28	<.001



Graph 11: Within Group WOMAC Comparison



Graph 12: Within Group JSN Comparison

Within-Group Analysis-

Experimental Group:

WOMAC: Pre (45.6±11.4) → Post (11.27±6.62). Significant reduction ($p < 0.001$), showing marked improvement in pain, stiffness, and function.

Joint Space Narrowing (JSN): Pre (2.50± 0.53) → Post (3.54±0.35). Significant improvement ($p < 0.001$), suggesting structural benefit.

Control Group:

WOMAC: Pre (51.51±5.96) → Post (1.24±0.43). Also showed significant improvement ($p < 0.001$).

JSN: Pre (46.27±10.34) → Post (4.65±3.91). Significant changes ($p < 0.001$).

In the experimental group, WOMAC scores reduced significantly and JSN values improved significantly from pre- to post-intervention, confirming the effectiveness of the intervention.

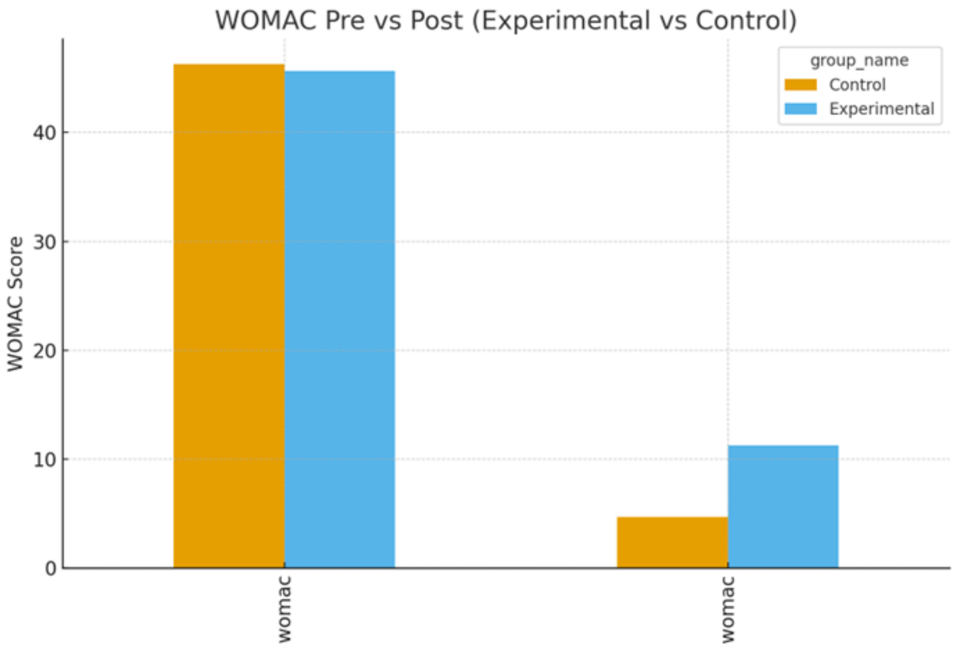
In the control group, WOMAC and JSN also showed statistically significant improvements post-intervention, though the magnitude of change was smaller compared to the experimental group.

Table 7: BETWEEN GROUP PAIRED TEST

Outcomes	**Mean± Standard deviation**	**t**	**df**	**Significance(2-tailed)**
Pre WOMAC (experimental vs control)	5.89± 13.17	2.41	28	0.023
Post WOMAC (experimental vs control)	10.03±6.57	8.21	28	<.001
Pre JSN (experimental vs control)	43.77±10.43	22.59	28	<.001
Post JSN (experimental vs control)	1.11±4.01	1.48	28	0.148

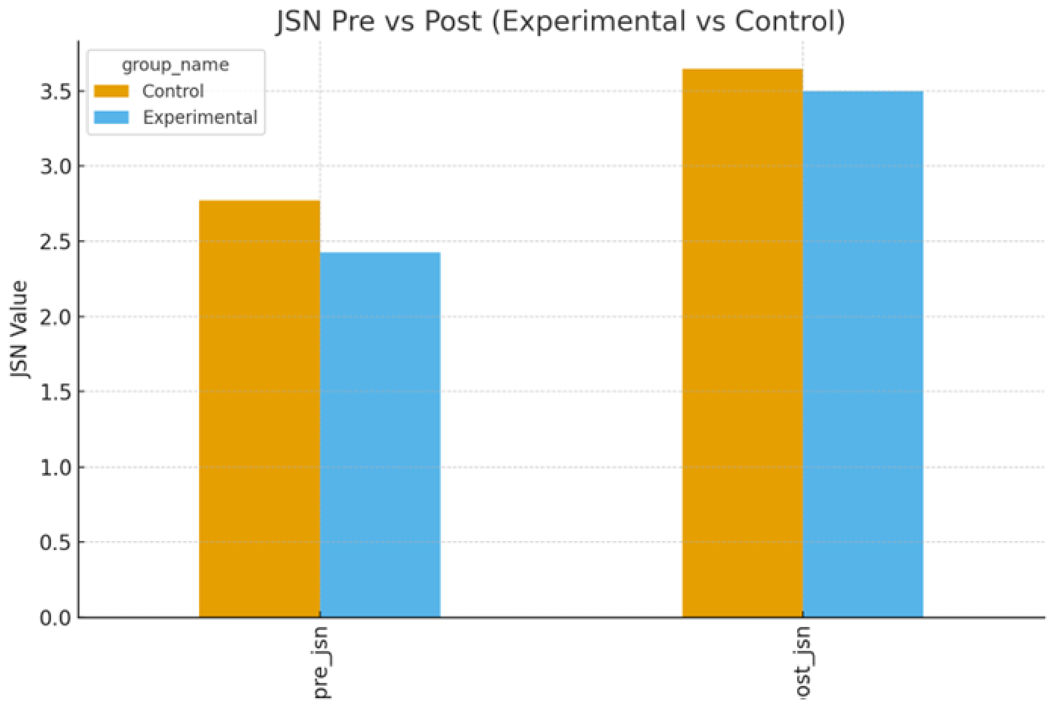
Between-Group Analysis

- **WOMAC Pre:** Small but significant baseline difference (p = 0.023), indicating the experimental group started with slightly better scores.
- **WOMAC Post:** Significant difference (p = 0.001), experimental group had **much greater improvement** compared to control.
- **JSN Pre:** Significant baseline difference (p = 0.001), control group had worse joint space narrowing initially.
- **JSN Post:** No significant difference between groups (p = 0.148), meaning structural outcomes were **comparable**, despite functional improvement favoring the experimental group.



Graph 13: Between Group WOMAC Comparison

Both groups showed significant reductions in WOMAC scores after the intervention. The experimental group (PEMF + VMO strengthening) demonstrated a greater decrease compared to the control group (PEMF alone), reflecting superior improvements in pain relief, stiffness reduction, and functional ability.



Graph 14: Between Group JSN Comparison

Joint space width improved significantly in both groups following treatment. Although both groups benefited, the difference between them at post-intervention was not statistically significant, suggesting that PEMF primarily influenced structural changes, while VMO strengthening contributed more to functional outcomes.

RESULTS

Results

Both groups showed significant improvements in WOMAC scores and joint space after the intervention ($p<0.001$). The experimental group demonstrated a greater reduction in WOMAC scores (Pre: 45.6±11.4 → Post: 11.27±6.62) compared to the control group (Pre: 51.5±5.96 → Post: 1.24±0.43), indicating superior improvement in pain, stiffness, and function. Although joint space improved significantly within both groups, no significant difference was observed between groups post-intervention ($p=0.148$

DISCUSSION

Discussion

This randomized controlled trial examined whether combining pulsed electromagnetic field (PEMF) therapy with vastus medialis oblique (VMO) strengthening produces additional benefits compared to PEMF alone in patients with knee osteoarthritis (OA). The primary outcomes assessed were functional improvements using the WOMAC index and structural changes through joint space narrowing (JSN).

The results indicated that PEMF therapy, whether used independently or in combination with exercise, produced significant within-group improvements in pain, stiffness, and joint function. These findings align with prior studies reporting PEMF's role in alleviating symptoms of OA through mechanisms such as anti-inflammatory effects, chondroprotection, and subchondral bone remodeling([29]). Bagnato et al. (2015) demonstrated that PEMF treatment over six weeks significantly reduced WOMAC scores and improved quality of life in patients with knee OA, supporting our findings of symptomatic improvement with PEMF therapy alone [(49)]. The present study extends these findings by showing that incorporation of VMO strengthening exercises further enhanced functional recovery. This can be explained by the role of the VMO in providing dynamic stabilization to the patellofemoral and tibiofemoral joints, improving load distribution, and reducing abnormal stresses across the knee joint. [(28)]

Between-group comparisons revealed a significant difference in post-intervention WOMAC scores, favoring the experimental group. These findings suggest that PEMF alone is effective, but when combined with targeted muscle strengthening, the functional benefits are amplified. This aligns with previous evidence highlighting that exercise interventions focusing on quadriceps strength are essential in OA management, as quadriceps weakness is strongly associated with disability and progression of knee OA.

In terms of structural changes, both groups demonstrated significant improvements in JSN from baseline. However, no statistically significant difference was found between the experimental and control groups after intervention. This indicates that while PEMF may have a direct influence on cartilage metabolism and subchondral bone remodeling, VMO strengthening primarily contributes to functional rather than structural outcomes. These findings are supported by prior literature suggesting that exercise interventions have limited capacity to directly modify joint structure but substantially improve functional status, pain, and quality of life.

Nevertheless, the study is not without limitations. Baseline differences in WOMAC and JSN scores between groups may have influenced the outcomes despite randomization. The short duration of intervention limits conclusions regarding long-term structural effects.

In summary, the results of this study demonstrate that PEMF therapy is effective in improving pain, stiffness, and joint function in patients with knee OA. Importantly, combining PEMF with VMO strengthening yields greater functional benefits than PEMF alone, highlighting the importance of integrating both electrotherapeutic and exercise-based approaches in the physiotherapeutic management of knee osteoarthritis.

CONCLUSION

Conclusion

This study demonstrated that pulsed electromagnetic field (PEMF) therapy combined with VMO strengthening exercises is effective in reducing symptoms and supporting joint health in individuals with knee osteoarthritis. Participants in the experimental group reported significant reductions in pain and stiffness, along with improved overall function, reinforcing evidence for its role as a valuable non-invasive treatment option in conservative OA management.

When PEMF was combined with vastus medialis oblique (VMO) strengthening exercises, participants achieved even greater functional improvements, as reflected in superior WOMAC score reductions compared to PEMF alone. These findings highlight the importance of targeted quadriceps strengthening in enhancing mobility, reducing disability, and improving quality of life in knee OA patients.

Although the combined intervention improved joint space, the difference compared with PEMF alone was not statistically significant. This suggests that functional benefits of VMO strengthening are more likely related to improved muscular support, patellar tracking, and biomechanical efficiency rather than direct structural changes in the joint.

Overall, integrating PEMF with VMO strengthening appears to provide a more comprehensive rehabilitation strategy. PEMF offers pain relief and structural support, while VMO strengthening contributes to functional recovery. Together, these approaches represent an effective, non-invasive alternative that may delay or reduce the need for surgical interventions in knee osteoarthritis.

LIMITATIONS AND RECOMMENDATIONS FOR FUTURE STUDY

Limitations

Nevertheless, a study has some limitations that should be acknowledged. The study has some important considerations. The short duration of intervention and follow-up limited the assessment of long-term functional and structural outcomes. Joint space narrowing (JSN) was measured using conventional radiography, which may not detect early or subtle cartilage changes compared to advanced imaging like MRI. Although randomization was applied, baseline differences in WOMAC and JSN scores between groups may have influenced the results. Additionally, the small sample size from a single center may limit the generalizability of the findings.

Future Scope of Research

The findings of this study highlight the potential of pulsed electromagnetic field (PEMF) therapy and vastus medialis oblique (VMO) strengthening in the management of knee osteoarthritis. However, further research is needed to build upon these results and address the limitations identified.

Long-term follow-up is another important area. While the current study demonstrated short-term improvements, it remains unclear whether these benefits are sustained over months or years. **Extended-duration trials** are necessary to determine whether PEMF and VMO strengthening can slow structural progression, delay surgical interventions, or provide lasting functional recovery.

In terms of assessment tools, future research should utilize **advanced imaging modalities such as MRI or ultrasound** to complement radiographic joint space narrowing (JSN) measurements. These techniques can capture early changes in cartilage composition, synovial inflammation, and bone marrow lesions, providing a deeper understanding of structural effects.

Finally, comparative studies examining PEMF in combination with **other physiotherapeutic or regenerative modalities**, such as neuromuscular training, platelet-rich plasma (PRP), or stem cell therapy, could provide valuable insights into multimodal management strategies for osteoarthritis.

SUMMARY

Summary

Knee osteoarthritis (OA) is a prevalent musculoskeletal disorder characterized by pain, stiffness, reduced mobility, and progressive joint degeneration. Conventional physiotherapy interventions often emphasize general strengthening of muscle groups, but the role of isolated vastus medialis oblique (VMO) strengthening has not been adequately explored despite its critical role in patellar alignment and knee stability. Similarly, pulsed electromagnetic field (PEMF) therapy has been shown to reduce pain and stiffness and support cartilage health, yet its combined use with VMO strengthening in knee OA remains under-researched. The present randomized controlled trial was conducted on 58 participants with grade I–III knee OA to evaluate the effectiveness of PEMF therapy combined with VMO strengthening exercises compared to PEMF therapy alone. Interventions were provided over 20 sessions in four weeks, and outcomes were measured using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and radiographic joint space narrowing (JSN). Findings revealed that both groups showed significant improvement in WOMAC scores and joint space after the intervention. However, the experimental group demonstrated superior reduction in WOMAC scores, indicating greater improvement in pain, stiffness, and physical function compared to the control group. Although both groups showed increased joint space width post-intervention, no statistically significant difference was observed between them. In conclusion, PEMF therapy combined with VMO strengthening exercises is effective in improving symptoms and functional ability in patients with knee OA. The addition of targeted VMO strengthening exercises enhances clinical outcomes, particularly in reducing

pain and improving functional activity, though both interventions demonstrated comparable effects on joint space narrowing. These findings highlight the importance of integrating specific muscle strengthening with electrotherapy to optimize conservative management of knee osteoarthritis.

STATEMENT OF FUNDING

Source of Funding-Not Applicable

Nature of Funding-Not Applicable

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ANNEXURES

Annexure 1 Approval Letter

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE,
BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/180

Date: 12/05/2025

APPROVAL LETTER
APPENDIX- VIII

MEMBERS

Dr. Smaraki Mohanty
Clinician

Dr. Satyajit Mohanty
Scientific Member

Mr. Shib Shankar Mohanty
Legal Expert

Ms. Annie Hans
Social Scientist

Ms. Subhashree Samal
Lay Person

Mr. Deepak Ku. Pradhan
Scientific Member

IEC-SECRETARIAT

Mr. Gouranga Ku. Padhy
Mr. Susant Ku. Raychudamani

To,

SURIYA ARCHITA MAHAVIR
ABSMARI
273, PAHAL, BHUBANEWAR-752101

Protocol Title: Effect of Pulsed Electromagnetic field Therapy Combined with Vastus Medialis Oblique Muscle Strengthening Exercises in Osteoarthritis Patients-A Randomized Control Trial

Protocol ID.: ABS-IEC-2025-PHY-085

Subject: Approval for the conduct of the above referenced study

Dear Mr./**Ms.**/Dr **SURIYA ARCHITA MAHAVIR**
With reference to your Submission letter dated 06/01/2025 the ABSMARI IEC has reviewed and discussed your application for conduct of the study on dated 26/04/2025.

The following documents were reviewed and discussed

S.N.	Documents	Document (Version/Date)
1	IEC Application Form	26/04/2025
2	Informed Consent Form	26/04/2025
3	Undertaking form PI	26/04/2025
4	CRF	26/04/2025
5	COI from the Investigators	26/04/2025

The following members were present at meeting held on 26-04-2025

ABSMARI ETHICS COMMITTEE * BHUBANESWAR * Dt. 12/05/25

1

ABSMARI ETHICS COMMITTEE

ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE, BHUBANESWAR, ODISHA

CDSCO Reg. No.: ECR/1981/Inst/OD/24

Prof. (Dr.) E. Venkata Rao
Chairperson

Mr. Chinmaya Kumar Patra
Member Secretary

Ref. No. ABSMARI/IEC/2025/180

Date: 12/05/2025

S.N.	Name of the Member	Designation & Qualification	Representation as per NDCT 2019	Gender (M/F)	Affiliation with the Institution (Y/N)
1	Prof. Dr. E. Venkata Rao	Professor (MBBS, MD, Dept. of Community Med.) IMS & Sum Hospital, BBSR	Chair Person	M	N
2	Dr. Smaraki Mohanty	Asst. Prof-IMS & Sum Hospital/MBBS, MD (Community Med)	Clinician	F	N
3	Mr. Shiba Sankar Mohanty	Junior Counsel-Lt. Ramachandra Sarangi's Chamber / BA LLB	Legal Expert	M	N
4	Mr. Chinmaya Kumar Patra	Principal-ABSMARI, MPT	Member Secretary	M	Y
5	Ms. Annie Hans	Disability Inclusive Development Co-Ordinator in Humanity and Inclusion (India/Nepal/Srilanka). /MA in Social Work	Social Scientist	F	N
6	Ms. Subhashree Samal	Ret. Reader-Pol Sc.	Lay Person	F	N
7	Mr. Deepak Kumar Pradhan	Asst. Prof-ABSMARI, MPT	Scientific Member	M	Y

This is to confirm that only members who are independent of the Investigator and the Sponsor of the trial have voted/ provided opinion on the trial.

This Committee approves the documents and the conduct for the study in the presented form with necessary recommendation.

The ABSMARI IEC must be informed about the progress of the study in the prescribed format attached, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent/assent and request to provide a copy of the final report.

The ABSMARI IEC follows procedures that are in compliance with the requirements of ICH (International Conference on Harmonization) guidance related to GCP (Good Clinical Practice) and applicable Indian regulations.

Yours sincerely,

Mr. Chinmaya Kumar Patra
Member Secretary
ABSMARI Ethics Committee
Pahal, Bhubaneswar

Member Secretary
ABSMARI ETHICS COMMITTEE

ABSMARI ETHICS COMMITTEE * BHUBANESWAR * Dt. 12/05/25

2

Utkal Signature, Plot No.-273, Ground Floor, Pahal, Bhubaneswar-752101 +91-63707-03654 iec@absmari.com

MY PHYSIO SPOT

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52/2 PATHAK BUILDING,
NEHRU ROAD,
VILE PARLE (EAST),
MUMBAI – 400057.

Date:. 28/03/2025

NO OBJECTION CERTIFICATE (NOC)

To Whom It May Concern

This is to certify that I, Dr. Rajkumar Varma (PT), Consultant Physiotherapist at MY PHYSIO SPOT, have no objection to Archita Mahavir Suriya, a postgraduate student pursuing Master of Physiotherapy in Orthopedic Specialty, conducting her dissertation-related data/sample collection at our center.

The title of her dissertation study is: " Effect of Pulsed Electromagnetic Field Therapy Combined with Vastus Medialis Oblique Muscle Strengthening Exercises in Osteoarthritis Patients-A Randomized Control Trail. "

I have been informed about the methodology and procedures involved in the study. The research involves non-invasive intervention using Pulsed Electromagnetic Field Therapy device for the treatment of knee osteoarthritis patients combined with a set of muscle strengthening exercises.

The study will be conducted under ethical guidelines, with informed consent taken from all participants. The sessions will be carried out within the clinical settings of our center without interfering with regular patient care.
We support this academic initiative and extend our full cooperation to Archita Mahavir Suriya for the successful completion of her research.

For. MYPHYSIOSPOT

Dr. Rajkumar Varma

(Authorized signature)

Annexure 2

CONSENT FORM

EFFECT OF PULSED ELECTROMAGNETIC FIELD THERAPY COMBINED WITH VASTUS MEDIALIS OBLIQUE MUSCLE STRENGTHENING EXERCISES IN OSTEOARTHRITIS PATIENTS-A RANDOMISED CONTROL TRIAL

This is to certify that I ………………………………………………………… have been given that required information with respect to my participation as a volunteer in the above-mentioned study. The contents of form have been explained to me in my own language.

I have understood the nature of the study and I volunteer to participate in this research study as subject.

Name: ………………………………………………………….
Age/Gender …….
Address: ……………………………………..
…………………………………….
…………………………………….

Contact No. ……………………………..
Date: / / Sign: …………………
Place: MUMBAI

I undersigned SURIYA ARCHITA MAHAVIR have explained the study details and have cleared all the queries put forth by above volunteer to the best of my ability. I confirm that all data and test result achieved will be kept strictly confidential and will be withheld from any misuse.

Date: / / Sign: ……………………
Place: MUMBAI

Annexure 3

EVALUATION FORM

Patient Information

- **Name:** ____________________________
- **Age:** _______
- **Gender:** Male / Female ☐/ Other
- **Date of Assessment:** ______________
- **Occupation:** ______________________
- **Dominance:** ______________
- **Height:** ___________
- **Weight:** ____________________
- **Contact**: ______________________
- **Referred by:** ____________________

Chief Complaint:

HOPI:

Duration of Symptoms: ______________

Onset: Sudden / Gradual

Pain Aggravated by: Walking / Stairs climbing/Stairs descending / Prolonged Sitting /Prolonged standing

Pain Relieved by: Rest/ Medication/ Heat/Ice

Past Medical History

Other Relevant History: ___________________________

On Observation

Swelling:

Crepitus:

Deformity:

Gait Pattern**:**

Posture:

On Examination:

Range of Motion (ROM) – Active

Movement	**Right Knee (°)**	**Left Knee (°)**
Flexion	_____	_____

Movement	Right Knee (°)	Left Knee (°)
Extension	______	______

Passive

Movement	Right Knee (°)	Left Knee (°)
Flexion	______	______
Extension	______	______

Muscle Girth Measurement

Side	Girth 10 cm above patella	Girth 15 cm above patella	Girth 20 cm above patella
Right	__________	__________	____________
Left	__________	__________	____________

Muscle Strength Testing

Muscle Group	Right Knee	Left Knee
Quadriceps	______	______
Hamstrings	______	______
Hip Muscles	______	______

Functional Assessment

- **Walking Tolerance:** Normal / Limited / Needs Support

- **Stair Climbing:** Normal /With Difficulty / Unable
- **Sit to Stand:** Easy / Difficult / Needs Assistance

Special Tests

Investigation: ____

Stage of OA (Kellgren-Lawrence Scale)

☐ Grade I ☐ Grade II ☐ Grade III ☐ Grade IV

OUTCOME MEASURES	PRE-INTERVENTION	POST INTERVENTION
WOMAC		
JSN		

WOMAC

Name:____ Date:______________

Instructions: Please rate the activities in each category according to the following scale of difficulty: 0 = None, 1 = Slight, 2 = Moderate, 3 = Very, 4 = Extremely

Circle **one number** for each activity

Pain	1. Walking	0	1	2	3	4
	2. Stair Climbing	0	1	2	3	4
	3. Nocturnal	0	1	2	3	4
	4. Rest	0	1	2	3	4
	5. Weight bearing	0	1	2	3	4
Stiffness	1. Morning stiffness	0	1	2	3	4
	2. Stiffness occurring later in the day	0	1	2	3	4
Physical Function	1. Descending stairs	0	1	2	3	4
	2. Ascending stairs	0	1	2	3	4
	3. Rising from sitting	0	1	2	3	4
	4. Standing	0	1	2	3	4
	5. Bending to floor	0	1	2	3	4
	6. Walking on flat surface	0	1	2	3	4
	7. Getting in / out of car	0	1	2	3	4
	8. Going shopping	0	1	2	3	4
	9. Putting on socks	0	1	2	3	4
	10. Lying in bed	0	1	2	3	4
	11. Taking off socks	0	1	2	3	4
	12. Rising from bed	0	1	2	3	4
	13. Getting in/out of bath	0	1	2	3	4
	14. Sitting	0	1	2	3	4
	15. Getting on/off toilet	0	1	2	3	4
	16. Heavy domestic duties	0	1	2	3	4
	17. Light domestic duties	0	1	2	3	4

Total Score: ______ / 96 = _______%

Comments / Interpretation (to be completed by therapist only):

Annexure 5

Master Chart

SRNO	GROUP	GENDER	AGE	PRE WOMAC	POST WOMAC	PRE JSN	POST JSN
1	1	MALE	50	28	6	2.8	3.3
2	1	FEMALE	57	57	25	2.9	3.6
3	1	FEMALE	55	45	10	2.3	3.4
4	1	FEMALE	63	53	18	1.2	3.3
5	1	FEMALE	56	60	10	2.3	3.5
6	1	MALE	36	41	6	3	3.5
7	1	FEMALE	51	64	34	2.9	3.3
8	1	MALE	32	31	8	2.9	3.6
9	1	FEMALE	55	42	8	1.7	3.4
10	1	FEMALE	48	69	19	1.9	2.3
11	1	FEMALE	60	43	8	2.8	3.6
12	1	FEMALE	49	52	10	2	3.1
13	1	FEMALE	66	32	3	2.6	3.4
14	1	MALE	61	45	6	3.1	4
15	1	FEMALE	54	42	6	2.8	3.6
16	1	FEMALE	48	29	5	1.9	3.2
17	1	FEMALE	44	51	10	1.8	3.6
18	1	FEMALE	62	58	12	2.9	4
19	1	FEMALE	64	32	6	2.6	4
20	1	MALE	58	56	16	2.5	3.6
21	1	FEMALE	62	45	12	3.2	4
22	1	FEMALE	54	31	11	1.6	3.2
23	1	FEMALE	55	38	9	2.9	3.6
24	1	FEMALE	46	48	12	2.2	3.5
25	1	FEMALE	47	53	20	2.5	3.8
26	1	MALE	54	45	11	1.8	3.6
27	1	MALE	65	61	11	1.9	2.9
28	1	FEMALE	47	29	7	2.5	3.8
29	1	MALE	60	43	8	2.8	3.8

SR NO	GROUP	GENDER	AGE	PRE WOMAC	POST WOMAC	POST JSN	POST JSN
1	2	FEMALE	54	55	5	2.7	4
2	2	MALE	48	40	6	3.5	3.8
3	2	MALE	56	42	20	2.3	3.5
4	2	MALE	61	33	2	3.5	3.8
5	2	FEMALE	59	62	7	3.3	3.8
6	2	FEMALE	47	28	1	2	3.4
7	2	FEMALE	49	52	7	3.1	3.7
8	2	FEMALE	51	42	2	2	2.9
9	2	MALE	64	37	3	3	4
10	2	MALE	46	47	7	2.9	4
11	2	MALE	55	38	0	3	4
12	2	MALE	45	58	6	2.4	3.8
13	2	MALE	55	38	3	2.9	3.4
14	2	MALE	55	38	0	2.9	3.4
15	2	MALE	45	56	6	2.7	3.4
16	2	MALE	47	58	3	2.7	3.8
17	2	MALE	48	58	8	2.9	3.8
18	2	MALE	59	49	3	2	3.4
19	2	MALE	56	62	10	2.5	3.2
20	2	FEMALE	53	52	4	2.8	3.4
21	2	MALE	39	38	2	3.1	4
22	2	FEMALE	55	43	7	2.9	3.4
23	2	MALE	49	62	6	2.4	3.8
24	2	MALE	52	38	4	3.1	4
25	2	MALE	53	41	3	2.9	3.5
26	2	MALE	57	56	5	2.9	3.8
27	2	MALE	47	38	3	2.9	3.8
28	2	MALE	49	28	0	3.2	3.8
29	2	MALE	40	53	2	1.9	3.2

Annexure 5– Similarity and Ai Report

Archita Suriya

EFFECT OF PULSED ELECTROMAGNETIC FIELD THERAPY COMBINED WITH VASTUS MEDIALIS OBLIQUE MUSCLE STRE...

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Frequently Asked Questions

How should I interpret Turnitin's AI writing percentage and false positives?
The percentage shown in the AI writing report is the amount of qualifying text within the submission that Turnitin's AI writing detection model determines was either likely AI-generated text from a large-language model or likely AI-generated text that was likely revised using an AI paraphrase tool or word spinner.

False positives (incorrectly flagging human-written text as AI-generated) are a possibility in AI models.

AI detection scores under 20%, which we do not surface in new reports, have a higher likelihood of false positives. To reduce the likelihood of misinterpretation, no score or highlights are attributed and are indicated with an asterisk in the report (*%).

The AI writing percentage should not be the sole basis to determine whether misconduct has occurred. The reviewer/instructor should use the percentage as a means to start a formative conversation with their student and/or use it to examine the submitted assignment in accordance with their school's policies.

What does 'qualifying text' mean?
Our model only processes qualifying text in the form of long-form writing. Long-form writing means individual sentences contained in paragraphs that make up a longer piece of written work, such as an essay, a dissertation, or an article, etc. Qualifying text that has been determined to be likely AI-generated will be highlighted in cyan in the submission, and likely AI-generated and then likely AI-paraphrased will be highlighted purple.

Non-qualifying text, such as bullet points, annotated bibliographies, etc., will not be processed and can create disparity between the submission highlights and the percentage shown.