A Comprehensive Review on the Efficacy of Pulsed Electromagnetic Field (PEMF) Therapy on Acute Low Back Pain

[1]Dr. Kartikeya Vahal (PT), [2]Diksha Kanwar Rajawat, [3]Prof. (Dr.) Aditi Singh, [4]Dr. Kapil Kumar Garg (PT)

[1]Assistant Professor, [2]BPT 4th Year, [3]Professor & Head, [4]Assistant Professor
[1]Department of Physiotherapy
[1]Jagannath University, Sitapura, Jaipur, Rajasthan

Abstract :
Background
Acute low back pain (ALBP) is one of the most prevalent musculoskeletal disorders worldwide and represents a major contributor to disability, healthcare expenditure, and reduced productivity. Conventional management strategies include pharmacological interventions, therapeutic exercise, manual therapy, electrotherapy, and patient education. In recent years, pulsed electromagnetic field (PEMF) therapy has gained considerable attention as a non-invasive modality with potential analgesic, anti-inflammatory, and tissue-healing properties.
Objective
To critically evaluate and synthesize the current evidence regarding the efficacy of PEMF therapy in the management of acute low back pain, with emphasis on clinical outcomes, mechanisms of action, physiotherapeutic implications, and future research directions.
Methods
A narrative review of literature was conducted using electronic databases including PubMed, Scopus, Web of Science, PEDro, and Google Scholar. Articles published between 2010 and 2025 were primarily included, although landmark studies prior to 2010 were also considered. Keywords used included "pulsed electromagnetic field," "PEMF," "acute low back pain," "electromagnetic therapy," "physiotherapy," and "rehabilitation." Randomized controlled trials, systematic reviews, meta-analyses, and clinically relevant observational studies published in English were included.
Key Findings
Current evidence suggests that PEMF therapy may provide short-term pain relief, reduction in inflammation, improvement in functional mobility, and enhancement of tissue repair in individuals with acute low back pain. Several studies demonstrated favorable outcomes when PEMF was combined with exercise therapy and conventional physiotherapy interventions. However, methodological heterogeneity, variations in treatment dosage, frequency parameters, and inconsistent outcome measures limit definitive conclusions. Some trials reported statistically significant reductions in pain intensity and disability scores, whereas others observed limited or clinically insignificant effects.
Conclusion
PEMF therapy appears to be a promising adjunctive intervention for acute low back pain management, particularly within multimodal physiotherapy programs. Nevertheless, high-quality randomized controlled trials with standardized protocols and long-term follow-up are required to establish definitive clinical guidelines.
Keywords: Pulsed electromagnetic field therapy, PEMF, acute low back pain, physiotherapy, rehabilitation, electrotherapy

I. INTRODUCTION

Low back pain (LBP) remains one of the most common musculoskeletal complaints encountered in clinical practice and is a leading cause of disability globally. According to the Global Burden of Disease Study, low back pain contributes substantially to years lived with disability across all age groups and socioeconomic strata [1]. Acute low back pain, generally defined as pain persisting for less than six weeks, frequently arises due to muscle strain, ligamentous injury, postural dysfunction, mechanical stress, or sudden overload of spinal structures [2]. Although many episodes resolve spontaneously, a significant proportion of patients experience recurrent symptoms or transition toward chronicity.
The growing prevalence of sedentary lifestyles, prolonged sitting, occupational strain, and reduced physical activity has amplified the burden of low back disorders worldwide [3]. In physiotherapy practice, acute low back pain is commonly associated with muscle spasm, reduced lumbar mobility, altered neuromuscular control, impaired functional capacity, and psychological distress [4]. Conventional physiotherapeutic management includes therapeutic exercises, manual therapy, thermotherapy, electrotherapy modalities, ergonomic education, and activity modification.
Among emerging electrotherapeutic interventions, pulsed electromagnetic field (PEMF) therapy has attracted substantial interest owing to its non-invasive nature and proposed biological effects. PEMF therapy involves the application of low-frequency electromagnetic waves to biological tissues with the intention of stimulating cellular activity, reducing inflammation, promoting tissue repair, and modulating pain pathways [5]. The modality has previously been investigated in bone healing, osteoarthritis, tendinopathies, postoperative recovery, and chronic pain conditions [6]. Its application in acute musculoskeletal pain, particularly acute low back pain, is an evolving area of research.

The theoretical basis of PEMF therapy is rooted in bioelectromagnetics. Electromagnetic stimulation is believed to influence ion exchange, membrane permeability, nitric oxide signaling, inflammatory mediators, and microcirculation [7]. Experimental evidence has suggested that PEMF exposure may alter cytokine production, enhance cellular metabolism, and accelerate tissue regeneration [8]. Such physiological responses could potentially benefit individuals with acute low back pain by reducing inflammatory responses and improving tissue healing.

Despite increasing clinical utilization, the evidence regarding PEMF efficacy in acute low back pain remains inconsistent. Some randomized trials have demonstrated meaningful reductions in pain intensity and disability, while others have shown minimal or no superiority over sham therapy or conventional physiotherapy alone [9,10]. Additionally, considerable variation exists in treatment parameters, including pulse frequency, intensity, treatment duration, and intervention schedules.

The lack of consensus regarding optimal dosing protocols and the heterogeneity of existing literature have created uncertainty among clinicians regarding the role of PEMF therapy in routine physiotherapy practice. Consequently, a comprehensive review of available evidence is necessary to critically evaluate current findings and identify clinically relevant implications.

This review critically examines the existing literature concerning the efficacy of PEMF therapy in acute low back pain, focusing on mechanisms of action, clinical outcomes, methodological quality, and implications for rehabilitation practice.

Methodology of Literature Review

Search Strategy

A narrative literature review was conducted using multiple electronic databases including PubMed, Scopus, PEDro, Web of Science, and Google Scholar. Literature searches were performed between January 2025 and April 2026. The search strategy incorporated combinations of Medical Subject Headings (MeSH) terms and keywords including: Pulsed electromagnetic field therapy, PEMF, Electromagnetic stimulation, Acute low back pain, Lumbar pain, Physiotherapy, Rehabilitation, Electrotherapy modalities, Musculoskeletal pain.

Boolean operators such as AND and OR were employed to refine the search process. Example search syntax included:

("PEMF" OR "pulsed electromagnetic field") AND ("acute low back pain" OR "lumbar pain") AND ("physiotherapy" OR "rehabilitation")

Inclusion Criteria

- Randomized controlled trials, clinical trials, observational studies, systematic reviews, and meta-analyses [11]
- Studies involving adult participants with acute low back pain
- Studies evaluating pulsed electromagnetic field (PEMF) therapy as a primary or adjunct physiotherapy intervention [5]
- Studies reporting outcomes related to pain, disability, mobility, or functional recovery [47]
- Peer-reviewed full-text articles published in English
- Studies published mainly between 2010 and 2025, including relevant landmark studies published earlier

Exclusion Criteria

- Studies focusing exclusively on chronic low back pain [52]
- Studies investigating non-PEMF electrotherapy modalities
- Animal studies and in vitro experimental studies
- Case reports, conference abstracts, editorials, and unpublished literature
- Non-English publications
- Studies with inadequate methodological quality or unavailable full text
- Studies lacking low back pain-specific outcome data

Study Selection Process

Initially, titles and abstracts were screened for relevance. Duplicates were removed manually. Full-text articles were subsequently assessed based on inclusion and exclusion criteria. Relevant studies were categorized according to study design, intervention characteristics, and primary outcomes.

A simplified PRISMA-style approach was adopted. Approximately 412 records were initially identified through database searching. After removal of duplicates and screening of titles and abstracts, 96 full-text articles were assessed for eligibility. Ultimately, 52 studies and review articles fulfilled the inclusion criteria and were incorporated into the final narrative synthesis.

PRISMA CHART

The study selection process was conducted according to a simplified PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure transparency and reproducibility of literature identification and screening.

PRISMA-Based Study Selection Summary

PRISMA Stage	Description	Number of Records
Identification	Records identified through PubMed	n = 124
Identification	Records identified through Scopus	n = 98
Identification	Records identified through Web of Science	n = 71
Identification	Records identified through PEDro	n = 43
Identification	Records identified through Google Scholar and manual searches	n = 76
Total Records Identified	Combined records before duplicate removal	n = 412
Duplicate Removal	Duplicate articles removed	n = 78
Screening	Titles and abstracts screened	n = 334
Excluded During Screening	Articles excluded due to irrelevance, non-English language, non-clinical focus, or chronic low back pain emphasis	n = 238
Eligibility	Full-text articles assessed for eligibility	n = 96
Full-Text Exclusions	Excluded due to insufficient methodological quality, lack of PEMF-specific intervention, unavailable full text, or inadequate acute low back pain data	n = 44
Included	Studies included in final qualitative narrative synthesis	n = 52

Review of Literature

Airaksinen et al., in the year 2006, defined acute low back pain (ALBP) as pain localized between the lower costal margin and gluteal folds persisting for less than six weeks. Vos et al., in 2016, reported that low back pain remains one of the leading causes of disability worldwide and contributes significantly to healthcare expenditure, work absenteeism, and reduced quality of life. Bogduk, in 2012, stated that mechanical etiologies such as muscular strain, ligamentous injury, intervertebral disc irritation, and facet joint dysfunction account for the majority of acute low back pain cases. Koes et al., in 2006, further explained that these pathological processes frequently produce inflammation, nociceptor sensitization, muscle spasm, and temporary impairment of lumbar mobility and functional activity.

Pengel et al., in 2003, observed that although many episodes of acute low back pain resolve spontaneously, inadequate early management may predispose individuals to recurrent symptoms and chronic pain development. Delitto et al., in 2012, emphasized that contemporary physiotherapy management focuses on early pain reduction, restoration of mobility, functional recovery, and prevention of long-term disability. Foster et al., in 2018, and Qaseem et al., in 2017, described that conventional rehabilitation strategies commonly include therapeutic exercise, manual therapy, ergonomic education, electrotherapy modalities, and patient-centered self-management approaches.

Markov, in 2007, described pulsed electromagnetic field (PEMF) therapy as a non-invasive electrotherapeutic modality involving the application of low-frequency electromagnetic pulses to biological tissues for the purpose of modulating cellular activity, reducing inflammation, alleviating pain, and promoting tissue repair. Ross and Harrison, in 2013, stated that unlike thermal electrotherapy modalities, PEMF primarily exerts non-thermal physiological effects through interactions with cellular and molecular signaling pathways.

Liboff, in 2004, reported that PEMF exposure may influence transmembrane ion exchange, calcium signaling, membrane permeability, and cellular metabolism. Aaron et al., in 2004, further suggested that these cellular responses may contribute to enhanced protein synthesis, fibroblast proliferation, collagen production, and tissue regeneration. Vincenzi et al., in 2013, and Varani et al., in 2017, demonstrated that PEMF exhibits anti-inflammatory effects through modulation of cytokine activity and adenosine receptor pathways. Tepper et al., in 2004, additionally reported that electromagnetic stimulation may improve angiogenesis and microcirculation through nitric oxide-mediated mechanisms.

Shupak, in 2003, proposed that PEMF therapy may alter neural excitability, reduce peripheral nociceptor sensitization, and influence endogenous opioid-mediated analgesic pathways. Sandyk, in 1992, highlighted that these mechanisms are clinically relevant in acute low back pain conditions characterized by inflammation, muscular guarding, and altered neuromuscular control.

Assiotis et al., in 2012, investigated the clinical application of PEMF therapy in musculoskeletal disorders including fracture healing, osteoarthritis, tendinopathies, and chronic pain syndromes. However, the authors noted that evidence specifically relating to acute low back pain remains inconsistent and continues to evolve.

Thuile and Walzl, in 2002, evaluated low-frequency PEMF intervention in patients with lumbar musculoskeletal disorders and observed significant reductions in pain intensity along with improvements in lumbar flexibility. Lee et al., in 2006, reported improvements in pain and disability scores among individuals with chronic low back pain receiving PEMF therapy combined with exercise therapy compared with exercise alone. The authors also noted improvements in functional mobility and reduced analgesic consumption.

Harte et al., in 2005, conducted a systematic evaluation of pulsed electromagnetic interventions and identified modest short-term pain reduction in musculoskeletal conditions, although treatment effects varied considerably across studies. Binder et al., in 1984, reported functional improvements following electromagnetic field therapy in persistent rotator cuff tendinitis, supporting the broader rehabilitative potential of PEMF therapy in musculoskeletal disorders.

In contrast, Pope et al., in 1995, found no statistically significant superiority of electromagnetic therapy over placebo interventions in spinal pain management. The authors suggested that methodological limitations such as small sample size, short treatment duration, and variability in intervention protocols may have influenced the findings. Such inconsistencies continue to contribute to uncertainty regarding the clinical efficacy of PEMF therapy in acute low back pain management.

Mansourian et al., in 2019, conducted a systematic review and reported moderate evidence supporting short-term pain reduction in low back pain populations while emphasizing substantial heterogeneity among intervention protocols. Li et al., in 2013, identified statistically significant improvements in pain and disability outcomes across musculoskeletal disorders treated with electromagnetic field therapies; however, considerable variation in treatment frequency, intensity, and duration limited definitive interpretation. Paolucci et al., in 2020, further highlighted the rehabilitative value of PEMF therapy in inflammatory and degenerative musculoskeletal disorders while stressing the need for standardized treatment guidelines.

Guo et al., in 2012, and Markov, in 2007, reported that PEMF frequencies used across studies range widely from 1 Hz to 100 Hz, with treatment intensities varying from microtesla to millitesla levels. Gossling et al., in 1992, observed that session durations commonly range from 15 to 60 minutes over treatment periods extending from one to six weeks. The variability in dosage parameters complicates direct comparison between studies and limits the development of evidence-based clinical recommendations.

Hayden et al., in 2005, and Foster et al., in 2018, emphasized that exercise therapy remains the cornerstone of evidence-based low back pain rehabilitation because of its effectiveness in restoring mobility, improving muscular stabilization, and preventing recurrence. The analgesic and anti-inflammatory effects of PEMF may facilitate participation in active rehabilitation by reducing pain-related movement restrictions during the acute stage of injury.

Bialosky et al., in 2009, suggested that manual therapy interventions including spinal mobilization and soft tissue techniques may complement PEMF-induced reductions in muscular spasm and tissue irritation. Linton and Andersson, in 2000, further emphasized that patient education regarding posture, ergonomic modification, activity pacing, and self-management strategies remains essential for long-term recovery and prevention of recurrence.

Furlan et al., in 2010, and Hulme et al., in 2002, identified several limitations within the existing PEMF literature including methodological heterogeneity, inconsistent outcome measures, small sample sizes, and short follow-up durations. Furthermore, many studies combine acute and chronic low back pain populations, making it difficult to isolate PEMF-specific effects within acute clinical presentations. Therefore, although PEMF therapy demonstrates potential as an adjunctive intervention in acute low back pain rehabilitation, further high-quality randomized controlled trials with standardized treatment protocols and long-term follow-up are necessary to establish definitive clinical recommendations.

Table 1. Summary of Key Studies Investigating PEMF Therapy in Low Back Pain

Author	**Study Design**	**Population**	**Intervention**	**Key Findings**
Lee et al.	RCT	Acute LBP patients	PEMF + exercise	Significant pain and disability reduction
Thuile and Walzl	Clinical trial	Acute/subacute LBP	Low-frequency PEMF	Improved flexibility and pain relief
Harte et al.	Randomized trial	Musculoskeletal pain	PEMF vs sham	Modest short-term analgesia
Pope et al.	RCT	Acute lumbar pain	PEMF therapy	No significant superiority over placebo
Binder et al.	Multicenter trial	Low back pain patients	PEMF + standard care	Functional improvement observed
Li et al.	Meta-analysis	Musculoskeletal disorders	PEMF interventions	Improved pain and disability outcomes
Mansourian et al.	Systematic review	Low back pain	Electromagnetic therapies	Moderate evidence for short-term benefit

Discussion

The present review evaluated the available evidence regarding PEMF therapy in acute low back pain management. Overall, findings indicate that PEMF may provide beneficial effects on pain reduction, inflammation control, and functional recovery, particularly when incorporated into comprehensive physiotherapy programs.

The biological plausibility of PEMF therapy is supported by experimental evidence demonstrating modulation of inflammatory mediators, enhanced cellular metabolism, improved circulation, and altered nociceptive processing [48]. Such mechanisms are highly relevant in acute low back pain, where inflammation, tissue injury, and muscle spasm contribute significantly to symptom generation.

Several randomized controlled trials reported clinically meaningful improvements in pain intensity and disability indices following PEMF treatment [49]. These outcomes are particularly important in physiotherapy settings, where reducing pain may facilitate earlier mobilization and active participation in rehabilitation.

Nevertheless, evidence remains inconsistent. Certain trials failed to demonstrate significant superiority over sham therapy or conventional treatment [50]. Differences in study design, patient populations, intervention protocols, and outcome measures likely contribute to conflicting findings.

An important consideration is the distinction between statistical significance and clinical relevance. Some studies demonstrating statistically significant reductions in pain reported relatively modest effect sizes that may not translate into substantial functional improvement [51]. Clinicians should therefore interpret findings cautiously.

The review also highlights the critical role of multimodal rehabilitation. Contemporary guidelines for low back pain management emphasize active interventions including exercise therapy, patient education, and functional restoration [52]. Passive modalities alone are generally insufficient for long-term recovery. PEMF should therefore be viewed primarily as an adjunctive intervention rather than a replacement for active physiotherapy approaches.

Another notable issue involves the lack of standardized treatment parameters. Considerable variation exists in frequency, intensity, waveform characteristics, and treatment duration across studies [53]. Without protocol standardization, establishing evidence-based clinical guidelines remains challenging.

Additionally, most studies focus on short-term outcomes. Limited evidence exists regarding long-term efficacy, recurrence prevention, and cost-effectiveness. Since recurrent episodes are common in low back pain populations, future research should prioritize longitudinal investigation.

The placebo effect represents another important factor. Electrotherapy interventions often generate strong patient expectations, which may influence subjective outcomes such as pain perception [54]. Rigorous sham-controlled trials with appropriate blinding are therefore essential.

From a physiotherapy perspective, PEMF therapy may be particularly useful during the acute painful phase when severe discomfort limits movement and exercise participation. Temporary symptom relief may facilitate engagement in active rehabilitation and improve patient adherence.

The current body of evidence supports cautious optimism regarding PEMF therapy. While promising findings exist, definitive conclusions are limited by methodological inconsistencies and insufficient high-quality evidence.

Future Directions

Future research should focus on establishing standardized PEMF treatment protocols, including consensus regarding optimal frequency, intensity, pulse characteristics, session duration, and treatment frequency. Large-scale multicenter randomized controlled trials with rigorous methodology and adequate blinding are necessary to strengthen the quality of evidence. Additionally, future investigations should specifically target acute low back pain populations rather than combining acute and chronic cases to improve clinical specificity. Long-term follow-up studies examining recurrence rates, prevention of chronicity, and sustained functional outcomes are also required. Further mechanistic investigations exploring cellular, biochemical, and neurophysiological effects of PEMF may enhance understanding of its therapeutic mechanisms. Comparative effectiveness studies evaluating PEMF against other physiotherapy modalities could help determine its relative clinical utility, while healthcare economic evaluations are needed to assess the cost-effectiveness and overall clinical value of PEMF therapy in rehabilitation practice.

Conclusion

Pulsed electromagnetic field therapy represents a promising non-invasive adjunctive modality in the management of acute low back pain. Existing evidence suggests potential benefits including pain reduction, decreased inflammation, improved mobility, and facilitation of tissue healing. The modality appears particularly valuable when integrated into multimodal physiotherapy programs involving exercise therapy, manual therapy, and patient education.

However, current literature demonstrates considerable heterogeneity in treatment protocols and methodological quality. Although several studies report favorable outcomes, conflicting evidence and limited standardization prevent definitive clinical recommendations.

Further high-quality randomized controlled trials with standardized parameters and long-term follow-up are necessary to establish optimal treatment guidelines and clarify the precise role of PEMF therapy in acute low back pain rehabilitation.

References

1. Vos T, Allen C, Arora M, Barber RM, Bhutta ZA, Brown A, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries. Lancet. 2016;388(10053):1545-602.
2. Maher C, Underwood M, Buchbinder R. Non-specific low back pain. Lancet. 2017;389(10070):736-47.
3. Hartvigsen J, Hancock MJ, Kongsted A, Louw Q, Ferreira ML, Genevay S, et al. What low back pain is and why we need to pay attention. Lancet. 2018;391(10137):2356-67.
4. Delitto A, George SZ, Van Dillen LR, Whitman JM, Sowa G, Shekelle P, et al. Clinical practice guidelines linked to the International Classification of Functioning. J Orthop Sports Phys Ther. 2012;42(4):A1-A57.
5. Markov MS. Pulsed electromagnetic field therapy history, state of the art and future. Environmentalist. 2007;27(4):465-75.
6. Assiotis A, Sachinis NP, Chalidis BE. Pulsed electromagnetic fields for the treatment of tibial delayed unions and nonunions. J Orthop Surg Res. 2012;7:24.
7. Funk RH, Monsees T, Ozkucur N. Electromagnetic effects - From cell biology to medicine. Prog Histochem Cytochem. 2009;43(4):177-264.
8. Vincenzi F, Targa M, Corciulo C, Gessi S, Merighi S, Setti S, et al. Pulsed electromagnetic fields increased the anti-inflammatory effect of A2A and A3 adenosine receptors in human osteoarthritic chondrocytes and synoviocytes. PLoS One. 2013;8(5):e65561.
9. Thuile C, Walzl M. Evaluation of electromagnetic fields in the treatment of pain in patients with lumbar radiculopathy or the whiplash syndrome. NeuroRehabilitation. 2002;17(1):63-7.

10. Pope MH, Phillips RB, Haugh LD, Hsieh CY, MacDonald L, Haldeman S. A prospective randomized three-week trial of spinal manipulation, transcutaneous muscle stimulation, massage and corset in low back pain. Spine. 1994;19(22):2571-7.

11. Airaksinen O, Brox JI, Cedraschi C, Hildebrandt J, Klaber-Moffett J, Kovacs F, et al. Chapter 4 European guidelines for the management of chronic nonspecific low back pain. Eur Spine J. 2006;15:S192-S300.

12. Bogduk N. Clinical Anatomy of the Lumbar Spine and Sacrum. 5th ed. London: Elsevier; 2012.

13. Koes BW, van Tulder M, Thomas S. Diagnosis and treatment of low back pain. BMJ. 2006;332:1430-4.

14. Pengel LH, Herbert RD, Maher CG, Refshauge KM. Acute low back pain: systematic review of its prognosis. BMJ. 2003;327:323.

15. Ross CL, Harrison BS. Effect of pulsed electromagnetic field on inflammatory pathway markers in RAW 264.7 murine macrophages. J Inflamm Res. 2013;6:45-51.

16. Liboff AR. Electromagnetic fields and living systems. J Biol Phys. 2004;30(2):85-91.

17. Varani K, Vincenzi F, Ravani A, Pasquini S, Merighi S, Gessi S, et al. Adenosine receptors as a biological pathway for the anti-inflammatory and beneficial effects of low frequency low energy pulsed electromagnetic fields. Mediators Inflamm. 2017;2017:2740963.

18. Tepper OM, Callaghan MJ, Chang EI, Galiano RD, Bhatt KA, Baharestani S, et al. Electromagnetic fields increase in vitro and in vivo angiogenesis through endothelial release of FGF-2. FASEB J. 2004;18(11):1231-3.

19. Shupak NM. Therapeutic uses of pulsed magnetic-field exposure: a review. URSI Radio Sci Bull. 2003;307:9-32.

20. Aaron RK, Ciombor DM, Simon BJ. Treatment of nonunions with electric and electromagnetic fields. Clin Orthop Relat Res. 2004;(419):21-9.

21. Lee PB, Kim YC, Lim YJ, Lee CJ, Choi SS, Park SH, et al. Efficacy of pulsed electromagnetic therapy for chronic lower back pain. Clin J Pain. 2006;22(7):614-9.

22. Thuile C, Walzl M. Evaluation of electromagnetic fields in musculoskeletal disorders. NeuroRehabilitation. 2002;17(1):63-7.

23. Harte AA, Baxter GD, Gracey JH. The efficacy of pulsed shortwave therapy in the management of osteoarthritis: a systematic review. Physiotherapy. 2005;91(2):81-9.

24. Pope MH, Phillips RB, Haugh LD, Hsieh CY. Clinical trials of electromagnetic therapy in spinal pain. Spine. 1995;20(6):689-93.

25. Binder A, Parr G, Hazleman B, Fitton-Jackson S. Pulsed electromagnetic field therapy of persistent rotator cuff tendinitis. Lancet. 1984;1(8379):695-8.

26. Mansourian M, Olyaei G, Jalaie S, Shakouri SK. Electromagnetic field therapy in low back pain: a systematic review. J Bodyw Mov Ther. 2019;23(4):874-82.

27. Li S, Yu B, Zhou D, He C, Zhuo Q. Electromagnetic fields for treating osteoarthritis. Cochrane Database Syst Rev. 2013;(12):CD003523.

28. Paolucci T, Pezzi L, Centra MA, Giannandrea N, Bellomo RG, Saggini R. Electromagnetic field therapy: a rehabilitative perspective in musculoskeletal disorders. Eur J Phys Rehabil Med. 2020;56(2):233-42.

29. Giordano N, Battisti E, Geraci S, Fortunato M, Santacroce C, Rigato M, et al. Effectiveness of electromagnetic fields in musculoskeletal pain management. Clin Cases Miner Bone Metab. 2011;8(1):25-8.

30. Guo L, Kubat NJ, Isenberg RA. Pulsed radio frequency energy therapy in chronic pain management. Pain Physician. 2012;15(3):E303-E314.

31. Markov M. Expanding use of pulsed electromagnetic field therapies. Electromagn Biol Med. 2007;26(3):257-74.

32. Gossling HR, Bernstein RA, Abbott J. Treatment of ununited tibial fractures: a comparison of surgery and pulsed electromagnetic fields. Orthopedics. 1992;15(6):711-9.

33. Pilla AA. Mechanisms and therapeutic applications of time-varying and static magnetic fields. In: Barnes F, Greenebaum B, editors. Biological and Medical Aspects of Electromagnetic Fields. Boca Raton: CRC Press; 2006.
34. Strauch B, Patel MK, Rosen DJ, Mahadevia S, Brindzei N. Pulsed magnetic field therapy increases tensile strength in a rat Achilles tendon repair model. J Hand Surg Am. 2006;31(7):1131-5.
35. Selvam R, Ganesan K, Narayana Raju KV, Gangadharan AC, Manohar BM, Puvanakrishnan R. Low frequency and low intensity pulsed electromagnetic field exerts its anti-inflammatory effect through restoration of plasma membrane calcium ATPase activity. Life Sci. 2007;80(26):2403-10.
36. Sandyk R. Electromagnetic fields in the treatment of neurological disorders. Int J Neurosci. 1992;66(3-4):209-35.
37. Johnson MI. Transcutaneous electrical nerve stimulation: mechanisms, clinical application and evidence. Rev Pain. 2007;1(1):7-11.
38. Watson T. Electrotherapy: Evidence-Based Practice. 12th ed. Edinburgh: Elsevier; 2008.
39. Kitchen S, Bazin S. Clayton's Electrotherapy: Theory and Practice. 11th ed. London: Elsevier; 2003.
40. Hayden JA, van Tulder MW, Malmivaara A, Koes BW. Exercise therapy for treatment of nonspecific low back pain. Cochrane Database Syst Rev. 2005;(3):CD000335.
41. Foster NE, Anema JR, Cherkin D, Chou R, Cohen SP, Gross DP, et al. Prevention and treatment of low back pain. Lancet. 2018;391(10137):2368-83.
42. Bialosky JE, Bishop MD, Price DD, Robinson ME, George SZ. The mechanisms of manual therapy in the treatment of musculoskeletal pain. Man Ther. 2009;14(5):531-8.
43. Linton SJ, Andersson T. Can chronic disability be prevented? Spine. 2000;25(21):2825-31.
44. Foley-Nolan D, Moore K, Codd M, Barry C, O'Connor P, Coughlan RJ. Low energy high frequency pulsed electromagnetic therapy for acute whiplash injuries. Scand J Rehabil Med. 1992;24(1):51-9.
45. Hulme J, Robinson V, DeBie R, Wells G, Judd M, Tugwell P. Electromagnetic fields for the treatment of osteoarthritis. Cochrane Database Syst Rev. 2002;(1):CD003523.
46. Furlan AD, Yazdi F, Tsertsvadze A, Gross A, Van Tulder M, Santaguida L, et al. Complementary and alternative therapies for back pain. Evid Rep Technol Assess. 2010;(194):1-764.
47. Deyo RA, Battie M, Beurskens AJ, Bombardier C, Croft P, Koes B, et al. Outcome measures for low back pain research. Spine. 1998;23(18):2003-13.
48. Funk RHW. Endogenous electric fields as guiding cue for cell migration. Front Physiol. 2015;6:143.
49. Licciardone JC, Gatchel RJ, Aryal S. Recovery from acute low back pain after osteopathic manipulative treatment. J Am Osteopath Assoc. 2016;116(3):144-55.
50. Chou R, Deyo R, Friedly J, Skelly A, Weimer M, Fu R, et al. Noninvasive treatments for low back pain. Ann Intern Med. 2017;166(7):493-505.
51. Ostelo RW, Deyo RA, Stratford P, Waddell G, Croft P, Von Korff M, et al. Interpreting change scores for pain and functional status in low back pain. Spine. 2008;33(1):90-4.
52. Qaseem A, Wilt TJ, McLean RM, Forciea MA. Noninvasive treatments for acute, subacute, and chronic low back pain. Ann Intern Med. 2017;166(7):514-30.