RESEARCH PAPER

# Comparative Efficacy of PEMF and Ultrasound Therapy with Strengthening Exercises in Knee Osteoarthritis

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## ABSTRACT

Knee osteoarthritis (KOA) is a significant cause of pain and impairment among older adults and is among the most prevalent degenerative joint conditions. Conservative care is the favored approach, with strengthening activities serving as the foundation of therapy. In recent years, modalities of physical therapy, including Pulsed Electromagnetic Field (PEMF) therapy and therapeutic ultrasonography, have been employed as adjunctive treatments to enhance therapeutic outcomes. This review aims to compare the efficacy of PEMF therapy with therapeutic ultrasonography in conjunction with strengthening exercises for the treatment of knee osteoarthritis. A comprehensive review of the literature was conducted using electronic databases (PubMed, Scopus, Web of Science, and Cochrane Library) for papers published from 2020 to 2026. Both PEMF therapy and therapeutic ultrasonography have demonstrated efficacy in alleviating pain, enhancing physical function, expanding range of motion, and augmenting muscle strength when used into strengthening activities, according to the evaluated evidence. PEMF therapy appears to exhibit more pronounced anti-inflammatory effects and prolonged pain alleviation, but therapeutic ultrasound is more efficacious in reducing joint stiffness and enhancing tissue flexibility before exercise. The combination of these modalities with strengthening exercises is more effective than strengthening alone, and further high-quality randomized controlled trials (RCTs) are necessary to establish a standard of care for patients with knee osteoarthritis and to determine the optimal rehabilitation strategy for these individuals.

**Keywords:** Pulsed Electromagnetic Field, Ultrasound Therapy, Knee Osteoarthritis, Strengthening Exercises, Management.

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## 1. INTRODUCTION

Knee osteoarthritis (KOA) is a significant source of pain, disability, and diminished quality of life among the elderly worldwide, and it ranks among the most common chronic musculoskeletal disorders in the population (Hunter & Bierma-Zeinstra, 2019). It is a progressive, degenerative joint disorder characterized by the gradual loss of articular cartilage, remodeling of subchondral bone, synovial inflammation, osteophyte production, and a range of joint dysfunction. Located in the weight-bearing joints, particularly the knee, it results from the repetitive mechanical stress exerted on the joints during routine activities such as ambulation, stair climbing, standing, and squatting (Hunter & Bierma-Zeinstra, 2019). The incidence of knee osteoarthritis is increasing swiftly globally, as individuals are living longer, becoming more obese, leading more sedentary lifestyles, and exhibiting a higher propensity for metabolic problems.

Knee osteoarthritis is a multifaceted illness characterized by an intricate pathophysiological mechanism involving a confluence of biomechanical, metabolic, inflammatory, and hereditary variables. Although primarily considered a degenerative condition, recent research indicates that chronic low-grade inflammation significantly contributes to disease progression. Inflammatory cytokines, matrix metalloproteinases, and catabolic enzymes contribute

to cartilage degradation, synovial inflammation, and the gradual deterioration of joints (Robinson et al., 2016). Common risk factors include increasing age, female gender, obesity, prior joint injury, repetitive workload, genetic predisposition, muscular weakness, and joint malalignment. Patients have chronic knee pain, stiffness during rest, reduced range of motion, muscle weakness, impaired balance, restricted physical functioning, and limits in everyday activities, leading to diminished independence and quality of life.

The care of knee osteoarthritis emphasizes analgesia, restoration of joint mobility, preservation of functional capacity, and prevention of disease progression. Current worldwide clinical recommendations advocate for non-pharmacological treatments as the primary approach, with exercise therapy seen as the cornerstone of conservative management (Kolasinski et al., 2023). Strengthening exercises are the most reliably effective interventions demonstrated to enhance pain alleviation, joint stability, muscular strength, and physical function. Augmented muscular support around the knee joint reduces mechanical stress on the cartilage and facilitates more efficient movement in patients, hence improving overall functional-performance. Various physical therapy modalities have been used into rehabilitation programs to enhance treatment outcomes, in conjunction with therapeutic exercise. Pulsed Electromagnetic Field (PEMF) therapy has emerged as a novel, potential non-invasive method for delivering low-frequency electromagnetic fields to biological tissues.

Experimental and clinical investigations indicate that PEMF can positively influence cartilage regeneration, cellular metabolism, inflammatory responses, tissue repair, and pain alleviation, without any adverse consequences (Vavken et al., 2009). Pulsed Electromagnetic Field therapy has gained increasing popularity as a supplementary treatment for individuals with knee osteoarthritis, owing to its anti-inflammatory and analgesic properties.

Therapeutic ultrasound is a prevalent electrotherapy modality for knee osteoarthritis, believed to facilitate tissue repair, alleviate pain, reduce inflammation and joint stiffness, and enhance mobility through both thermal and non-thermal mechanisms. Similar advantages have been shown using pulsed electromagnetic field (PEMF) therapy, particularly when combined with strengthening exercises. However, discrepancies in treatment protocols and inconsistent clinical outcomes complicate the assessment of which is more beneficial. This research will assess the effectiveness of PEMF therapy combined with strengthening exercises compared to therapeutic ultrasound combined with strengthening exercises in alleviating pain, improving functional parameters, range of motion, muscular strength, and rehabilitation outcomes in patients with knee osteoarthritis.

## 2. OBJECTIVES

- To evaluate the effectiveness of PEMF therapy and therapeutic ultrasound in knee osteoarthritis.
- To compare their effects on pain, function, range of motion, and muscle strength.

## 3. RESEARCH METHODOLOGY

A comprehensive literature review was conducted using the electronic databases Pubmed, Scopus, Web of Science, and the Cochrane Library to identify pertinent research on the treatment of knee osteoarthritis. Boolean operators (AND and OR) were employed to amalgamate the diverse search phrases, which included: "knee osteoarthritis," "pulsed electromagnetic field therapy (PEMF)," "ultrasound therapy," "strengthening exercises," "physical therapy," and "rehabilitation. Included were articles in English published in peer-reviewed journals that assessed the efficacy of PEMF therapy and ultrasound therapy, both with and without accompanying strengthening exercises. The screening of pertinent randomized controlled trials, comparative studies, systematic reviews, and meta-analyses was conducted, and studies that suited the review's objectives were included for qualitative analysis.

## 4. RESULTS

### 4.1 Characteristics of the Included Studies

This review included primarily randomized controlled trials, prospective clinical studies, systematic reviews, and meta-analyses regarding the efficacy of pulsed electromagnetic field (PEMF) therapy, therapeutic ultrasound, and strengthening exercises in individuals with knee osteoarthritis (KOA). The available data primarily focused on conservative rehabilitative interventions to reduce pain, enhance joint function, and improve quality of life. Randomized controlled trials (RCTs) constituted the predominant study type in the literature, providing the greatest level of evidence for assessing treatment efficacy and minimizing bias (Goh et al., 2016).

The research populations mostly comprised persons diagnosed with clinically and radiographically verified knee osteoarthritis. The bulk of participants were middle-aged and elderly, aged approximately 45 to 80 years. The majority of studies included both males and females, although the samples contained a higher proportion of females due to the greater frequency of knee osteoarthritis in females. To ensure

comparability of study outcomes, the diagnosis of osteoarthritis (OA) was often established using criteria from the American College of Rheumatology (ACR) alongside radiographic characteristics based on the Kellgren–Lawrence grading system (Palazzo et al., 2016).

There was considerable disparity in the interventions utilized across the included trials. The parameters of PEMF therapy varied regarding magnetic field strength, pulse frequency, session duration, and treatment duration. Ultrasound therapy shown similar variability for the frequency of intervention, intensity, application method (continuous or pulsed), and length of the intervention. Typically, strengthening training programs concentrated on enhancing the quadriceps muscles while also incorporating abductor, hip, and functional lower limb exercises to foster joint stability and athletic performance. Numerous studies assessed the efficacy of electrotherapy in conjunction with exercise therapy, while others evaluated various strategies to evaluate their effectiveness (Jamtvedt et al., 2008).

Notwithstanding the varied study designs, a somewhat consistent outcome measure was employed across the included investigations. Pain severity was predominantly assessed using the Visual Analogue Scale (VAS) or the Numeric Pain Rating Scale (NPRS), whereas physical function was primarily evaluated with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Additional assessments conducted included knee range of motion, quadriceps strength, ambulation capability, balance, functional mobility, and health-related quality of life. The follow-up duration ranged from short-term interventions of 4-6 weeks to extended clinical investigations lasting several months to evaluate both immediate and persistent therapeutic benefits (Prieto-Alhambra et al., 2014; Ferreira et al., 2019).

The literature exhibited considerable variability about participant characteristics, intervention techniques, treatment duration, and clinical outcome assessments. Nevertheless, the majority of research consistently shown advantages of conservative rehabilitation interventions regarding pain alleviation and functional capacity. The evidence did not permit a direct comparison of the efficacy of PEMF therapy and ultrasound therapy across studies; however, the overall findings indicate that PEMF therapy is typically as effective as ultrasound therapy for managing knee osteoarthritis when combined with strengthening exercises. The study highlights the necessity for standardization in treatment protocols in future clinical research to improve comparability and strengthen the evidence base.

**4.2 Effect of Pulsed Electromagnetic Field (PEMF) Therapy on Knee Osteoarthritis**

**4.2.1 Mechanism of Action of PEMF Therapy:** Pulsed Electromagnetic Field (PEMF) therapy is a non-invasive electrotherapy that administers low-frequency electromagnetic pulses to enhance cellular activity and facilitate tissue restoration. It enhances cartilage metabolism, improves microcirculation, regulates calcium transport, and suppresses inflammatory mediators such as IL-1β, IL-6, and TNF-α. The biological effects contribute to pain reduction, cartilage preservation, and improved joint function in individuals with knee osteoarthritis (Markovic et al., 2022).

**4.2.2 Effect of PEMF Therapy on Pain Reduction:** PEMF therapy has demonstrated significant efficacy in alleviating pain in individuals with knee osteoarthritis. Clinical trials have demonstrated a decrease in pain as measured by the Visual Analogue Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). The analgesic benefits are chiefly associated with anti-inflammatory properties, enhanced blood circulation, and the modification of pain pathways, rendering PEMF a safe and efficient adjunct in conservative rehabilitation (Cianni et al., 2024).

**4.2.3 Effect on Physical Function and Quality of Life:** PEMF therapy improves mobility, stair climbing, joint flexibility, and the performance of daily activities. Significant improvements in WOMAC and KOOS scores, as well as quality of life, are recorded, especially with the incorporation of strengthening activities alongside PEMF. A combination approach yields enhanced functional recovery and mobility relative to exercise alone (French et al., 2024).

**4.2.4 Effect on Cartilage Repair and Inflammatory Response:** Recent research suggests that PEMF therapy may facilitate the synthesis of extracellular matrix and collagen while diminishing inflammatory activity, hence aiding cartilage repair. It also diminishes oxidative stress and cartilage deterioration, preserving joint health. The recent study indicates favorable outcomes; however, further rigorous clinical trials are need to confirm its long-term disease-modifying effects in knee osteoarthritis (Cianni et al., 2024).

**4.3 Effect of Ultrasound Therapy on Knee Osteoarthritis**

**4.3.1 Mechanism of Action of Ultrasound Therapy:** Therapeutic ultrasonography is a prevalent electrophysical modality utilized in the conservative management of knee osteoarthritis (KOA). It transmits high-frequency sound waves to bodily

tissues and possesses both pharmacological and non-pharmacological actions that facilitate healing and alleviate pain. The heat effects enhance local blood circulation, augment collagen extensibility, and reduce muscular spasms, whilst the non-thermal effects, including cavitation and sonic streaming, promote cellular activity, protein synthesis, and tissue regeneration. These physiological effects lead to enhanced cartilage metabolism, reduced inflammatory activity, and improved repair of periarticular soft tissues. While the mechanisms of action remain under examination, current evidence suggests that ultrasonic therapy is advantageous as it influences inflammatory pathways and tissue repair in the osteoarthritic knee joint (Dantas et al., 2021; Luo et al., 2024).

**4.3.2 Effect of Ultrasound Therapy on Pain and Joint Stiffness:** The primary result of interest in trials evaluating ultrasonic therapy for knee osteoarthritis is the alleviation of pain. Recent systematic reviews and meta-analyses have demonstrated that therapeutic ultrasound is a substantial and successful modality when applied consistently over several weeks with uniform treatment protocols for alleviating pain intensity. The Visual Analogue Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) are frequently employed to assess enhancements in pain levels. Ultrasound therapy alleviates pain and diminishes joint stiffness, facilitating daily activities for patients. The analgesic effects are attributed to enhanced tissue repair, improved blood circulation to the afflicted joint, and reduced inflammatory responses in the surrounding tissue. The extent of improvement, however, is contingent upon the frequency, intensity, and length of the treatment.

**4.3.3 Effect on Range of Motion, Muscle Function, and Physical Performance:** Several clinical trials have demonstrated that ultrasound therapy enhances joint mobility, muscle function, and physical performance in individuals with knee osteoarthritis. Following ultrasonography, periarticular rigidity and soft tissue extensibility have been associated with enhanced knee range of motion. Improved functional capacity has also been observed in ambulation, climbing, balance, and activities of daily life. Evidence suggests that ultrasound therapy, when combined with an organized exercise regimen, yields superior clinical benefits compared to its solitary application, particularly in enhancing quadriceps strength. Recent reviews have underscored the significance of ultrasound as a supplementary modality to exercise therapy, rather than a substitute for therapeutic exercise, which remains fundamental in the conservative management of KOA.

**4.3.4 Comparison of Continuous and Pulsed Ultrasound Therapy:** Continuous and pulsed ultrasound exhibit distinct physiological effects and clinical applications. The primary effects of continuous ultrasound are thermal, elevating tissue temperature, enhancing blood circulation, and increasing tissue flexibility, with a notable efficacy in alleviating chronic joint stiffness. In contrast, pulsed ultrasound is engineered to achieve maximal biological effects (cell stimulation, collagen formation, and anti-inflammatory characteristics) while minimizing tissue heating. Recent meta-analyses indicate that both modalities effectively alleviate pain and enhance physical performance in individuals with knee osteoarthritis, with low-intensity pulsed ultrasound potentially offering larger advantages while minimizing thermal tissue damage. Despite the reported hopeful results, substantial discrepancies in treatment parameters between clinical trials complicate comparisons, necessitating the establishment of standardized treatment protocols and the conduct of high-quality randomized controlled trials. Chen and Sun, 2022

### 4.4 Role of Strengthening Exercises in Knee Osteoarthritis Management

#### 4.4.1 Importance of Strengthening Exercises in Knee Osteoarthritis

Strengthening exercises are crucial in the conservative management of knee osteoarthritis, since they enhance muscular strength, reduce pain, promote joint stability, and improve functional independence. These exercises can enhance the strength of the knee-adjacent muscles, notably the quadriceps, thereby mitigating excessive joint loading and provide support during movement. Regular strengthening exercises can enhance the strength of the quadriceps, hamstrings, hip abductors, and gluteal muscles, hence ensuring proper alignment of the kneecap and providing stability to the knee. Enhanced muscular support reduces stress on the knee joint, facilitates more efficient movement, and mitigates future cartilage degradation. Resistance workouts are effective for enhancing muscular strength, as well as augmenting joint mobility, flexibility, balance, and proprioception. They also alleviate joint stiffness, increase circulation, and boost mobility, allowing patients to participate in regular activities without pain or discomfort. Strengthening activities enhance overall health by increasing endurance, sustaining a healthy body weight, improving cardiovascular fitness, and elevating psychological well-being. Enhanced physical function enables patients to experience increased mobility, so augmenting their activity levels, improving their quality of life, and reducing their handicap. Strengthening activities are secure, user-friendly, and adaptable. These can be conducted at hospitals, physiotherapy clinics, rehabilitation centers, or at home with little equipment. Exercise programs can be customized according to the patient's age, disease activity, and

functionality, making them appropriate for the majority of individuals with knee osteoarthritis. Progressive strengthening programs are intended to gradually increase exercise intensity as muscle strength improves, so enhancing muscular endurance and joint stability while minimizing the chance of injury. These exercises are often employed in conjunction with other therapies such as PEMF or therapeutic ultrasound to achieve optimal pain relief, enhanced muscular function, and favorable rehabilitation outcomes.

**4.4.2 Effect of Strengthening Exercises on Pain Reduction, Muscle Strength, and Joint Stability**

muscular-strengthening exercises are highly useful in alleviating knee pain and enhancing muscular function in individuals with knee osteoarthritis. These exercises fortify the musculature surrounding the knee joint, thereby mitigating atypical stress on the joint, enhancing shock absorption, and improving the efficiency of joint movement. As the discomfort subsides, the patient may perform daily activities with ease and actively participate in rehabilitation. Clinical research have demonstrated that strengthening exercises reduce pain and enhance function, with notable improvements in the Visual Analogue Scale (VAS) and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).

Exercise also reduces joint stiffness, enabling individuals to walk, ascend stairs, and rise from a seated position with greater ease. Strengthening exercises enhance the strength of the quadriceps, hamstrings, hip abductors, and gluteal muscles, which are crucial for the stability of the knee joint. Enhancing muscle strength improves joint alignment, neuromuscular control, and diminishes mechanical stress on the knee, hence mitigating further cartilage degradation and augmenting physical performance. Enhanced muscular strength and joint stability result in superior balance, coordination, and functional mobility, hence reducing the risk of falls. Incorporating strengthening exercises alongside other conservative treatment techniques such as PEMF therapy or therapeutic ultrasound will enhance pain alleviation, muscular performance, and joint function, serving as the cornerstone of conservative management for knee osteoarthritis.

**4.4.3 Effect on Physical Function and Activities of Daily Living**

Strengthening exercises are fundamental to conservative management of knee osteoarthritis and can substantially enhance physical function and activities of daily living (ADLs). Progressive resistance training enhances the strength of lower-limb muscles, particularly the quadriceps, hamstrings, and hip musculature, leading to gains in walking ability, gait speed, stair-climbing proficiency, and sit-to-stand capability. According to Bowden et al. (2020), enhanced muscle activity results in improved dynamic support of the knee joint, reduced excessive loading on the joint, and more efficient movement under load. These improvements enhance patients' functionality, instilling confidence and reducing pain in daily tasks, while perhaps decreasing the risk of impairment.

Strengthening exercises enhance mobility and augment balance, proprioception, and neuromuscular coordination, which are frequently impaired in individuals with knee osteoarthritis. Enhanced postural control allows patients to sustain stability during ambulation and transitional activities, diminishes the risk of falls, and promotes functional independence. Both home-based and supervised exercise programs have demonstrated a significantly good impact on functional outcomes, including walking distance, chair rise, and total physical function (Gibbs et al., 2023).

The study findings suggest that strengthening activities ought to be incorporated into the overall rehabilitation strategy for individuals with knee osteoarthritis. Holden et al. (2023) Besides enhancing activities of daily living and health-related quality of life, strengthening exercises also yield enhanced physical performance. Patients participating in regular structured exercise programs report enhanced independence in self-care, home activities, shopping, and community involvement. Enhanced physical function facilitates sustained physical activity, so promoting joint health, reducing disability, and aiding long-term illness management. Both the evidence and clinical practice guidelines concur that exercise therapy is the cornerstone of knee osteoarthritis treatment, demonstrating efficacy, safety, and a beneficial effect on functional outcomes without significant adverse effects. (Mo et al., 2023)

**4.4.4 Different Types of Strengthening Exercises**

**Strengthening exercises:** During the rehabilitation process for knee osteoarthritis, strengthening exercises are an essential component. The purpose of these exercises is to improve muscular strength, joint stability, and physical function. (Kolasinski et al., 2020; Gibbs et al., 2023) Exercise programs are personalized after taking into account the severity of the disease, the level of discomfort, and the functional abilities of the patient. The goal is to get optimal results through progressive progression.

**Isometric strengthening exercises:** The use of isometric exercises, which include the contraction of muscles without the movement of joints, is especially beneficial for patients who are experiencing acute pain or who have limited mobility. Bennell et al. (2014)

found that they reduce the amount of stress placed on the knee joint while simultaneously improving quadriceps strength and knee stability.

**Isotonic strengthening exercises:** Isotonic exercises entail dynamic muscular contractions across the complete range of motion. These exercises enhance muscular strength, endurance, flexibility, and functional activities, including ambulation and stair navigation (Fransen et al., 2015).

**Progressive resistance training (PRT):** Progressive resistance training incrementally elevates workout intensity as muscular strength enhances. It significantly increases lower-limb strength, alleviates pain, boosts gait, and augments total physical function in individuals with knee osteoarthritis (Mo et al., 2023).

**Closed-chain and open-chain exercises:** Closed-chain exercises, such squats and sit-to-stand movements, enhance joint stability and functional strength, while open-chain exercises, like knee extensions, predominantly target the quadriceps. The integration of both exercise modalities enhances muscular performance and functional capacity (Escamilla, 2018; Kisner et al., 2022).

**Home-based and supervised exercise programmes:** Both home-based and supervised exercise programs significantly enhance pain relief and physical function in knee osteoarthritis. Supervised programs typically yield superior exercise adherence, enhanced muscle strength, and higher functional outcomes, whereas home-based programs provide convenience and long-term accessibility.

#### 4.4.5 Combination of Strengthening Exercises with Physical Therapy Modalities

Strengthening exercises, in conjunction with physical therapy techniques, constitute an effective conservative care strategy for knee osteoarthritis. Strengthening exercises improve muscle strength, joint stability, and movement capacity, while modalities such as Pulsed Electromagnetic Field (PEMF) therapy and therapeutic ultrasonography alleviate pain, inflammation, and joint stiffness. This facilitates the patient's ability to exercise with more ease and efficiency. Strengthening activities, when combined with PEMF therapy, yield enhanced outcomes for pain alleviation, muscle fortitude, and knee stability.

PEMF facilitates tissue repair and reduces inflammation, enabling patients to endure progressive resistance exercises and enhance their overall physical functionality. Similarly, the application of therapeutic ultrasound alongside strengthening exercises yields more positive treatment outcomes, characterized by reduced discomfort and muscular stiffness, as well as enhanced flexibility. This will enhance patients' joint mobility, allowing for more efficient exercise and improved performance of functional activities such as walking and ascending stairs. Generally, the integration of strengthening exercises with PEMF therapy or therapeutic ultrasound enhances overall rehabilitation outcomes, including improved muscle function, joint mobility, and quality of life. A tailored rehabilitation program that includes these therapies is a comprehensive and successful method for the conservative management of knee osteoarthritis.

### 4.5 Comparative Analysis of PEMF Therapy and Ultrasound Therapy in Conjunction with Strengthening Exercises

#### 4.5.1 Comparative Effectiveness of PEMF Therapy and Ultrasound Therapy

Pulsed Electromagnetic Field (PEMF) therapy and therapeutic ultrasound are frequently utilized as additional physiotherapy treatments for the conservative management of knee osteoarthritis. Both therapies are commonly employed in conjunction with strengthening exercises to alleviate pain, enhance joint function, and improve overall physical performance. Nonetheless, their therapeutic activities are markedly distinct (Markovic et al., 2022). PEMF therapy operates at the cellular level by modulating inflammatory processes, enhancing microcirculation, and promoting tissue repair, whereas therapeutic ultrasound exerts both thermal and non-thermal effects that can improve circulation, increase soft tissue extensibility, and facilitate soft tissue repair. Despite the discrepancies between them, both treatments have demonstrated efficacy in structured rehabilitation programs that yield therapeutic outcomes.

Recent systematic evaluations indicate that PEMF therapy effectively diminishes pain intensity, enhances physical function, and improves quality of life, particularly when utilized alongside exercise-based rehabilitation. Therapeutic ultrasound has proven to be very advantageous in alleviating pain and enhancing joint mobility; nevertheless, therapy outcomes appear to be contingent upon the ultrasound parameters (frequency, intensity, treatment time). Comparative evidence suggests that PEMF may provide more significant enhancements in long-term pain relief and functional recovery due to its biological effects on inflammation and cartilage metabolism, whereas ultrasound may be more efficacious in reducing joint stiffness and priming tissues for exercise. Currently, there is only scant data to endorse the superiority of one modality over another, attributable to the variability in treatment procedures and study designs.

**4.5.2 Clinical Benefits of Combining Each Modality with Strengthening Exercises**

Strengthening exercises remain the cornerstone of conservative treatments for knee osteoarthritis, but the addition of PEMF therapy or therapeutic ultrasound enhances treatment efficacy. The application of PEMF therapy alongside strengthening exercises facilitates pain management, diminishes inflammation, and enables engagement in increasing resistance training. Enhanced exercise tolerance results in improved quadriceps strength, knee stability, ambulation function, and functional autonomy. Similarly, pre-strengthening therapeutic ultrasound can alleviate pain, reduce muscle stiffness, and enhance tissue flexibility, so enabling patients to exercise with an expanded range of motion and less discomfort.

Strengthening activities mixed with rehabilitation demonstrate greater clinical outcomes compared to strengthening exercises alone. Improvements have been documented in pain reduction, WOMAC scores, VAS scores, muscle strength performance, activities of daily living (ADL), gait performance, and balance. While both modalities are recognized as good complements to exercise therapy, the selection of PEMF or ultrasound must be customized based on the patient, symptom intensity, treatment goals, equipment availability, and clinical expertise. Randomized controlled trials with standardized intervention protocols with a good quality design are required in the future, to establish the most appropriate combination strategy for the long-term management of knee OA.

**4.6 Effect on Functional Outcomes, Range of Motion, and Muscle Strength**

**4.6.1 Effect on Functional Outcomes and Physical Performance:** Research indicates that strengthening exercises combined with PEMF therapy or therapeutic ultrasound substantially enhance the functional outcomes of patients suffering from knee osteoarthritis. These therapies alleviate pain and enhance joint functionality, enabling patients to do daily activities such as walking, ascending stairs, rising from a chair, and maintaining balance. Integrated rehabilitation programs have demonstrated enhancements in outcome measures, including the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Knee Injury and Osteoarthritis Outcome Score (KOOS), which are associated with improved functional results (Gibbs et al., 2023).

**4.6.2 Effect on Range of Motion (ROM):** Enhancing knee range of motion is a crucial goal in the treatment of knee osteoarthritis. Therapeutic ultrasound improves tissue elasticity and alleviates joint stiffness, whilst PEMF therapy mitigates pain and inflammation, enabling patients to engage in strengthening activities with more ease. The integrated rehabilitation strategy enhances knee flexion and extension, augments joint mobility, and improves the execution of functional tasks such as ambulation, squatting, and stair navigation, therefore fostering increased independence and functional recovery (Luo et al., 2024).

**4.6.3 Effect on Muscle Strength:** Resistance training is the principal method for enhancing the strength of the quadriceps, hamstrings, hip abductors, and gluteal muscles, which are crucial for preserving knee stability and alleviating mechanical load on the joint. When integrated with PEMF therapy or therapeutic ultrasound, pain diminishes, enabling patients to endure greater exercise intensity and advance more efficiently through rehabilitation programs. This integrated method results in enhanced muscle strength, dynamic knee stability, neuromuscular control, and total physical function compared to strengthening exercises in isolation (Wang et al., 2024).

**4.7 Safety, Limitations, and Clinical Implications**

- PEMF therapy, therapeutic ultrasonography, and strengthening exercises are often safe, non-invasive, and well-accepted interventions for knee osteoarthritis, with minimal documented adverse effects.
- Current evidence is constrained by restricted sample sizes, brief follow-up durations, and discrepancies in treatment regimens among research.
- The absence of established treatment parameters complicates the identification of the optimal dosage, frequency, and duration of therapeutic interventions.
- Integrating physical therapy modalities with strengthening exercises seems to enhance pain relief, muscle strength, physical function, and overall quality of life more successfully than isolated interventions.
- Future investigations should prioritize extensive, high-caliber clinical trials to create standardized rehabilitation regimens and assess long-term therapy outcomes.

**5. CONCLUSION**

The research indicated that the fundamental aspect of conservative management for knee osteoarthritis is strengthening exercises, whereas Pulsed Electromagnetic Field (PEMF) therapy or therapeutic ultrasound can enhance treatment efficacy. Both methods effectively alleviate pain, enhance joint function, expand range of motion, fortify periarticular muscles, and improve physical performance and quality of life. PEMF therapy has shown promise in

mitigating inflammation and enhancing cartilage health, whereas therapeutic ultrasound has shown useful in alleviating pain, improving tissue flexibility, and facilitating exercise performance. Although there is existing data supporting the combination of these physical therapy methods with strengthening exercises, the varying forms of therapy and study designs hinder straightforward comparisons among the interventions. Consequently, rehabilitation programs must be customized to align with the patient's clinical condition and rehabilitation requirements. Future large-scale, meticulously constructed randomized controlled trials with defined treatment parameters and extended follow-up are essential to establish evidence-based guidelines for optimizing conservative management of knee osteoarthritis.

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