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Transcutaneous Electrical Nerve Stimulation for Pain and Function in Knee Osteoarthritis: A Narrative Review

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Abstract

Background: Knee osteoarthritis (OA) is a common degenerative joint condition associated with chronic pain and functional limitations, particularly among adults and older populations. Transcutaneous Electrical Nerve Stimulation (TENS) is widely used in physiotherapy as a non-pharmacological intervention, yet its clinical effectiveness in mild to moderate knee OA remains inconsistent.
Objective: This narrative review aimed to summarize and critically discuss recent clinical evidence on the effects of TENS on pain and physical function in individuals with mild to moderate knee osteoarthritis.
Methods: A narrative literature review was conducted using targeted searches of PubMed and ScienceDirect. Clinical studies published between 2020 and 2025 that investigated TENS interventions and reported pain and/or physical function outcomes were included. Evidence was synthesized descriptively without systematic selection or quantitative pooling.
Results: Recent randomized controlled trials suggest that TENS may provide short-term pain relief and support functional performance in knee osteoarthritis. Treatment effects varied according to individual characteristics, stimulation parameters, and rehabilitation context, with more consistent functional benefits observed when TENS was combined with exercise.
Conclusion: TENS appears to be a safe adjunctive modality for pain management and functional support in mild to moderate knee osteoarthritis. However, heterogeneity across studies limits definitive conclusions, and further research is needed to optimize clinical application.

Keywords
Knee Osteoarthritis; Transcutaneous Electrical Nerve Stimulation; Pain; Physical Function

Introduction

Knee osteoarthritis (OA) is the most prevalent degenerative joint disorder affecting adults and older populations worldwide and represents a major cause of chronic pain, functional limitation, and reduced quality of life. The global burden of knee OA continues to increase in parallel with population ageing, rising obesity rates, and prolonged life expectancy. Recent epidemiological data indicate a substantial prevalence of knee OA across diverse populations, including in Asian countries, where demographic transitions and occupational demands further exacerbate disease impact. In Indonesia, community-based data have reported a notable prevalence of knee OA in urban settings, with higher rates observed among older adults and women, underscoring the growing public health relevance of this condition.[1]

Pathophysiologically, knee OA is characterized by progressive degeneration of articular cartilage, alterations in subchondral bone structure, osteophyte formation, and low-grade synovial inflammation. These structural changes contribute to persistent pain, joint stiffness, muscle weakness, and impaired sensorimotor control, collectively leading to functional decline and limitations in daily activities.[2] As the disease progresses, individuals often experience reduced mobility, diminished participation in occupational and social roles, and an increased risk of disability. From a socioeconomic perspective, knee OA is associated with substantial healthcare costs, productivity loss, and increased demand for surgical interventions such as total knee arthroplasty in advanced stages.[3]

Conservative management remains the cornerstone of treatment for mild to moderate knee OA, with the primary goals of pain reduction, functional preservation, and delay of disease progression. International clinical guidelines emphasize the importance of non-pharmacological interventions, particularly exercise-based rehabilitation, weight management, and patient education, as first-line strategies.[4] Pharmacological treatments, including non-steroidal anti-inflammatory drugs and opioids, may provide short-term symptom relief but are associated with well-documented adverse effects, especially among older adults and individuals with comorbidities. Consequently, there is growing interest in safe, non-invasive modalities that can complement exercise therapy and reduce reliance on long-term medication use.[5]

Transcutaneous Electrical Nerve Stimulation (TENS) is a non-invasive electrotherapy modality widely used in physiotherapy practice for the management of musculoskeletal pain. TENS delivers low-voltage electrical currents through surface electrodes applied to the skin, aiming to modulate nociceptive input and alter pain perception. The proposed mechanisms of action include inhibition of pain transmission at the spinal level, activation of descending inhibitory pathways, and stimulation of endogenous opioid release within the central nervous system.[6,7] Through these peripheral and central mechanisms, TENS has been applied in a variety of chronic pain conditions, including knee OA.

Clinical evidence regarding the effectiveness of TENS in knee OA, however, remains mixed. Several studies and systematic reviews have reported beneficial effects of TENS on pain intensity, whereas others have demonstrated modest or variable outcomes.[8] Differences in stimulation parameters, treatment duration, comparator interventions, and outcome measures have contributed to heterogeneity across studies, limiting clear clinical guidance. Moreover, emerging evidence suggests that individual biological factors may influence responsiveness to TENS. For example, genetic polymorphisms related to pain modulation, such as variations in the

catechol-O-methyltransferase (COMT) gene, have been shown to affect analgesic responses to TENS, indicating that treatment effects may be partially patient specific.[9]

Beyond pain relief, the potential role of TENS in improving physical function has gained increasing attention. Functional impairments in knee OA are multifactorial and not solely dependent on pain severity. Deficits in neuromuscular activation, proprioception, and motor control contribute to reduced performance in tasks such as stair negotiation and walking. Experimental and clinical studies have suggested that TENS may enhance functional performance through mechanisms that extend beyond analgesia, including improvements in sensorimotor integration and neuromuscular coordination.[10] When combined with therapeutic exercise, TENS has been reported to support functional gains, although findings remain inconsistent and appear to depend on stimulation intensity and clinical context.[11,12]

Safety considerations further support interest in TENS as a therapeutic option for knee OA. Compared with pharmacological treatments, particularly opioid-based therapies, TENS is associated with minimal adverse effects and favorable tolerability. A recent randomized controlled trial demonstrated that wearable TENS provided pain relief comparable to weak opioids while resulting in significantly fewer adverse events, highlighting its potential role as a safer adjunct in pain management strategies for knee OA.[13] This is particularly relevant for older adults, who are more vulnerable to medication-related complications.

Despite the expanding body of research, uncertainty persists regarding the overall clinical value of TENS in knee OA management, particularly in individuals with mild to moderate disease, where conservative intervention may yield the greatest long-term benefit. Variability in study designs, intervention protocols, and outcome measures continues to limit definitive conclusions. Furthermore, many reviews have focused on systematic synthesis, whereas narrative integration of recent clinical evidence may offer complementary insights into contextual and patient-specific factors influencing treatment outcomes.

Therefore, this narrative review aims to synthesize and critically discuss recent clinical evidence on the effects of Transcutaneous Electrical Nerve Stimulation on pain and physical function in individuals with mild to moderate knee osteoarthritis, with particular emphasis on its relevance to physiotherapy practice and multimodal rehabilitation strategies.

Methods

Study Design

This study was conducted as a narrative review aimed at synthesizing and critically discussing recent clinical evidence on the effects of Transcutaneous Electrical Nerve Stimulation (TENS) on pain and physical function in individuals with mild to moderate knee osteoarthritis. A narrative review design was selected to allow a flexible and interpretive integration of evidence from studies with heterogeneous designs, intervention protocols, outcome measures, and clinical contexts. Unlike systematic reviews, narrative reviews do not seek exhaustive literature coverage or quantitative synthesis but instead emphasize contextual interpretation and clinical relevance. Accordingly, this review did not follow PRISMA guidelines, did not register a protocol, and did not perform formal risk-of-bias or certainty-of-evidence assessments, which is methodologically appropriate for this review type.

Data Sources and Search Strategy

Relevant literature was identified through targeted electronic searches of PubMed and ScienceDirect, two databases that comprehensively index peer-reviewed biomedical, rehabilitation, and musculoskeletal research. These databases were selected because they provide broad coverage of randomized controlled trials and clinical studies related to electrotherapy modalities, osteoarthritis management, and physiotherapy interventions. Preliminary exploration indicated substantial overlap between the two databases; therefore, additional databases were not included.

The literature search focused on studies published between January 2020 and December 2025 to capture recent and clinically relevant evidence reflecting contemporary perspectives on TENS application and knee osteoarthritis management. Search terms were developed to address the core concepts of the review and combined using Boolean operators. The primary search strategy was as follows: “knee osteoarthritis” AND “transcutaneous electrical nerve stimulation” AND (“pain” OR “physical function”). Searches were limited to articles published in the English language. Reference lists of included studies were screened manually to identify potentially relevant articles that may not have been captured through electronic searching.

Eligibility Criteria

Studies were considered eligible for inclusion if they involved human participants diagnosed with mild to moderate knee osteoarthritis based on clinical and/or radiological criteria, including adult and older adult populations, and examined Transcutaneous Electrical Nerve Stimulation (TENS) as a primary intervention or as part of a rehabilitation program. Eligible studies were required to report outcomes related to pain and/or physical function, including patient-reported measures, task-based functional assessments, or neuromuscular outcomes relevant to functional performance. Original clinical studies with diverse designs, such as randomized controlled trials, quasi-experimental studies, and observational studies, were included to align with the inclusive and interpretive nature of a narrative review. Only studies published between 2020 and 2025 were considered.

Studies were excluded if they were review articles, systematic reviews, meta-analyses, editorials, opinion papers, conference abstracts, or case reports; if TENS was not a primary or clearly identifiable intervention; if pain or physical function outcomes were not reported; if non-human participants were involved; or if full-text articles were unavailable.

Study Selection Process

Study selection was conducted by a single reviewer. Titles and abstracts retrieved from the database searches were screened for relevance based on the predefined eligibility criteria. Full-text articles were subsequently reviewed to confirm inclusion. In cases where eligibility was unclear or interpretation of study relevance was uncertain, discussion with co-authors was undertaken to support interpretive clarity and consensus. This collaborative approach was used to enhance transparency and minimize subjective bias, recognizing that narrative reviews inherently involve author judgment.

Data Extraction

Data extraction focused on capturing information relevant to the clinical application of Transcutaneous Electrical Nerve Stimulation (TENS) in knee osteoarthritis rather than exhaustive methodological detail. Extracted data included the author and year of publication, participant characteristics such as osteoarthritis severity and key clinical features, characteristics of the TENS intervention (including stimulation frequency, intensity, duration, and mode of application), comparator interventions when applicable, outcome domains assessed (pain, physical function, and neuromuscular measures), and key findings relevant to clinical practice and

rehabilitation. Data extraction was conducted descriptively without the use of a standardized extraction form, in accordance with the interpretive nature of a narrative review methodology.

Outcome Measures

Pain outcomes were typically assessed using validated patient-reported measures, such as visual analogue scales or numerical rating scales, reflecting subjective pain intensity. Functional outcomes included task-based assessments (e.g., stair-climbing performance), self-reported physical function questionnaires, and performance-based measures relevant to daily activities. In selected studies, neuromuscular outcomes, such as quadriceps muscle activation or inhibition, were reported to provide insight into potential mechanisms underlying functional changes. No restrictions were placed on specific outcome instruments, allowing inclusion of studies that reflected diverse clinical assessment practices.

Data Synthesis

Consistent with the narrative design of this review, findings were synthesized using a descriptive and thematic approach rather than quantitative pooling or meta-analysis. Results were organized into key thematic domains aligned with the objectives of the review, including pain-related outcomes, physical function outcomes, neuromuscular and mechanistic considerations, and broader clinical and safety considerations. Within each domain, similarities and differences across studies were examined, and potential explanations for variability in findings were explored. Emphasis was placed on identifying patterns relevant to physiotherapy practice, particularly the influence of stimulation parameters, patient characteristics, and rehabilitation context.

Methodological Considerations

No formal methodological quality appraisal, risk-of-bias assessment, or grading of evidence certainty was conducted. This decision was intentional and consistent with the aims and scope of a narrative review. The purpose of this review was not to establish definitive effect estimates but to contextualize recent clinical findings and highlight areas of agreement, uncertainty, and emerging interest within the literature. Where appropriate, cautious language was used to avoid overinterpretation of findings.

Results

Study Selection and General Characteristics

A total of five studies met the eligibility criteria and were included in this narrative review. All included studies employed a randomized controlled trial (RCT) design and were published between 2020 and 2023. Sample sizes ranged from 37 to 110 participants and involved individuals diagnosed with mild to moderate knee osteoarthritis, chronic knee osteoarthritis, or symptomatic knee osteoarthritis accompanied by quadriceps muscle weakness. Across studies, participant populations varied in terms of disease severity, baseline pain intensity, and functional status.

Transcutaneous Electrical Nerve Stimulation (TENS) was applied either as a standalone intervention or in combination with therapeutic exercise. Comparator interventions included sham stimulation, weak opioid therapy, transcranial direct current stimulation (tDCS), and exercise alone. Considerable heterogeneity was observed in TENS application parameters, including stimulation frequency (high-frequency versus low-frequency), intensity (sensory-level versus motor-level), treatment duration (single-session versus multi-week interventions), and delivery mode (conventional or wearable devices). An overview of the characteristics of the included studies is presented in Table 1.

Table 1. Characteristics of Included Studies

Author (Year)	Population	Sample Size	Intervention	Comparator	Outcome Domains	Main Findings
Govil et al. (2020)[9]	Mild–moderate knee OA	75	HF-TENS or LF-TENS	Placebo TENS	Pain	Analgesic response varied according to COMT genotype
Maheu et al. (2022)[13]	Knee OA with moderate–severe pain	110	Wearable TENS	Weak opioids	Pain, safety	Comparable pain relief with fewer adverse events
Iijima et al. (2020)[10]	Pre-radiographic to mild knee OA	59	TENS	Sham TENS	Physical function	Improved stair-climbing performance
Sajadi et al. (2020)[11]	Chronic knee OA	40	TENS + exercise	tDCS + exercise	Pain, function	Both groups improved pain and function
Pietrosimone et al. (2020)[12]	Knee OA with quadriceps weakness	37	Exercise + sensory- or motor-level TENS	Exercise alone	Neuromuscular	Motor-level TENS reduced muscle inhibition

Pain Outcomes

Pain was the most frequently assessed outcome across the included studies. All five studies reported pain-related outcomes using validated patient-reported measures. Overall, the findings indicated that TENS was associated with reductions in knee pain intensity; however, the magnitude and consistency of analgesic effects varied across studies.

Govil et al. reported that the analgesic response to TENS was influenced by genetic variability. Individuals carrying the catechol-O-methyltransferase (COMT) rs4680 G allele demonstrated greater reductions in resting knee pain compared with non-carriers, particularly when low-frequency stimulation was applied. This study highlighted interindividual variability in pain response to TENS based on biological factors.[9]

Maheu et al. evaluated wearable TENS over a three-month period and compared its effectiveness with weak opioid therapy. Pain reduction achieved with wearable TENS was comparable to that observed with pharmacological treatment. In addition, participants in the TENS group experienced significantly fewer adverse events, indicating a favorable safety profile.[13]

In studies comparing TENS with sham or alternative neuromodulation techniques, pain reductions were observed within intervention groups, although between-group differences were not always statistically significant. In the trial conducted by Sajadi et al., both TENS combined with exercise and tDCS combined with exercise resulted in significant within-group improvements in pain, with no significant differences between groups.[11]

Physical Function Outcomes

Physical function outcomes were assessed in three of the included studies using task-based or performance-oriented measures. Functional improvements were reported, although findings were less consistent than those observed for pain outcomes. Iijima et al. examined the immediate effects of TENS on stair-climbing performance in individuals with early-stage knee osteoarthritis. Following a single TENS session, participants demonstrated a significant reduction in stair-climbing time compared with sham stimulation. This improvement occurred in the absence of significant changes in pain intensity or quadriceps strength.[10]

In the study by Sajadi et al., physical function outcomes improved significantly within both intervention groups (TENS plus exercise and tDCS plus exercise). No significant differences were observed between the two neuromodulation approaches, suggesting that functional gains were comparable when either modality was combined with exercise therapy.[11] Functional outcomes were not consistently reported across all studies, and differences in outcome measures and assessment timing limited direct comparison. Overall, functional improvements associated with TENS appeared to be more evident when the intervention was integrated into a broader rehabilitation program rather than delivered in isolation.

Neuromuscular Outcomes

Neuromuscular outcomes were specifically assessed in one study. Pietrosimone et al. investigated the effects of sensory-level versus motor-level TENS combined with therapeutic exercise on quadriceps muscle activation in individuals with knee osteoarthritis and quadriceps weakness. The authors reported that motor-level TENS combined with exercise significantly reduced arthrogenic muscle inhibition compared with sensory-level TENS or exercise alone.[12]

Although neuromuscular improvements were observed, these changes did not consistently translate into superior long-term functional outcomes within the study period. Neuromuscular measures were not assessed in the other included studies, limiting broader conclusions regarding this outcome domain.

Safety and Adverse Events

Safety outcomes were explicitly reported in one study. Maheu et al. documented a significantly lower incidence of adverse events in the wearable TENS group compared with the weak opioid group. Reported adverse events in the opioid group included gastrointestinal and central nervous system symptoms, whereas adverse events associated with TENS were minimal and transient.[13] The remaining studies did not report serious adverse events related to TENS application, supporting its general tolerability in individuals with knee osteoarthritis.

Summary of Findings

Across the included studies, TENS was consistently associated with short-term pain reduction, while functional and neuromuscular outcomes demonstrated greater variability. Pain outcomes were reported across all studies and appeared to be more responsive to TENS than functional outcomes. Functional improvements were more frequently observed when TENS was combined with exercise or assessed using task-based measures. Neuromuscular effects were dependent on stimulation intensity and were reported in a limited number of studies.

The heterogeneity in participant characteristics, TENS protocols, comparator interventions, and outcome measures contributed to variability in reported results. Nevertheless, the included studies collectively provide evidence supporting the role of TENS as a supportive intervention for pain management and functional rehabilitation in individuals with knee osteoarthritis.

Discussion

This narrative review examined recent clinical evidence on the effects of Transcutaneous Electrical Nerve Stimulation (TENS) in individuals with mild to moderate knee osteoarthritis, with particular attention to pain, physical function, and neuromuscular outcomes. Overall, the findings suggest that TENS provides clinically meaningful short-term pain relief and may support functional performance in selected contexts. However, the magnitude, consistency, and durability of these effects varied substantially across studies, reflecting heterogeneity in participant characteristics, intervention protocols, and rehabilitation settings.[9–13]

Analgesic Effects of TENS in Knee Osteoarthritis

Pain reduction was the most consistently reported outcome across the included studies. This finding aligns with established neurophysiological theories underlying TENS, including inhibition of nociceptive transmission at the spinal level, activation of descending inhibitory pathways, and stimulation of endogenous opioid release.[6,7] The observed analgesic effects across diverse study designs and comparators support the role of TENS as a viable non-pharmacological modality for pain modulation in knee osteoarthritis.

Notably, the study by Govil et al. demonstrated that analgesic responsiveness to TENS was influenced by genetic variability, particularly polymorphisms in the catechol-O-methyltransferase (COMT) gene.[9] Individuals carrying the rs4680 G allele exhibited greater pain reduction, especially with low-frequency stimulation. These findings provide a biological explanation for the heterogeneity of pain outcomes reported in previous trials and suggest that individual differences in neurotransmitter metabolism and endogenous pain inhibition capacity may substantially influence treatment response. This emerging evidence supports a shift away from a “one-size-fits-all” approach toward more individualized neuromodulation strategies in knee osteoarthritis management.

Comparative evidence further contextualizes the analgesic role of TENS. In the randomized controlled trial conducted by Maheu et al., wearable TENS was found to be non-inferior to weak opioid therapy for pain relief over a three-month period while being associated with significantly fewer adverse events.[13] This finding is clinically important, as pharmacological pain management—particularly opioid use—is associated with considerable risks, including gastrointestinal, cognitive, and dependency-related complications. The comparable analgesic efficacy and superior safety profile of TENS support its potential role as a safer alternative or adjunct to medication-based pain management, especially among older adults and individuals with multiple comorbidities.

Nevertheless, analgesic outcomes were not uniformly superior to comparator interventions across all studies. In trials comparing TENS with sham stimulation or alternative neuromodulation approaches, pain reductions were sometimes observed within intervention groups without significant between-group differences.[10,11] These findings suggest that contextual factors, placebo responses, and concurrent rehabilitation interventions may influence pain outcomes, highlighting the complexity of pain modulation in knee osteoarthritis.

Functional Outcomes Beyond Pain Relief

Functional performance outcomes demonstrated greater variability than pain outcomes across the included studies. This variability is not unexpected, as functional impairment in knee osteoarthritis is multifactorial and influenced by pain, muscle strength, neuromuscular control, proprioception, and psychosocial factors. Improvements in pain do not necessarily translate directly into functional gains, particularly in the short term.

Iijima et al. reported significant improvements in stair-climbing performance following a single TENS session in individuals with early-stage knee osteoarthritis, despite no significant changes in pain intensity or quadriceps strength.[10] This dissociation suggests that TENS may influence functional performance through mechanisms other than analgesia, such as enhanced sensorimotor integration or neuromuscular coordination. From a clinical perspective, this finding is relevant because functional limitations often emerge early in the disease process and may precede severe pain.

In contrast, functional improvements were more consistently observed when TENS was combined with therapeutic exercise. Sajadi et al. demonstrated that both TENS plus exercise and transcranial direct current stimulation (tDCS) plus exercise resulted in significant within-group improvements in pain and function, with no significant differences between the two neuromodulation techniques.[11] These results suggest that exercise remains the primary driver of functional improvement, while neuromodulation modalities may act as supportive interventions that facilitate participation or enhance short-term performance.

Collectively, the functional findings indicate that TENS alone may produce modest and context-dependent functional benefits, whereas its integration into multimodal rehabilitation programs appears to be more effective. This supports current clinical practice guidelines that emphasize exercise as the cornerstone of knee osteoarthritis management, with adjunctive modalities used to optimize rehabilitation outcomes.

Neuromuscular Effects and Mechanistic Considerations

Neuromuscular outcomes were specifically addressed in the study by Pietrosimone et al., which demonstrated that motor-level TENS combined with exercise significantly reduced quadriceps arthrogenic muscle inhibition compared with sensory-level TENS or exercise alone.[12] Arthrogenic muscle inhibition is a well-recognized contributor to persistent quadriceps weakness and functional limitation in knee osteoarthritis. By enhancing motor unit recruitment, motor-level TENS may temporarily improve neuromuscular activation and joint stability.

However, the clinical significance of these neuromuscular changes remains uncertain. Although reductions in muscle inhibition were observed, these changes did not consistently translate into superior long-term functional outcomes. This finding suggests that while TENS may facilitate short-term neuromuscular activation, sustained functional recovery likely depends on progressive and task-specific exercise training. Neuromuscular facilitation provided by TENS may therefore be best viewed as a means of enhancing exercise effectiveness rather than as an independent therapeutic goal.

Safety and Clinical Applicability

The safety profile of TENS emerged as a consistent strength across the reviewed studies. No serious adverse events related to TENS were reported, and the incidence of adverse effects was minimal compared with pharmacological treatments.[13] This favorable safety profile is particularly relevant in knee osteoarthritis populations, which often include older adults with multiple comorbidities and heightened vulnerability to medication-related complications.

From a clinical standpoint, TENS offers several practical advantages. It is non-invasive, relatively low-cost, and easily administered in both clinical and home-based settings. These characteristics support its feasibility as an adjunctive modality within routine physiotherapy practice. However, clinicians should be cautious not to overestimate its effects or rely on TENS as a standalone intervention. Instead, TENS should be strategically integrated into comprehensive rehabilitation programs to support pain management, facilitate exercise participation, and address individual patient needs.

Variability of Evidence and Methodological Considerations

The variability observed across studies reflects both biological and methodological factors. Interindividual differences in pain processing, genetic variability, and disease presentation may influence responsiveness to TENS. At the methodological level, heterogeneity in stimulation parameters, treatment duration, comparator interventions, and outcome measures complicates direct comparison across studies.

Short-term interventions may capture immediate neuromodulatory effects without reflecting longer-term adaptations, whereas longer trials integrated into structured rehabilitation programs may better represent real-world clinical outcomes. Additionally, the use of diverse outcome measures limits synthesis and highlights the need for greater standardization in future research.

Implications for Practice and Future Research

The findings of this narrative review suggest that TENS plays a supportive but variable role in knee osteoarthritis management. Its most consistent benefit appears to be short-term pain reduction, with functional and neuromuscular benefits dependent on clinical context and intervention design. Clinicians should consider patient-specific factors, including pain severity, functional goals, and tolerance to stimulation, when incorporating TENS into treatment plans.

Future research should focus on standardizing TENS protocols, identifying optimal stimulation parameters, and exploring individual-level modifiers of treatment response. Long-term trials examining the sustained effects of TENS within exercise-based rehabilitation programs are needed to clarify its clinical value beyond short-term symptom relief.

Conclusion

This narrative review suggests that Transcutaneous Electrical Nerve Stimulation (TENS) may offer clinically relevant benefits in the management of mild to moderate knee osteoarthritis, particularly with respect to short-term pain reduction. Across the reviewed studies, analgesic effects were the most consistently reported outcomes, supporting the role of TENS as a non-pharmacological modality for pain modulation in this population. In certain contexts, TENS was also associated with improvements in physical function and neuromuscular activation; however, these effects were less consistent and appeared to depend on stimulation parameters and rehabilitation context.

The available evidence indicates that functional benefits are more likely when TENS is integrated into multimodal rehabilitation programs, particularly in combination with therapeutic exercise, rather than when applied as a standalone intervention.

Neuromuscular effects, such as reductions in quadriceps muscle inhibition, suggest that TENS may facilitate exercise performance and early functional engagement, although these changes do not consistently translate into sustained long-term improvements.

Despite these encouraging findings, several limitations must be acknowledged. This review employed a narrative approach and did not follow systematic review guidelines, which may have resulted in incomplete literature coverage. Study selection and data extraction were primarily conducted by a single reviewer, introducing potential selection and interpretive bias. In addition, no formal methodological quality appraisal or risk-of-bias assessment was performed, limiting objective evaluation of the included studies. The predominance of short-term outcomes, along with substantial heterogeneity in intervention protocols, outcome measures, and follow-up durations, further restricts the generalizability of the findings and precludes definitive conclusions regarding long-term effectiveness.

Overall, TENS should be considered a supportive adjunct within comprehensive, individualized rehabilitation strategies for knee osteoarthritis rather than a primary intervention. Further well-designed clinical studies are needed to clarify optimal application parameters and to identify patient-specific factors that influence responsiveness to TENS.

Author Contribution

I Gede Putu Wahyu Mahendra: Conceptualization; Methodology; Data curation; Formal analysis; Writing—original draft; Supervision. Sayu Aryantari Putri Thanaya: Methodology; Data curation; Writing—review & editing.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

Ethical approval was not required for this study as it involved secondary analysis of previously published literature only.

References

1. Kurniari PK, Hidayat R, Parlindungan F, Pratama MZ, Wibowo SAK, Sarmidi S, et al. Prevalence, risk factors, and quality of life of knee osteoarthritis in urban community in Indonesia: a COPCORD study. Int J Rheum Dis. 2025;28(1):e70014.
2. Yunus MHM, Nordin A, Kamal H. Pathophysiological perspective of osteoarthritis. Medicina (B Aires). 2020;56(11):614.
3. Chen X, Shao C, Li L, Zuo Z, Wang Y. Prevalence of knee osteoarthritis in the Chinese population, 2013–2023: a systematic review and meta-analysis. J Orthop Surg Res. 2025;20(1):916.
4. Ettlin L, Nast I, Huber EO, Niedermann K. Does the conservative non-pharmacological management of knee osteoarthritis in Switzerland reflect the clinical guidelines? A survey among general practitioners, rheumatologists, and orthopaedic surgeons. Front Rehabil Sci. 2021;2: [pages not available].
5. Saad LB, Hassan S. Alternative treatments for NSAIDs: a comprehensive review. Indian J Appl Res. 2024; [volume and issue not available]:5–7.
6. Yuan SG, Chen J, Chen MX, Zheng NS, Zhang ZW, Wang HJ, et al. High-intensity electroacupuncture is superior to low-intensity electroacupuncture for knee osteoarthritis: a meta-analysis of randomized controlled trials. Acupunct Med. 2024;42(6):303–10.
7. Travers MJ, O'Connell NE, Tugwell P, Eccleston C, Gibson W. Transcutaneous electrical nerve stimulation (TENS) for chronic pain: the opportunity to begin again. Cochrane Database Syst Rev. 2020;(4): [pages not available].
8. Wu Y, Zhu F, Chen W, Zhang M. Effects of transcutaneous electrical nerve stimulation (TENS) in people with knee osteoarthritis: a systematic review and meta-analysis. Clin Rehabil. 2022;36(4):472–85.
9. Govil M, Mukhopadhyay N, Holwerda T, Sluka K, Rakel B, Schutte DL. Effects of genotype on TENS effectiveness in controlling knee pain in persons with mild to moderate osteoarthritis. Eur J Pain. 2020;24(2):398–412.
10. Iijima H, Eguchi R, Shimoura K, Yamada K, Aoyama T, Takahashi M. Transcutaneous electrical nerve stimulation improves stair climbing capacity in people with knee osteoarthritis. Sci Rep. 2020;10(1):7294.
11. Sajadi S, Karimi M, Forogh B, Raissi GR, Zarnegar F, Ahadi T. Randomized clinical trial comparing of transcranial direct current stimulation (tDCS) and transcutaneous electrical nerve stimulation (TENS) in knee osteoarthritis. Neurophysiol Clin. 2020;50(5):367–74.
12. Pietrosimone B, Luc-Harkey BA, Harkey MS, Davis-Wilson HC, Pfeiffer SJ, Schwartz TA, et al. Using TENS to enhance therapeutic exercise in individuals with knee osteoarthritis. Med Sci Sports Exerc. 2020;52(10):2086–95.
13. Maheu E, Soriot-Thomas S, Noel E, Ganry H, Lespessailles E, Cortet B. Wearable transcutaneous electrical nerve stimulation (actiTENS) is effective and safe for the treatment of knee osteoarthritis pain: a randomized controlled trial versus weak opioids. Ther Adv Musculoskelet Dis. 2022;14:1759720X211066233.