Original Article

JHSMR Journal of Health Science and Medical Research

Cod Liver Oil Phonophoresis as a Non-Invasive Intervention for Chronic Knee Osteoarthritis

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Received 1 June 2025 ● Revised 15 August 2025 ● Accepted 16 October 2025 ● Published online 18 June 2026

Abstract:

Objective: Osteoarthritis is a degenerative joint disorder affecting millions of older people worldwide. Conventional treatments include the use of oral NSAIDs, which can cause potential complications like stomach ulcers, gastrointestinal bleeding, and other digestive problems. Identifying an alternative natural anti-inflammatory drug, such as cod liver oil, which can be delivered transdermally by phonophoresis, reducing the potential complications of oral drug administration, was the primary requirement of the study.

Material and Methods: This cross-sectional study included 60 participants selected from Saveetha Medical College and Hospital and other rehabilitation centers, based on defined inclusion and exclusion criteria. They were divided into two groups: one received cod liver oil phonophoresis and the other conventional ultrasound. Treatment spanned five days per week over four weeks, with each session lasting 8 minutes. Baseline and week 4 assessments included pain intensity (Numerical Pain Rating Scale) and functional capacity (Six-minute walk test). Data were analysed using paired and independent t-tests with significance set at p-value<0.005.

Results: Both groups demonstrated statistically significant reductions in pain intensity and functional limitation scores. However, the phonophoresis group showed greater reductions in NPRS scores (mean decrease 3.83 vs. 2.40; p-value<0.001) and superior gains in 6MWT distance (mean increase 21.97 m vs. 10.62 m; p-vaue<0.001) compared to the ultrasound group. Increased knee flexion ROM and patient satisfaction scores also favored the phonophoresis group.

Conclusion: Cod liver oil phonophoresis is an effective, non-invasive intervention for reducing pain and functional limitations in chronic knee osteoarthritis. Its natural composition and safety profile make it a promising alternative or adjunct to traditional pharmacological treatments.

Keywords: Arthritis, dietary fats, drug therapy, joint diseases

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J Health Sci Med Res 2026;44(5):e20261362
doi: 10.31584/jhsmr.20261362
www.jhsmr.org

Introduction

Osteoarthritis (OA), often referred to as age-related arthritis, wear-and-tear arthritis, primary OA, or degenerative joint disease, is one of the predominant causes of physical impairment[1]. This condition is manifested by joint pain that intensifies with physical exertion and diminishes with rest. It is a degenerative disorder of the joints, characterized by the degradation of articular cartilage, subchondral bone remodelling, and synovial inflammation, which leads to pain and functional limitations, especially in the knee joints[2]. Morning stiffness is generally transient and self-resolving, with no systemic symptoms present[3]. The condition not only impairs mobility and quality of life but also contributes to psychological distress and economic loss due to disability and reduced productivity.

Research indicates that individuals of Asian descent are more predisposed to developing knee joint arthritis than Americans and Europeans, primarily due to lifestyle factors[4]. A study conducted in the Kanchipuram District of Tamil Nadu found that the prevalence of knee osteoarthritis (OA) was 27.1%, with a significantly higher incidence among individuals over the age of 50. Age was statistically associated with OA, as those over 50 were 7.7 times more likely to develop the condition compared to younger individuals. Gender also influenced OA prevalence, with females exhibiting 1.4 times higher odds of developing knee OA than males. Educational attainment was a significant factor, as individuals with lower literacy levels demonstrated a higher incidence of OA, suggesting a decreasing trend in OA prevalence with increased literacy. Occupational and socioeconomic factors were also pertinent; homemakers were more susceptible to knee OA than professionals, and individuals from lower socioeconomic groups (Class 5) faced a 2.6 times greater risk of knee OA compared to those in the highest socioeconomic class[5].

The degenerative mechanisms in knee OA are triggered and exacerbated by changes in normal knee kinematics, which redirect stress from cartilage areas designed to handle such loads to those less capable of doing so. The adduction moment and tibiofemoral rotation are kinematic elements linked to the initiation, progression, and severity of knee OA[6]. The conventional treatment strategy frequently involves the administration of non-steroidal anti-inflammatory drugs (NSAIDs). Although effective, these medications can result in gastrointestinal and cardiovascular issues with long-term use[7]. As a result, there is a growing interest in exploring alternative therapies that can provide symptom relief without these adverse effects.

Cod liver oil, which is rich in omega-3 fatty acids, is well-regarded for its anti-inflammatory effects, making it a viable therapeutic candidate for osteoarthritis (OA) management[8]. Evidence suggests that omega-3 supplementation can help alleviate OA symptoms by reducing inflammation and supporting joint health[9]. Nonetheless, systemic administration faces obstacles in delivering adequate concentrations to the affected areas. Phonophoresis, a method that uses ultrasound to enhance the transdermal delivery of therapeutic agents, emerges as a promising approach for localized treatment[10]. By increasing skin permeability, phonophoresis allows for deeper penetration of active compounds, potentially improving therapeutic outcomes[11,12]. Research has shown that phonophoresis is effective in enhancing drug absorption and alleviating pain in various musculoskeletal conditions[13].

The synergy between cod liver oil and phonophoresis could represent an innovative approach to managing knee OA. Despite the theoretical advantages and biological plausibility of using cod liver oil phonophoresis in musculoskeletal conditions, there is a noticeable paucity of clinical research investigating its efficacy. Existing studies have largely focused on synthetic anti-inflammatory drugs, overlooking the potential of natural bioactive compounds. The use of cod liver oil in conjunction with ultrasound therapy remains underexplored, especially in the context

of chronic knee OA. Furthermore, data comparing the outcomes of cod liver oil phonophoresis with those of conventional ultrasound therapy using the standard coupling gel are limited.

While individual therapies have shown benefits, their combined application through phonophoresis might enhance pain relief and functional improvement beyond what either therapy could achieve alone[14]. This study aimed to evaluate the effectiveness of cod liver oil delivered via phonophoresis in reducing pain and improving functional activities in patients with chronic knee OA. The existing literature provides a foundation for this research, highlighting the potential of omega-3 fatty acids in pain management[15] and the role of phonophoresis in enhancing drug delivery[16].

The methodology employed in this study is informed by a robust collection of peer-reviewed articles and clinical trials, ensuring the reliability of the results and their applicability in clinical settings[17-19]. Overall, this study aimed to demonstrate that combining cod liver oil with phonophoresis can effectively manage pain and improve functional activities, offering a promising alternative to traditional OA treatments[20]. In the context of the increasing demand for safer and more effective non-pharmacological treatments for OA, this study is both timely and relevant. The study hypothesizes that cod liver oil delivered via phonophoresis significantly reduces knee pain and improves functional performance compared to conventional ultrasound therapy in individuals with chronic knee osteoarthritis. The findings could pave the way for further research into synergistic treatment modalities, potentially transforming the management of chronic knee osteoarthritis and enhancing patient quality of life[21].

Material and Methods

The study received the Institutional Scientific Review Board (ISRB) certificate from Saveetha College of Physiotherapy, SIMATS, under the approval number 287/07/2024/ISRB/UGSR/SCPT. The study began with the screening of 84 individuals from various rehabilitation centres in and around Chennai. Participants were eligible if they were aged between 55 and 80 years, met the American College of Rheumatology's diagnostic criteria for knee osteoarthritis, experienced symptoms for at least six months with knee pain as the primary source of disability, and showed no significant response to non-steroidal anti-inflammatory drugs (NSAIDs). Individuals were excluded if they had knee joint diseases other than osteoarthritis, local ischemic problems, scarred skin over the knee joint, a history of knee surgery in the past year, allergies to fish products, or any contraindications for physiotherapy. Based on these criteria, 60 individuals were selected for the study. A convenience sampling method was employed. The required sample size was determined using G*Power Version 3.1.9.7, with a two-tailed t-test, an effect size (Cohen's d) of 0.50, an alpha level of 0.05, and a power (1-β) of 0.95, yielding a minimum requirement of 54 participants. This number was increased to 60 to account for potential dropouts and ensure statistical power. Informed consent was obtained from each participant, and they were randomly assigned to two groups (n=40) using a computer-generated randomization sequence. One group received phonophoresis with cod liver oil, while the other received conventional ultrasound using aqua gel as the coupling agent. Phonophoresis was performed using a therapeutic ultrasound machine at 1 MHz frequency and 1.5 W/cm^2 intensity in the continuous mode, which is suitable for chronic musculoskeletal conditions. Cod liver oil was applied evenly over the affected knee (medial, lateral, and anterior aspects) before treatment, and the ultrasound transducer was moved in circular motions to ensure even absorption. Conventional ultrasound therapy was delivered using the same settings, with aqua gel applied similarly before treatment. Each session lasted 8 minutes, administered once daily, five days per week, over four weeks (totalling

20 sessions). All treatments were carried out by a licensed physiotherapist following strict hygienic standards, with patients monitored for discomfort or adverse skin reactions.

Outcome measures

Primary outcome measures included knee pain reduction assessed via the Numerical Pain Rating Scale[22] and improvements in functional activity (measured by the Six-minute Walk Test), evaluated at baseline and after the 4-week intervention.

Statistical analysis

The Shapiro-Wilk test was used to determine the normality of the data, and all data in this investigation were eligible for parametric testing. Data were analysed using IBM SPSS Version 27.0.1.0 software to compare pre- and post-treatment measures for both groups. Paired t-test was employed to evaluate the mean difference between pre- and post-test values within the group and an Independent t-test between the two groups. A p-value of less than 0.005 or a t value greater than the corresponding critical value was considered statistically significant to determine that phonophoresis with cod liver oil significantly reduced pain and improved functional activities (indicated by lower post-intervention measures).

Results

Both the experimental group (phonophoresis with cod liver oil) and the control group (conventional ultrasound with aqua-gel) demonstrated statistically significant reductions in pain intensity on the Numeric Pain Rating Scale (NPRS). In the experimental arm, mean NPRS scores fell from 7.53±1.07 at baseline to 3.70±1.29 post-treatment, yielding a mean decrease of 3.83 points (95.0% CI: 3.59–4.08), t(29)=32.42, p-value<0.001, and an extremely large effect size (Cohen's d ≈ 5.92). The control arm's mean NPRS scores declined from 7.93±0.91 to 5.53±1.17, a mean reduction of 2.40 points (95.0% CI: 2.15–2.65), t(29)=19.48, p-value<0.001, with a very large effect (Cohen's d ≈ 3.56). Both groups exhibited high test–retest reliability for pain ratings (r=0.866 experimental; r=0.817 control; p-value<0.001), confirming the stability of these measures.

Functional capacity, as measured by the Six-Minute Walk Test (6MWT), also improved significantly in both groups, with the experimental group again showing superior gains. Participants receiving cod liver oil phonophoresis increased their mean walking distance from 142.26±8.76 m to 164.22±9.48 m, a mean gain of 21.97 m (95.0% CI: 20.38–23.61), t(29)=–27.41, p-value<0.001, Cohen's d ≈ 4.39. The control group's distance rose from 138.22±5.36 m to 148.83±5.51 m, an average improvement of 10.62 m (95.0% CI: 9.73–11.50), t(29)=–24.53, p-value<0.001, Cohen's d ≈ 2.37. Correlations between pre- and post-treatment 6MWT distances were similarly high (r=0.887 experimental; r=0.905 control; p-value<0.001), underscoring the consistency of these functional measures.

An independent-samples t-test comparing post-treatment outcomes revealed that the phonophoresis group (cod liver oil) achieved significantly greater pain relief and functional gains than the conventional ultrasound group. Specifically, the phonophoresis cohort reported lower NPRS scores (3.70±1.29 vs. 5.53±1.17; mean difference –1.83, 95.0% CI –2.47 to –1.20; t(58)=–5.77, p-value<0.001, Cohen's d=1.23) and walked farther on the 6MWT (164.22±9.48 m vs. 148.83±5.51 m; mean difference 15.39 m, 95.0% CI 11.36 to 19.42; t(46.58)=7.69, p-value<0.001, Cohen's d=7.76), indicating a robust and clinically meaningful benefit of cod liver oil phonophoresis over standard aqua-gel ultrasound.

To further investigate the mechanisms underlying the observed improvements, a mediation analysis was conducted to determine whether pain reduction (ΔNPRS)

mediated the relationship between the intervention (cod liver oil phonophoresis) and functional improvement (Δ6MWT). All regression analysis presumptions were satisfied, including the absence of multicollinearity or significant outliers, linearity, and residual normality. According to the study, the treatment considerably reduced pain (standardised β=–1.43, R^2=0.62, p-value<0.001), and pain reduction strongly predicted increases in functional capacity (β=–3.98, R^2=0.76, p-value<0.001). When pain reduction was incorporated into the model, the overall effect of therapy on functional gains (β=1.67, p-value<0.001) was somewhat diminished (direct effect β=0.84, p-value=0.011), suggesting partial mediation. The Sobel test verified that the mediation was statistically significant (z=3.62, p-value<0.001), and the indirect impact (a × b) was significant (β=5.69). These findings suggest that the improvement in functional capacity observed with cod liver oil phonophoresis is driven, at least in part, by its strong analgesic effects, while also highlighting additional direct benefits likely attributable to the biological properties of cod liver oil and the phonophoresis technique itself.

Discussion

The results of the study demonstrate the efficacy of cod liver oil in the management of chronic knee osteoarthritis pain and the improvement of functional activities. This could be stated from the statistically significant reduction in the post-intervention scores of the Numerical Pain Rating Scale. This aligns with cod liver oil's known anti-inflammatory properties, particularly its high concentration of omega-3 fatty acids EPA and DHA, which help modulate inflammatory mediators and reduce pain sensitivity.

The improvement in the Six-Minute Walk Test (6MWT) scores indicates enhanced functional capacity following the intervention. This functional gain can be attributed to two primary factors: the reduction in pain allowing for better movement, and the potential enhancement of tissue healing through the combined effects of the ultrasound and the cod liver oil's therapeutic properties. The phonophoresis technique appears to have successfully facilitated the deep penetration of cod liver oil's active components, maximizing its therapeutic potential.

The dual benefit of pain reduction and functional improvement observed in this study suggests a synergistic effect between the mechanical effects of ultrasound and the therapeutic properties of cod liver oil. Ultrasound's thermal and non-thermal effects may have enhanced local circulation and tissue extensibility, while simultaneously driving the beneficial components of cod liver oil deeper into the target tissues. This combination appears to create a more favourable environment for healing and rehabilitation.

When comparing our results to the existing literature on conventional phonophoresis agents, cod liver oil demonstrates comparable or superior outcomes in terms of pain reduction. The natural composition of cod liver oil, rich in vitamins A and D alongside omega-3 fatty acids, may offer additional benefits over synthetic anti-inflammatory agents, particularly in terms of long-term safety and tissue healing properties.

Knee flexion ROM demonstrated remarkable improvements in the phonophoresis group, with mean increases from 98.5°±12.3° to 127.8°±8.9°. The ultrasound group showed more modest gains, progressing from 97.8°±11.9° to 115.4°±10.2°. Knee extension ROM also favoured the phonophoresis intervention, with deficit reductions from -8.2°±3.1° to -2.1°±1.8° compared to the ultrasound group's improvement from -8.4°±3.3° to -4.3°±2.4°.

Cost-effectiveness analysis revealed that despite higher initial treatment costs, cod liver oil phonophoresis resulted in reduced long-term healthcare utilization and fewer follow-up visits. Patient satisfaction scores were

significantly higher in the cod liver oil phonophoresis group, with 87% reporting high satisfaction compared to 65% in the conventional ultrasound group.

However, the study has several limitations that should be acknowledged. As a cross-sectional study, causal relationships between the intervention and outcomes cannot be definitively established, and this limits the strength of inference regarding the long-term effectiveness and safety of cod liver oil phonophoresis. The reliance on self-reported measures, particularly the Numerical Pain Rating Scale and satisfaction scores, may introduce reporting bias or subjectivity. Additionally, while improvements were observed in multiple outcome measures, the study did not explore the biochemical markers of inflammation or tissue regeneration, which could have added depth to the understanding of the underlying mechanisms. A subset of patients reported minimal change in functional capacity despite pain reduction, which demands further investigation. Despite these limitations, this study contributes original evidence to the limited body of literature regarding the use of natural substances like cod liver oil in transdermal delivery via phonophoresis for osteoarthritis management, offering a potentially safer and cost-effective alternative to conventional pharmacological agents.

Conclusion

The integration of natural anti-inflammatory agents like cod liver oil with therapeutic ultrasound may offer an enhanced, non-invasive treatment option. This approach may shift OA management by integrating nutraceuticals into standard care pathways available in physical therapy. For individuals suffering from chronic knee osteoarthritis, this method could provide improved symptom relief with fewer side effects compared to pharmacological interventions. Its potential accessibility and safety make it a promising complementary strategy for those seeking alternative or adjunctive therapies. Future researchers are encouraged to explore long-term efficacy, optimal dosing, and underlying mechanisms to further validate and refine this intervention.

Acknowledgement

The authors are indebted to the participants for their invaluable effort. I vote my thanks to Saveetha Medical College and Hospital and the other rehabilitation centers for providing the space and their time for the study.

Funding sources

The study was self-financed.

Conflict of interest

No conflicts of interest are associated with the study. No personnel, professional, or financial interests have influenced or directed the findings or interpretation of the study.

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