

## Effects of TENS and Exercise Therapy on Bilateral Knee Osteoarthritis: A Case Report

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### Abstract

**Background:** Knee osteoarthritis is a degenerative joint disorder associated with pain, reduced muscle strength, and limited joint mobility, leading to functional impairment. Combined physiotherapy interventions, such as Transcutaneous Electrical Nerve Stimulation (TENS) and exercise therapy, are widely used, but evidence in bilateral cases remains limited.

**Objective:** This case report aimed to explore the clinical effects of TENS combined with exercise therapy on pain, muscle strength, and joint range of motion in bilateral knee osteoarthritis.

**Methods:** A 45-year-old female with bilateral knee osteoarthritis underwent three physiotherapy sessions consisting of TENS and structured exercise therapy. Pain was measured using the Visual Analog Scale (VAS), muscle strength using Manual Muscle Testing (MMT), and joint mobility using goniometric range of motion (ROM). Outcomes were assessed across three time points (T1–T3) using descriptive analysis.

**Results:** Pain decreased from 3/10 to 1/10 at rest, 4/10 to 2/10 during movement, and 3/10 to 2/10 on palpation. Muscle strength improved from grade 3/5 to 4/5 in most muscle groups. Knee flexion increased from 115° to 125° (right) and 125° to 135° (left), indicating clinically relevant improvement.

**Conclusion:** TENS combined with exercise therapy was associated with improvements in pain, muscle strength, and joint mobility. However, findings should be interpreted cautiously due to the single-case design.

### Keywords

Osteoarthritis, Knee; Transcutaneous Electric Nerve Stimulation; Exercise Therapy; Pain Measurement; Range of Motion, Articular

### Introduction

Knee osteoarthritis (OA) is a chronic degenerative joint disorder characterized by progressive cartilage degradation, subchondral bone remodeling, osteophyte formation, and synovial inflammation. These structural changes contribute to pain, joint stiffness, reduced range of motion, and functional limitations that significantly impair quality of life.<sup>1</sup> The global burden of knee OA continues to rise due to population aging, increasing obesity rates, and sedentary lifestyles, making it one of the leading causes of disability worldwide.<sup>2</sup>

Clinically, knee OA presents with multifactorial symptoms, including mechanical pain exacerbated by weight-bearing activities, muscle weakness particularly in the quadriceps and decreased joint stability.<sup>3</sup> These impairments collectively reduce functional capacity, affecting activities such as walking, stair negotiation, and sit-to-stand transitions.<sup>4,5</sup> In bilateral knee OA, the functional burden is often more pronounced due to symmetrical joint involvement, which further compromises mobility and independence.<sup>6</sup>

Physiotherapy plays a central role in the conservative management of knee OA, with a primary focus on pain reduction, restoration of joint function, and improvement of overall physical performance.<sup>7</sup> Among commonly applied modalities, Transcutaneous Electrical Nerve Stimulation (TENS) is widely used for pain modulation.<sup>8</sup> TENS is believed to exert its analgesic effect through activation of large-diameter afferent fibers, thereby inhibiting nociceptive transmission via the gate control mechanism, as well as through endogenous opioid release.<sup>8,9</sup> In parallel, exercise therapy particularly strengthening and functional exercises has been consistently recommended to improve muscle performance, enhance joint stability, and support functional recovery.<sup>10,11</sup>

Recent evidence from randomized controlled trials and systematic reviews suggests that both TENS and exercise therapy can independently contribute to symptom reduction in knee OA.<sup>12,13</sup> However, findings regarding their combined effects remain inconsistent, particularly in clinical populations with bilateral involvement. While some studies report additive or synergistic benefits, others indicate only modest improvements, highlighting the need for further exploration in specific clinical contexts.<sup>6,14</sup>

Despite the growing body of literature, there remains a notable gap in evidence addressing the effectiveness of combined TENS and exercise therapy in real-world clinical settings, especially in patients with bilateral knee OA. Most available studies focus on unilateral cases or controlled experimental conditions, which may not fully reflect routine physiotherapy practice. Furthermore, detailed clinical documentation of intervention protocols and patient responses in bilateral cases is still limited.<sup>6,14</sup>

From a clinical perspective, case reports play an important role in bridging this gap by providing in-depth insights into individualized treatment approaches, clinical reasoning, and patient-specific responses to intervention. In bilateral knee OA, where functional impairment is often more complex, such detailed reporting is particularly valuable for informing clinical decision-making and generating hypotheses for future research.<sup>15</sup>

This case is considered clinically relevant due to the presence of bilateral knee involvement, functional limitations affecting daily activities, and the application of a combined physiotherapy approach integrating electrotherapy and exercise therapy. The case also reflects routine clinical practice, thereby enhancing its applicability to real-world settings.<sup>15</sup> Therefore, this case report aims to explore the clinical effects of combined Transcutaneous Electrical Nerve Stimulation and exercise therapy on pain intensity, muscle strength, and joint range of motion in a patient with bilateral knee osteoarthritis.

## Methods

This study was designed as a single-patient case report conducted in accordance with the CARE (CAse REport) guidelines to ensure completeness and transparency in clinical reporting. The study was carried out in an orthopedic rehabilitation setting where routine physiotherapy services were provided. Ethical considerations were addressed prior to data collection. Ethical approval was not required for this case report based on institutional policy. Written informed consent was obtained from the patient for participation and publication of anonymized clinical data.

A 45-year-old female presented with bilateral knee pain, functional limitation, and clinical diagnosis of bilateral knee osteoarthritis. The patient reported a long-standing history of bilateral knee pain; however, the exact duration could not be clearly specified. Her body mass index (BMI) was 29.62 kg/m<sup>2</sup>, indicating overweight status. The patient had previously worked in a nursing home, which may have involved physical activities contributing to cumulative knee joint loading. The patient had a medical history of cardiovascular disease, with no history of previous knee trauma or surgical intervention. Radiological assessment and Kellgren Lawrence grading were not available.

No adverse events or contraindications to physiotherapy interventions were identified during initial screening. The patient had not undergone recent surgical intervention and was not receiving concurrent invasive treatments. Clinical assessment included evaluation of pain intensity, muscle strength, and joint range of motion. Pain intensity was measured using the Visual Analog Scale (VAS), a widely validated tool for subjective pain assessment ranging from 0 (no pain) to 10 (worst imaginable pain). Muscle strength was assessed using Manual Muscle Testing (MMT), graded on a scale from 0 to 5, reflecting the patient's ability to generate muscle contraction against gravity and resistance. Joint mobility was evaluated using a standard universal goniometer to measure knee flexion and extension range of motion in degrees.

Pain intensity was assessed using the Visual Analog Scale (VAS), a widely used instrument with strong validity and reliability for measuring subjective pain in musculoskeletal conditions, including knee osteoarthritis. Muscle strength was evaluated using Manual Muscle Testing (MMT), which has demonstrated acceptable inter-rater reliability when standardized procedures are applied.<sup>2</sup> Joint range of motion (ROM) was measured using a universal goniometer, a tool with established validity and high intra- and inter-rater reliability in assessing knee joint mobility.

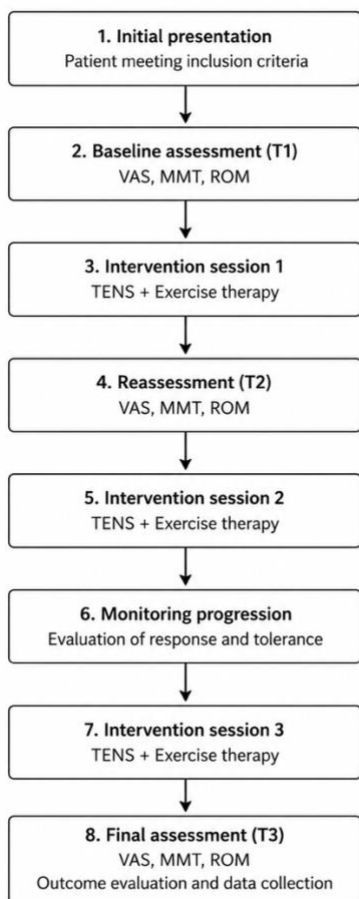
All baseline measurements were recorded prior to intervention (T1), followed by repeated assessments after each treatment session (T2 and T3) to monitor progression over time. The intervention consisted of a combination of Transcutaneous Electrical Nerve Stimulation (TENS) and structured exercise therapy. Transcutaneous Electrical Nerve Stimulation (TENS) was applied to both knees twice weekly using surface electrodes positioned over the medial and lateral aspects of the knee joints (bilaterally). The stimulation was delivered using a conventional mode, with intensity adjusted to the patient's tolerance at a comfortable sensory level. Each session lasted approximately 15 minutes.

Exercise therapy included strengthening and active movement exercises targeting the muscles surrounding the knee joint, particularly the quadriceps and hamstring muscle groups. The program incorporated exercises such as quadriceps setting, active knee flexion-extension, and functional movement training.

The exercise therapy program focused on quadriceps strengthening and stretching exercises. Each exercise was performed in 2–3 sets of 10–15 repetitions, with a total session duration of approximately 20 minutes. The program followed the principle of progressive overload, with gradual increases in repetitions and resistance based on the patient's tolerance and functional capacity. In addition to supervised sessions, the patient was prescribed a home exercise program consisting of quadriceps strengthening and stretching exercises, performed independently 1–2 times daily. The selection of combined TENS and exercise therapy was based on their complementary mechanisms, where TENS primarily addresses pain modulation, while exercise therapy targets muscle strength and joint function, thereby supporting functional recovery.

Exercise intensity was individualized based on patient tolerance and symptom response. The program followed the principle of progressive overload, with gradual increases in repetitions and improved movement control across sessions. Progression was applied conservatively to maintain exercises within a pain-free or minimally symptomatic range, ensuring both safety and adherence throughout the intervention period. Each treatment session was conducted under the supervision of a physiotherapist. The intervention was delivered over three sessions, with consistent procedures applied at each session to ensure standardization. The patient adhered fully to the intervention protocol and attended all scheduled sessions without absence. No adverse events or complications were reported during the intervention period. To provide a clearer overview of the clinical course, the patient timeline is presented below in a structured narrative format that can be converted into a flow diagram if required.

The clinical intervention timeline and outcome assessment protocol are presented in Figure 1. The process began with the patient's initial presentation and eligibility confirmation, followed by baseline assessment (T1) using the Visual Analog Scale (VAS), Manual Muscle Testing (MMT), and Range of Motion (ROM) measurements. Subsequently, the patient underwent three consecutive intervention sessions consisting of Transcutaneous Electrical Nerve Stimulation (TENS) combined with exercise therapy. Periodic reassessment and monitoring of clinical progression were conducted throughout the intervention period to evaluate treatment response and patient tolerance. The protocol concluded with a final assessment (T3) to determine changes in pain intensity, muscle strength, range of motion, and overall clinical outcomes following the intervention.



**Figure 1.** Clinical Intervention Timeline and Outcome Assessment Protocol

Outcome evaluation focused on changes in pain intensity, muscle strength, and joint range of motion across the three time points. Given the nature of a single-case design, data analysis was conducted using descriptive longitudinal comparison. Changes were interpreted based on absolute differences across time points and their potential clinical relevance. The clinical relevance of pain reduction was interpreted using the Minimal Clinically Important Difference (MCID). For patients with knee osteoarthritis, a reduction of approximately 1.5–2.0 points on the Visual Analog Scale (VAS) is generally considered clinically meaningful.<sup>1</sup>

Although statistical inference was not applicable due to the absence of a control group and sample size limitation (n=1), efforts were made to enhance interpretability through consistent measurement procedures and repeated observations. To ensure methodological transparency, this case report explicitly acknowledges inherent limitations, including the absence of randomization, lack of comparator group, and potential measurement bias associated with subjective assessment tools. These considerations were taken into account when interpreting the results.

**Results**

This section presents the clinical outcomes of a patient with bilateral knee osteoarthritis following three sessions of combined Transcutaneous Electrical Nerve Stimulation (TENS) and exercise therapy. Outcomes were evaluated across three time points: baseline (T1), mid-intervention (T2), and post-intervention (T3). The results are organized to reflect changes in pain intensity, muscle strength, and joint range of motion, in accordance with the study objectives. Prior to presenting outcome measures, baseline clinical characteristics are summarized to provide context for interpreting the observed changes.

To provide a comprehensive understanding of the patient’s condition prior to intervention, baseline clinical characteristics were documented and are presented in Table 1. These data include demographic information, primary complaints, and functional limitations, which are essential for contextualizing the patient’s clinical status and supporting the interpretation of subsequent outcome changes following the intervention.

**Table 1.** Baseline Clinical Characteristics of the Patient

Variable	Description
Age	45 years
Sex	Female
Diagnosis	Bilateral knee osteoarthritis
Duration of symptoms	Long-standing (exact duration not specified)
Body Mass Index (BMI)	29.62 kg/m <sup>2</sup> (overweight)
Occupation	Former nursing home worker
Primary complaints	Bilateral knee pain, stiffness, functional limitation
Pain characteristics	Increased during activity, morning stiffness, night discomfort
Functional limitations	Difficulty in squatting, stair climbing, and sit-to-stand
Comorbidities	Cardiovascular disease
History of trauma/surgery	None
Radiological grading (Kellgren–Lawrence)	Not available

To evaluate changes in symptom severity over the course of the intervention, pain intensity was measured at three time points and is presented in Table 2. This table illustrates the progression of pain across resting, movement, and palpation conditions, providing a detailed overview of symptom dynamics throughout the intervention period.

**Table 2.** Changes in Pain Intensity (VAS)

Pain Type	T1	T2	T3
Resting pain	3/10	3/10	1/10
Movement pain	4/10	3/10	2/10
Palpation pain	3/10	3/10	2/10

As shown in Table 2, resting pain decreased from 3/10 at baseline to 1/10 at T3. Movement-related pain decreased from 4/10 to 2/10, while palpation pain decreased from 3/10 to 2/10. The most notable reduction was observed in resting pain. From a clinical perspective, these changes suggest a reduction in symptom severity over the course of intervention. However, given the single-case design and absence of established thresholds within this report, the magnitude of change should be interpreted cautiously. Based on the Minimal Clinically Important Difference (MCID) threshold of approximately 1.5–2.0 points on the VAS, the observed reduction in resting and movement pain can be considered clinically meaningful.

To assess changes in muscle performance over the course of the intervention, muscle strength was evaluated using Manual Muscle Testing (MMT) at three time points and is presented in Table 3. This table provides a detailed overview of strength changes across key muscle groups surrounding the knee joint, allowing for the observation of functional improvements throughout the intervention period.

**Table 3.** Changes in Muscle Strength (MMT)

Muscle Group	T1	T2	T3
Right knee flexors	3/5	4/5	4/5
Left knee flexors	4/5	4/5	4/5
Right knee extensors	3/5	4/5	4/5
Left knee extensors	3/5	3/5	4/5

The data indicate improvements in most muscle groups, particularly in the right knee flexors and extensors, which increased from grade 3/5 to 4/5. The left knee extensors also demonstrated improvement by the final assessment (T3). These findings suggest enhanced muscle activation and strength following intervention. Nevertheless, it should be noted that MMT is a semi-quantitative assessment and may be subject to evaluator bias. Therefore, changes should be interpreted as indicative rather than definitive measures of strength improvement. However, as this is a single-case report, the observed changes should be interpreted cautiously due to potential measurement variability and the absence of a comparator.

To assess changes in joint mobility over the course of the intervention, knee range of motion was measured using standardized goniometric assessment at three time points and is summarized in Table 4. This table presents the progression of knee flexion in both joints, providing an objective overview of mobility improvements throughout the intervention period.

**Table 4.** Changes in Knee Range of Motion (ROM)

Joint	T1	T2	T3
Right knee (flexion)	115°	120°	125°
Left knee (flexion)	125°	130°	135°

Table 4 demonstrates progressive improvements in knee flexion range of motion in both joints. The right knee improved by 10°, while the left knee improved by 10° across the intervention period. These increases indicate improved joint mobility, which may contribute to enhanced functional capacity. However, as with other outcomes, these changes should be interpreted within the limitations of a single-case design.

To provide an integrated overview of outcome progression across the intervention period, the longitudinal trend of clinical changes across all measured variables is summarized in Table 5.

**Table 5.** Longitudinal Trend of Clinical Outcomes (T1–T3)

Time Point	Pain	Muscle Strength	Range of Motion (ROM)
Baseline (T1)	Moderate pain	Reduced strength	Limited ROM
Mid-intervention (T2)	Slight reduction in movement pain	Initial strength gains	Slight improvement in ROM
Post-intervention (T3)	Further reduction in pain	Improved muscle strength	Increased ROM

The patient completed all three intervention sessions without interruption. No adverse events or complications were reported during or after the intervention period. Patient adherence to the prescribed therapy was considered good based on attendance and participation.

Overall, the results demonstrate improvements in pain intensity, muscle strength, and joint range of motion following combined TENS and exercise therapy. While these findings suggest potential clinical benefit, interpretation must consider the absence of a control condition, the short duration of intervention, and the inherent limitations of a single-case design. The patient demonstrated full adherence to the intervention protocol and reported consistent participation in the prescribed home exercise program. No adverse events were observed throughout the study period. The reduction in pain exceeded the Minimal Clinically Important Difference (MCID), indicating clinically meaningful improvement.

## Discussion

This case report demonstrated that the combination of Transcutaneous Electrical Nerve Stimulation (TENS) and exercise therapy was associated with improvements in pain intensity, muscle strength, and joint range of motion in a patient with bilateral knee osteoarthritis. These findings align with current evidence supporting multimodal physiotherapy approaches in the management of knee osteoarthritis, although interpretation must remain cautious due to the inherent limitations of a single-case design.<sup>10,11,13</sup> This case is particularly noteworthy due to the bilateral involvement and the short duration of intervention, which demonstrated measurable clinical improvements within a limited number of treatment sessions.

The observed reduction in pain intensity is consistent with the proposed physiological mechanisms of TENS.<sup>12,16</sup> TENS is believed to modulate pain through activation of large-diameter afferent fibers, thereby inhibiting nociceptive transmission via the gate control theory, as well as through endogenous opioid release. In line with this mechanism, a recent systematic review involving

multiple clinical trials reported that TENS significantly reduces pain and improves functional outcomes in patients with knee osteoarthritis, particularly when combined with exercise interventions.<sup>12,13</sup>

In the present case, pain reduction was most pronounced in resting pain, followed by movement-related pain. This pattern may reflect early modulation of nociceptive input before full restoration of functional capacity. However, variability in pain reduction across different conditions (rest, movement, palpation) also highlights the complex and multifactorial nature of pain in osteoarthritis, which is influenced not only by structural joint changes but also by neuromuscular and psychosocial factors.<sup>17</sup>

The improvement in muscle strength observed in this case is likely attributable to the exercise therapy component, particularly strengthening exercises targeting the quadriceps muscle. Quadriceps weakness is a well-established contributor to knee joint instability and functional limitation in osteoarthritis.<sup>18</sup> Strengthening exercises enhance neuromuscular activation, improve joint alignment, and reduce mechanical stress on the articular surfaces. Evidence from systematic reviews consistently demonstrates that exercise therapy significantly improves muscle strength, reduces pain, and enhances physical function in individuals with knee osteoarthritis.<sup>10,11</sup>

Furthermore, the integration of TENS with exercise therapy may provide a synergistic effect. Pain reduction achieved through TENS may facilitate greater participation in exercise by reducing discomfort during movement, thereby enabling more effective muscle activation and strengthening. This interaction between pain modulation and functional training represents a key principle in physiotherapy, where symptom relief supports active rehabilitation.

The observed increase in joint range of motion (ROM) further supports the potential benefit of combined intervention. Improvements in ROM may be secondary to reduced pain, decreased muscle guarding, and enhanced flexibility resulting from repeated movement and exercise. Previous studies have shown that exercise-based interventions contribute to improved joint mobility and functional outcomes in knee osteoarthritis, although the magnitude of improvement may vary depending on exercise type and intensity.<sup>10,11</sup>

Despite these positive findings, it is important to contextualize the results within the broader literature. While some studies report significant benefits of TENS, others indicate variability in its effectiveness, with some meta-analyses suggesting only modest or short-term effects.<sup>19,20</sup> This inconsistency may be related to differences in stimulation parameters, patient characteristics, and study design. Similarly, although exercise therapy is widely recommended, there is no consensus regarding the optimal type, intensity, or duration of exercise for all patients with knee osteoarthritis.<sup>21</sup>

From a clinical reasoning perspective, the improvements observed in this case may be explained by the complementary mechanisms of the two interventions: TENS primarily addressing pain modulation, while exercise therapy targets biomechanical and neuromuscular deficits. In bilateral knee osteoarthritis, where functional impairment is often more pronounced, such a combined approach may be particularly relevant. The patient's overweight status and occupational background involving physical workload may have contributed to the development and progression of knee osteoarthritis, highlighting the importance of individualized physiotherapy interventions in similar clinical populations.

However, several important limitations must be acknowledged. First, this report involves a single patient (n=1), which limits generalizability and precludes causal inference. Second, the absence of a control condition makes it difficult to determine whether observed improvements were attributable to the intervention, natural disease variation, or placebo effects. Third, outcome measures such as VAS and MMT are partially subjective and may be influenced by evaluator bias. Fourth, the short duration of intervention (three sessions) does not allow assessment of long-term effects or sustainability of outcomes. Additionally, the absence of radiological grading and standardized functional outcome measures, as well as the inability to determine the exact duration of symptoms, may limit the comprehensiveness of clinical interpretation. Alternative interventions such as manual therapy, pharmacological management, or intra-articular injections may also be considered in the management of knee osteoarthritis, depending on patient characteristics and clinical presentation. Additionally, the absence of functional outcome measures such as WOMAC or KOOS further limits the ability to comprehensively assess functional improvement.

Additionally, this report did not include standardized patient-reported outcome measures such as WOMAC or KOOS, which are commonly used in knee osteoarthritis research to assess functional status. The absence of these measures limits the ability to comprehensively evaluate functional improvement and compare findings with existing literature. In terms of external validity, caution is required when generalizing these findings to broader populations. Factors such as age, disease severity, comorbidities, and adherence to therapy may influence treatment response. Therefore, while the results suggest potential benefit, they should be interpreted as exploratory rather than definitive evidence.

From a clinical perspective, this case highlights the practical relevance of combining passive and active physiotherapy interventions in managing bilateral knee osteoarthritis. The integration of TENS and exercise therapy may provide a feasible and accessible approach in routine clinical settings, particularly when tailored to individual patient needs. Future research should aim to validate these findings through well-designed randomized controlled trials with larger sample sizes, standardized intervention protocols, and longer follow-up periods. Additionally, future studies should incorporate comprehensive outcome measures, including patient-reported outcomes and objective functional assessments, to better understand the clinical impact of combined interventions.

## Conclusion

This case report explored the clinical effects of combined Transcutaneous Electrical Nerve Stimulation (TENS) and exercise therapy in a patient with bilateral knee osteoarthritis. The findings demonstrated improvements in pain intensity, muscle strength, and joint range of motion following three intervention sessions. These outcomes suggest that a multimodal physiotherapy approach integrating electrotherapy and therapeutic exercise may contribute to short-term clinical improvement in patients with bilateral knee osteoarthritis.

However, given the single-case design, absence of a control condition, and short intervention duration, the results should be interpreted with caution. The findings do not establish causality but rather indicate a potential association between the intervention and observed improvements. From a clinical perspective, the combination of TENS and exercise therapy may serve as a practical and accessible intervention strategy in routine physiotherapy settings, particularly for patients presenting with bilateral symptoms and functional limitations. Future research is recommended to validate these findings through randomized controlled trials with larger sample sizes, standardized intervention protocols, and longer follow-up periods to determine the effectiveness and sustainability of outcomes.

### Author Contribution

Atika Rianti Utami: Conceptualization, investigation, data collection, manuscript drafting, and literature review.

Wahyu Tri Sudaryanto: Supervision, methodology, formal analysis, manuscript review and editing, and corresponding author responsibilities.

Prihantoro Larasati: Clinical supervision, validation of intervention procedures, and final manuscript approval.

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### Conflict of Interest Statement

The authors declare no conflict of interest.

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### Ethics Statement

This case report was conducted in accordance with the CARE guidelines. Ethical approval was not required for a single case report based on institutional policy. Written informed consent was obtained from the patient for participation and publication of anonymized clinical data.

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