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Effect of Quadriceps Setting Exercise Combined with TENS on Knee Osteoarthritis: A Case Report

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Abstract

Background: Knee osteoarthritis is a degenerative joint disorder characterized by pain, reduced range of motion, muscle weakness, and functional limitations, particularly in older adults and individuals with obesity. Effective physiotherapy interventions are required to address these impairments and improve functional capacity.

Objective: To evaluate the clinical outcomes of quadriceps setting exercise combined with transcutaneous electrical nerve stimulation (TENS) in a patient with bilateral knee osteoarthritis.

Methods: This case report describes a 68-year-old female with bilateral knee osteoarthritis (right grade III, left grade II) with bilateral knee osteoarthritis and obesity who underwent five physiotherapy sessions (twice weekly). Interventions included quadriceps setting exercise and TENS. Outcomes were assessed using the Visual Analog Scale (VAS) for pain, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for functional ability, a goniometer for range of motion, and Manual Muscle Testing (MMT) for muscle strength. Descriptive analysis was applied to evaluate pre–post changes. This case involved a 3-week intervention period consisting of five physiotherapy sessions.

Results: Pain during movement decreased from VAS 8 to 5 (Δ=3 points). The WOMAC score improved from 43 to 33 (Δ=10 points; ~23% improvement). Knee flexion increased (right: 100° to 110°; left: 115° to 120°), and muscle strength improved to MMT grade 4 bilaterally. No adverse events were reported.

Conclusion: Quadriceps setting exercise combined with TENS shows potential to reduce pain and improve functional outcomes in knee osteoarthritis. However, findings from a single case should be interpreted cautiously and require further investigation.

Keywords
Knee Osteoarthritis; Exercise Therapy; Transcutaneous Electrical Nerve Stimulation; Activities of Daily Living

Introduction

Osteoarthritis (OA) is a chronic, progressive, and degenerative joint disorder characterized by cartilage degradation, subchondral bone remodeling, and synovial inflammation, leading to pain, stiffness, and functional impairment.[1] Knee osteoarthritis is the most commonly affected site, particularly due to its role as a primary weight-bearing joint, making it highly susceptible to mechanical stress and structural degeneration.[2]

Globally, knee osteoarthritis represents a significant and growing public health burden. The Global Burden of Disease Study 2021 reported approximately 374.7 million cases worldwide, with projections indicating a continuous increase due to population ageing and rising obesity rates.[3] In Indonesia, osteoarthritis remains highly prevalent among older adults, contributing substantially to disability and reduced quality of life.[4] These epidemiological trends highlight the urgency of developing effective and accessible rehabilitation strategies, particularly for high-risk populations.

Age and obesity are recognized as major risk factors for the development and progression of knee osteoarthritis.[3] Age-related changes impair the regenerative capacity of chondrocytes, resulting in decreased synthesis of extracellular matrix components and increased susceptibility to cartilage damage.[5] Meanwhile, obesity contributes not only through excessive mechanical loading on the knee joint but also via metabolic pathways, including the release of pro-inflammatory adipokines and cytokines that accelerate cartilage degeneration.[5] This dual mechanical and biochemical burden makes obese individuals particularly vulnerable to more severe symptoms and functional decline.

From a clinical perspective, patients with knee osteoarthritis frequently present with quadriceps muscle weakness, which plays a critical role in joint instability and disease progression.[6] Reduced muscle strength contributes to altered joint biomechanics, increased joint loading, and further structural deterioration.[7] Consequently, therapeutic exercise targeting the quadriceps muscle is a cornerstone of conservative management. Quadriceps setting exercise, an isometric strengthening approach, has been shown to improve muscle activation and enhance joint stability without imposing excessive joint stress.[8]

In addition to exercise therapy, pain management is a crucial component in the rehabilitation of knee osteoarthritis, as pain can inhibit muscle activation and limit participation in physical activity.[3] Transcutaneous electrical nerve stimulation (TENS) is a widely used electrotherapy modality that reduces pain through mechanisms such as gate control theory and endogenous opioid release.[9,10] By modulating pain perception, TENS may facilitate improved engagement in therapeutic exercise and enhance overall rehabilitation outcomes.

Although both quadriceps strengthening exercises and TENS have demonstrated individual effectiveness, evidence regarding their combined application, particularly in patients with knee osteoarthritis and obesity, remains limited. Most existing studies focus on randomized controlled trials in general OA populations, while case-based clinical evidence addressing the interaction between obesity, pain modulation, and functional recovery is still scarce. This represents an important gap in the literature, as obesity may act as a significant modifier of treatment outcomes.

Therefore, this case report aims to evaluate the clinical effects of quadriceps setting exercise combined with TENS on pain, range of motion, muscle strength, and functional ability in an obese patient with bilateral knee osteoarthritis. The findings are expected to provide clinically relevant insights into multimodal physiotherapy management in this specific population.

Methods

This study employed a case report design conducted in accordance with the CARE (CAse REport) guidelines to ensure comprehensive and transparent clinical reporting. The study was carried out at the Physiotherapy Department of RSJD Dr. RM. Soedjarwadi Klaten between September and October 2025. Written informed consent was obtained from the patient prior to participation, including consent for clinical data use and publication. This case was selected as a clinical case based on routine clinical presentation without probabilistic sampling.

The subject was a 68-year-old female presenting with bilateral knee pain that had persisted for approximately four months and was aggravated by walking and prolonged standing. The patient's height was 164 cm and weight was 68 kg, corresponding to a body mass index (BMI) of approximately 25.3 kg/m², classified as overweight according to World Health Organization criteria. The patient reported no history of chronic systemic disease. Medication history included pregabalin (75 mg), gabapentin (100 mg), ibuprofen (400 mg), and methylprednisolone (8 mg), which were prescribed for pain management prior to physiotherapy intervention. The patient's daily activity involved prolonged standing as a trader, which likely contributed to repetitive mechanical loading on the knee joint.

Clinical findings included inspection revealing no visible deformity, palpation indicating tenderness around the knee joint, and functional assessment demonstrating pain during movement and reduced activity tolerance. Special tests showed a positive ballotement test indicating joint effusion and a positive anterior drawer test suggesting anterior instability.

The chronological progression of the case is summarized as follows: the patient initially experienced knee pain four months prior to presentation, followed by clinical and radiological diagnosis. Physiotherapy intervention was initiated shortly thereafter and conducted over five sessions within a three-week period. Outcome evaluations were performed at baseline and after each treatment session, with a final assessment at the end of the intervention period. No long-term follow-up was conducted after completion of the intervention. The chronological progression of the case is summarized in Table 1 to provide a clear overview of the clinical course.

Table 1. Clinical Timeline of the Case

Time Point	Clinical Event
Month 0	Onset of bilateral knee pain
Month 4	Clinical and radiological diagnosis of knee osteoarthritis
Week 1	Initiation of physiotherapy intervention
Week 1–3	Five sessions of quadriceps setting exercise and TENS
Final session	Outcome evaluation

Outcome measures were selected based on their validity and clinical relevance. Pain intensity was assessed using the Visual Analog Scale (VAS), which has demonstrated high validity (r = 0.916–0.971). Functional ability was evaluated using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), with reported validity ranging from 0.809 to 0.964. Range of motion of the knee joint was measured using a goniometer, which has excellent validity (r = 0.98). Muscle strength of the quadriceps and hamstring muscles was assessed using Manual Muscle Testing (MMT), with reported validity of 0.768. All assessments were conducted by the same physiotherapist to ensure measurement consistency.

The intervention consisted of a combination of therapeutic exercise and electrotherapy, specifically quadriceps setting exercise and transcutaneous electrical nerve stimulation (TENS). The intervention protocol was designed based on established principles of therapeutic exercise and pain modulation, with adjustments made according to the patient's tolerance and clinical condition. To ensure clarity and reproducibility, the detailed intervention protocol is presented in Table 2.

Table 2. Therapeutic Intervention Protocol

Intervention	Parameter	Description
Quadriceps Setting Exercise	Frequency	2 sessions/week
	Intensity	Low–moderate isometric contraction based on patient tolerance
	Time	8–10 repetitions × 2–3 sets; 5–10 seconds hold per contraction
	Type	Isometric strengthening exercise
TENS	Frequency	2 sessions/week
	Intensity	Sensory-level stimulation (no visible muscle contraction)
	Mode	Conventional TENS
	Duration	15–20 minutes per session
	Electrode Placement	Around the knee joint (medial and lateral aspects)

The quadriceps setting exercise was performed in a supine or long-sitting position, with the patient instructed to contract the quadriceps muscle by pressing the knee downward while maintaining the contraction for several seconds. This approach aimed to improve neuromuscular activation without inducing excessive joint movement. TENS was applied using surface electrodes placed around the knee joint. The stimulation intensity was adjusted to produce a comfortable tingling sensation without eliciting muscle contraction. The TENS parameters were set at a frequency of 80–100 Hz with a pulse width of 100–200 μs using a conventional continuous mode.

Outcome evaluation was conducted at baseline and after each treatment session to monitor clinical progression. The analysis was performed using a descriptive longitudinal approach, focusing on absolute changes (Δ) and percentage improvements across sessions. Given the nature of a single-case design, no inferential statistical analysis was applied. This study received ethical approval from the Health Research Ethics Committee of RSJD Dr. RM. Soedjarwadi Klaten (No. B/000.9.2/357/2025). All procedures were conducted in accordance with ethical standards for human research.

Results

Clinical outcomes were evaluated at baseline and across five physiotherapy sessions. The results are presented descriptively to demonstrate changes in pain, functional ability, range of motion, and muscle strength over the intervention period. To provide a clear summary of clinical changes before and after the intervention, the main outcomes are presented in Table 3.

Table 3. Summary of Clinical Outcomes Before and After Intervention

Outcome	Baseline	Final Session	Change (Δ)	Interpretation
VAS (movement pain)	8/10	5/10	−3	Clinically meaningful reduction
VAS (rest pain)	4/10	2/10	−2	Improvement
VAS (tenderness)	3/10	1/10	−2	Improvement
WOMAC score	43	33	−10 (~23%)	Improved functional ability
Knee flexion (right)	100°	110°	+10°	Increased ROM
Knee flexion (left)	115°	120°	+5°	Increased ROM
Knee extension (right)	5°	0°	+5°	Normalization
Knee extension (left)	0°	0°	0	Maintained
MMT (quadriceps)	Grade 3–4	Grade 4	+1 grade	Strength improvement

As shown in Table 3, improvements were observed across all measured outcomes following five physiotherapy sessions. Pain intensity demonstrated a consistent reduction over time. At baseline, movement-related pain was reported at 8/10 on the Visual Analog Scale (VAS), which decreased to 5/10 at the final session (Δ=3 points). Resting pain decreased from 4/10 to 2/10, while tenderness decreased from 3/10 to 1/10. A reduction of ≥2 points on the VAS is considered clinically meaningful, indicating a significant improvement in pain perception.

Functional ability, as measured by the WOMAC index, improved from a baseline score of 43 to 33 at the final session (Δ=10 points), representing an approximate 23% improvement. This change reflects enhanced performance in daily activities such as walking, standing, and stair negotiation.

Range of motion (ROM) also improved following the intervention. Knee flexion increased from 100° to 110° in the right knee and from 115° to 120° in the left knee. Additionally, a limitation in right knee extension (5° flexion contracture) was resolved, achieving full extension (0°) at the final session. These findings indicate improved joint mobility and reduced stiffness.

Muscle strength assessment using Manual Muscle Testing (MMT) revealed improvement in quadriceps strength from grade 3–4 at baseline to grade 4 bilaterally after the intervention. This suggests enhanced neuromuscular activation and improved functional support of the knee joint.[21] To illustrate the progression of clinical improvement, pain intensity across each session is presented in Table 4.

Table 3. Progression of Pain Across Sessions

Session	VAS (Movement)	VAS (Rest)
Session 1	8	4
Session 2	7	3
Session 3	6	3
Session 4	6	2
Session 5	5	2

Across the five treatment sessions, progressive improvements were observed in all parameters without any reported adverse events or complications. The patient tolerated the intervention well and demonstrated good adherence to the prescribed exercise program. No long-term follow-up data were available beyond the five-session intervention period.

Discussion

This case report demonstrates that the combination of quadriceps setting exercise and transcutaneous electrical nerve stimulation (TENS) may contribute to clinically meaningful improvements in pain, joint mobility, muscle strength, and functional ability in a patient with bilateral knee osteoarthritis and obesity. The findings provide insight into the potential benefits of a multimodal physiotherapy approach, particularly in individuals with complex risk factors.

The reduction in pain observed in this case is consistent with both biomechanical and neurophysiological mechanisms. Quadriceps setting exercise enhances muscle activation and joint stability, thereby reducing abnormal joint loading and mechanical stress on articular surfaces.[11]Improved joint stability is known to decrease nociceptive stimulation arising from joint structures, which may explain the observed reduction in movement-related pain.[2] In parallel, TENS contributes to analgesia through activation of large-diameter afferent fibers (A-beta), which inhibit nociceptive transmission at the spinal level according to the gate control theory.[10] Additionally, TENS has been shown to stimulate the release of endogenous opioids such as endorphins and enkephalins, further enhancing pain modulation.[9]

An important observation in this case is the interaction between pain reduction and muscle activation. Pain is a well-established contributor to arthrogenic muscle inhibition, a condition in which neural inhibition limits effective muscle contraction.[5] The reduction in pain following TENS application likely facilitated improved quadriceps activation, thereby enhancing the effectiveness of the exercise intervention. This synergistic effect highlights the importance of combining pain management strategies with therapeutic exercise in the rehabilitation of knee osteoarthritis.[12]

Improvements in range of motion (ROM) observed in this case may be attributed to both direct and indirect mechanisms. Although quadriceps setting exercise is an isometric intervention, repeated muscle contractions can improve local circulation and reduce periarticular stiffness, thereby enhancing tissue extensibility.[7] Furthermore, pain reduction achieved through TENS likely increased the patient's tolerance to movement, enabling greater joint excursion during daily activities.[10] These findings are consistent with previous studies reporting that pain reduction is closely associated with improved joint mobility in individuals with knee osteoarthritis.[13]

Muscle strength improvement, as indicated by increased Manual Muscle Testing (MMT) scores, reflects neuromuscular adaptation to repeated isometric contraction. Early-phase strength gains are typically attributed to neural adaptations, including improved motor unit recruitment and firing synchronization, rather than structural hypertrophy.[14] This may explain why measurable strength improvements were observed within a relatively short intervention period. Additionally, the reduction in pain likely reduced inhibitory neural mechanisms, allowing for more effective muscle contraction.[5]

Functional improvement, as demonstrated by a reduction in WOMAC scores, appears to be the cumulative result of decreased pain, improved muscle strength, and enhanced joint mobility.[15] Stronger quadriceps muscles contribute to better load distribution across the knee joint, reducing stress on affected compartments and improving efficiency during functional tasks such as

walking and stair climbing.[16] The observed improvement of approximately 23% in WOMAC score suggests a meaningful enhancement in the patient's ability to perform daily activities.

A key contribution of this case lies in highlighting the role of obesity as a modifier of treatment outcomes. Obesity not only increases mechanical loading on the knee joint but also contributes to systemic inflammation through adipokine activity, which may exacerbate pain and structural degeneration.[5] Despite these challenges, the patient demonstrated positive clinical outcomes, suggesting that a combined intervention approach may be effective even in the presence of obesity-related risk factors. However, it is important to note that the patient's BMI in this case falls within the overweight category, which may influence the generalizability of the findings to individuals with higher degrees of obesity.

When compared with existing literature, the findings of this case are consistent with studies demonstrating that combined exercise and electrotherapy interventions yield superior outcomes compared to single-modality approaches.[12,17] Previous randomized controlled trials have reported significant reductions in pain and improvements in function following TENS application and quadriceps strengthening exercises.[7,9] Recent randomized controlled trials have also demonstrated that structured quadriceps strengthening combined with electrotherapy provides superior improvements in pain and function compared to exercise alone, particularly in moderate knee osteoarthritis populations.[7,9] However, most of these studies involve larger populations, and evidence from case-based clinical reports remains limited, particularly in patients with obesity. Therefore, this case contributes to the growing body of evidence by providing detailed clinical observations in a specific and clinically relevant population.[18]

Despite its contributions, this study has several limitations that should be acknowledged. First, as a single-case report, the findings cannot be generalized to broader populations. Second, the absence of a control condition limits the ability to attribute improvements solely to the intervention. Third, the intervention period was relatively short, and no long-term follow-up was conducted to assess the sustainability of outcomes. Additionally, certain technical parameters of TENS, such as frequency and pulse width, were not fully standardized, which may affect reproducibility.

From a clinical perspective, this case highlights the importance of a multimodal rehabilitation approach that integrates strengthening exercises with pain-modulating modalities. Clinicians should consider combining quadriceps activation exercises with TENS to optimize outcomes, particularly in patients with pain-related movement limitations. Furthermore, attention should be given to patient-specific factors such as obesity, activity level, and tolerance to intervention when designing individualized treatment programs.

In summary, this case provides a clinically relevant illustration of how targeted exercise combined with electrotherapy may improve key outcomes in knee osteoarthritis, while also emphasizing the need for further research to validate these findings in larger and more diverse populations.

Conclusion

This case report indicates that the combination of quadriceps setting exercise and transcutaneous electrical nerve stimulation (TENS) may provide beneficial effects in reducing pain and improving functional outcomes in a patient with bilateral knee osteoarthritis. Improvements were observed in pain intensity, joint range of motion, muscle strength, and functional ability over a short intervention period.

However, these findings should be interpreted with caution due to the single-case design, short duration of intervention, and absence of long-term follow-up. Therefore, the results cannot be generalized to broader populations without further evidence. From a clinical perspective, this case highlights the potential value of integrating targeted quadriceps strengthening with pain-modulating electrotherapy to optimize rehabilitation outcomes, particularly in patients presenting with functional limitations. Future studies with larger sample sizes and controlled designs are required to confirm these findings and establish standardized treatment protocols. Clinically, this case highlights the importance of integrating pain modulation and muscle activation strategies to optimize rehabilitation outcomes in knee osteoarthritis.

Author Contribution

Alya Fasha: Conceptualization, data collection, intervention implementation, and manuscript drafting.
Arif Pristianto: Supervision, methodology development, manuscript review, and editing.
Sukatwo: Data analysis, interpretation of findings, and proofreading.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

This study was approved by the Health Research Ethics Committee of RSJD Dr. RM. Soedjarwadi Klaten (Ethical Approval No. B/000.9.2/357/2025). Written informed consent was obtained from the patient prior to participation

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