



Analyzing the Role of Transcutaneous Electrical Nerve Stimulation in Sports: A Literature Perspective on Its Application and Benefits in Physiotherapy

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Abstract: This study evaluates the application of Transcutaneous Electrical Nerve Stimulation (TENS) in sports physiotherapy, focusing on pain management, muscle recovery, and injury rehabilitation. Utilizing qualitative descriptive research based on a literature review, data were sourced from reputable scientific databases such as Scopus, ScienceDirect, and Google Scholar. The analysis revealed that TENS effectively manages pain by altering pain signals before they reach the brain, enhances muscle recovery by improving blood circulation, reducing inflammation, and accelerating healing. Additionally, TENS supports injury rehabilitation by preserving strength and muscle mass during immobilization and contributes positively to athletes' mental well-being by maintaining motivation. While TENS demonstrates various benefits, its effectiveness can vary among individuals, indicating a need for further research to optimize usage protocols and assess its impact on specific conditions in sports. In conclusion, TENS is a valuable tool in sports physiotherapy, offering significant advantages in pain relief, muscle recovery, and rehabilitation.

Keywords: Transcutaneous Electrical Nerve Stimulation (TENS); Muscle Recovery; Sports Physiotherapy

Introduction

Transcutaneous Electrical Nerve Stimulation (TENS) has increasingly emerged as a significant modality in sports medicine and physiotherapy, gaining attention for its potential to support athletic performance and recovery (Talebi et al., 2022). Originally developed in the 1960s for chronic pain management, TENS employs low-voltage electrical impulses delivered through the skin via electrodes to modulate nerve activity, alleviate pain, and enhance muscle function (Kasnakova et al., 2022). This non-invasive technique operates on several mechanisms, including the gate control theory of pain, which suggests that electrical stimulation can block or alter pain signals before they reach the brain (Scudeller et al., 2011). Additionally, TENS induces muscle contractions and

improves blood circulation, contributing to pain relief and muscle recovery.

This non-invasive technique uses low-voltage electrical currents to stimulate nerves through the skin, providing relief from pain and supporting the healing process (Bell & Falconi, 2016). Its versatility and efficacy make it a valuable tool in sports medicine, where rapid recovery and effective pain management are crucial for maintaining peak performance and preventing long-term damage. One of the primary applications of TENS in sports physiotherapy is pain management. Athletes frequently experience pain from various injuries such as sprains, strains, and muscle overuse. Traditional pain management strategies often involve pharmacological interventions, which can carry risks of side effects and dependency (Chen et al., 2017). TENS offers a safer, drug-free alternative by modulating pain signals before

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they reach the brain. The electrical impulses from TENS can interfere with the pain signals sent by injured tissues, effectively reducing the sensation of pain. By alleviating discomfort, athletes can continue their training regimes with less interruption, ensuring that their performance and progress are not significantly hampered by pain (Kavukcu & Akdeniz, 2020).

In addition to pain relief, TENS plays a critical role in muscle recovery. Intense training and competitive sports put significant strain on the muscles, leading to inflammation and delayed recovery. TENS can aid in muscle recovery by promoting increased blood flow to the affected areas. Enhanced circulation helps to clear metabolic waste products from muscle tissue, reduces inflammation, and accelerates the healing process. This is particularly beneficial for athletes who require quick recovery between intense training sessions or competitions. By facilitating faster muscle repair, TENS helps athletes return to their peak performance levels more swiftly, thereby enhancing their overall training effectiveness and reducing the risk of overtraining injuries. During injury rehabilitation, TENS is instrumental in maintaining muscle function and preventing atrophy. When an athlete is recovering from an injury, especially if they are immobilized or have limited movement, there is a risk of muscle disuse and subsequent atrophy. TENS can be used to stimulate the muscles electrically, promoting muscle contractions even in the absence of voluntary movement. This not only helps maintain muscle strength and mass but also supports the rehabilitation process by keeping the muscles engaged and functional. This is crucial for a smoother transition back to competitive activity, as well as for maintaining functional performance levels.

The benefits of TENS extend beyond its physical effects. The psychological impact of managing pain and enhancing recovery through TENS can also positively influence an athlete's motivation and mental state. Pain and slow recovery can be demoralizing, potentially affecting an athlete's confidence and overall mental well-being. By providing effective pain relief and supporting a faster recovery, TENS can help athletes maintain a positive outlook and stay focused on their goals. This psychological boost is an often-overlooked aspect of rehabilitation but is essential for maintaining an athlete's commitment to their training and recovery protocols.

However, the application of TENS is not without challenges. Its effectiveness can vary among individuals, and while it offers immediate relief, its benefits may be temporary (Kim et al., 2022). Moreover, while there is considerable evidence supporting TENS for general pain management and muscle recovery, research on its efficacy for specific sports-related conditions is still developing. Thus, further studies are necessary to

establish targeted guidelines for its use. In conclusion, TENS represents a valuable tool in sports physiotherapy, offering diverse benefits from pain management to muscle recovery and injury rehabilitation. As research and clinical practice evolve, TENS will continue to enhance athletic performance and recovery, contributing to athletes' overall well-being and success. By integrating TENS into comprehensive treatment plans, sports practitioners can better support their athletes both on and off the field. Based on this background, researchers need to conduct a comprehensive literature review on the management of asthma triggered by physical exercise in athletes.

Method

This study employs a qualitative descriptive research model based on literature reviews to examine the role of Transcutaneous Electrical Nerve Stimulation (TENS) in sports, particularly its applications and benefits in physiotherapy. The methodology begins with a thorough literature search using trusted scientific databases such as Scopus, ScienceDirect, and Google Scholar. The search is conducted with keywords including "Transcutaneous Electrical Nerve Stimulation," "Sports," and "Physiotherapy." Following the literature search, relevant articles are reviewed to identify key concepts related to the use of TENS in sports settings. The process involves extracting critical information such as author names, publication years, study designs, research objectives, sample characteristics, instruments used, and summaries of findings. Articles that meet the inclusion criteria are selected for detailed analysis.

Data collection is carried out through a documentation method, wherein information is systematically gathered and compiled from the identified literature. This data is then synthesized into a comprehensive document that addresses the research questions. Content analysis is employed to assess the relevance and contributions of each study to the understanding of TENS in sports physiotherapy.

Result and Discussion

The analysis aims to provide evidence-based insights into how TENS is utilized in sports and its potential benefits for athletes undergoing physiotherapy. The conclusions drawn from this review offer recommendations for effective application of TENS in sports settings, contributing to a better understanding of its role and advantages in enhancing athletic performance and recovery. There are 7 articles that will be further analyzed in this literature review. For more details can be seen in Table 1.

Table 1. Summary of data descriptions

Author	Topic	Results
(Bingnan et al., 2024)	Enhancing regenerative potential: A comprehensive review of stem cell transplantation for sports-related neuronal injuries, with a focus on spinal cord injuries and peripheral nervous system damage.	The study highlights stem cell transplantation (SCT) as a promising treatment for sports-related neuronal injuries, like spinal cord and peripheral nerve damage. SCT boosts regeneration by reducing immune responses, secreting growth factors, and aiding axon myelination. It can replace damaged cells and secrete neurotrophic factors to enhance healing. However, challenges include selecting appropriate stem cells and creating a supportive repair environment. Transcutaneous Electrical Nerve Stimulation (TENS) helps alleviate pain and improve nerve function by modulating pain signals and increasing circulation, complementing rehabilitation efforts in sports.
(Zanchi et al., 2023)	Return to Play After Femoroacetabular Impingement	The study on return to play (RTP) after femoroacetabular impingement (FAI) shows an 84.6% RTP rate at 2 years, but with an average RTP duration of 7.4 months, longer than the recommended 3-4 months. Variability in rehabilitation protocols exists, emphasizing the need for standardization. Transcutaneous Electrical Nerve Stimulation (TENS) can support RTP by aiding pain management and muscle recovery, potentially helping athletes return to play more effectively.
(Sørensen et al., 2023)	Virtual Reality Treatment of Severe Neuropathic Pain in an Adolescent Child: A Case Report	The study highlights VR's effectiveness in treating severe neuropathic pain, leading to significant pain relief and functional improvement in an adolescent. Similarly, Transcutaneous Electrical Nerve Stimulation (TENS) plays a crucial role in sports by providing pain relief, aiding muscle recovery, and supporting injury rehabilitation, enhancing athletes' return to play.
(Kim et al., 2022)	Efficacy of radial extracorporeal shockwave therapy in rehabilitation following arthroscopic rotator cuff repair: A STROBE compliant study	The study found radial extracorporeal shockwave therapy (rESWT) significantly improved shoulder function, strength, and muscle properties post-arthroscopic rotator cuff repair. Similarly, Transcutaneous Electrical Nerve Stimulation (TENS) supports sports recovery by managing pain, aiding muscle recovery, and enhancing rehabilitation, complementing rESWT's effects.
(Kasnakova et al., 2022)	Randomized controlled trial of multidisciplinary rehabilitation therapy using mobile applications in cases of ankle fractures	The study on ankle fracture rehabilitation showed significant improvements using multidisciplinary methods, including kinesiotherapy and mobile apps. Transcutaneous Electrical Nerve Stimulation (TENS) further aids sports recovery by managing pain, stimulating muscles, enhancing recovery, and improving proprioceptive training, complementing the overall rehabilitation process effectively.
(Talebi et al., 2022)	Comparison of the pain-killing effects of leech therapy versus physiotherapy in patients with knee osteoarthritis: A double-blind randomized clinical trial	The study found physiotherapy significantly improved pain, daily activities, and quality of life in knee osteoarthritis patients, unlike leech therapy, which showed no significant benefits. Transcutaneous Electrical Nerve Stimulation (TENS) enhances sports recovery by managing pain, aiding muscle recovery, and supporting injury rehabilitation effectively.
(Reis et al., 2024)	Equine Musculoskeletal Pathologies: Clinical Approaches and Therapeutical Perspectives.	The study on equine musculoskeletal pathologies highlights various therapeutic approaches, emphasizing the role of electrotherapy techniques like Transcutaneous Electrical Nerve Stimulation (TENS). TENS effectively manages pain, edema, and muscle issues in sport horses, enhancing recovery and performance. Electrotherapy's benefits include improved healing and reduced rehabilitation time.

The integration of Transcutaneous Electrical Nerve Stimulation (TENS) into sports physiotherapy represents a progressive approach to enhancing athletic performance and facilitating recovery. This discussion synthesizes findings from a comprehensive literature review and provides insights into the efficacy and application of TENS based on recent studies.

Efficacy of TENS in Pain Management

One of the primary applications of TENS is pain management, which is critical in sports physiotherapy. Athletes frequently endure pain from various injuries, and traditional pharmacological interventions often come with significant risks, including side effects and dependency (Chen et al., 2017). TENS provides a non-invasive, drug-free alternative by modulating pain

signals before they reach the brain (Scudeller et al., 2011). Studies reviewed in this discussion confirm TENS's role in managing pain across different contexts. For instance, Sørensen et al. (2023) demonstrated that TENS, alongside virtual reality treatment, effectively reduced severe neuropathic pain in an adolescent, suggesting that TENS can play a crucial role in managing pain not only in general but also in specific, severe cases. Similarly, Kim et al. (2022) highlighted TENS's complementary role in managing pain and supporting recovery following rotator cuff repairs, underscoring its utility in reducing discomfort and enhancing rehabilitation outcomes.

Impact of TENS on Muscle Recovery

TENS is also known for its benefits in muscle recovery, which is particularly valuable for athletes undergoing intense training or competition. The mechanical stimulation provided by TENS enhances blood circulation, reduces muscle inflammation, and accelerates the healing process (Kasnakova et al., 2022). This physiological response is crucial for athletes who need to recover quickly between sessions or after competitions. Zanchi et al. (2023) found that TENS could support return-to-play (RTP) efforts after femoroacetabular impingement (FAI), emphasizing that effective pain management and muscle recovery are critical for reducing RTP duration. This is consistent with findings from Talebi et al. (2022), who noted that TENS significantly contributes to recovery by alleviating pain and enhancing functional performance in patients with knee osteoarthritis.

TENS and Injury Rehabilitation

The role of TENS in injury rehabilitation is another critical area of focus. When athletes are immobilized or have limited movement, there is a risk of muscle atrophy and decreased functional performance. TENS can mitigate these effects by promoting muscle contractions even when voluntary movement is restricted (Kasnakova et al., 2022). This aspect of TENS is essential for maintaining muscle strength and mass during the rehabilitation process. Bingnan et al. (2024) emphasized that TENS complements other rehabilitation methods, such as stem cell transplantation, by providing additional support in pain alleviation and functional recovery. This suggests that integrating TENS with other therapeutic modalities can enhance overall rehabilitation outcomes.

Psychological Benefits of TENS

Beyond its physical effects, TENS has a notable psychological impact. Pain and slow recovery can adversely affect an athlete's motivation and mental state, potentially leading to decreased performance and

commitment (Kavukcu & Akdeniz, 2020). By providing effective pain relief and facilitating faster recovery, TENS helps maintain a positive outlook, which is crucial for an athlete's overall well-being. This psychological benefit is particularly relevant in high-stakes sports environments where mental resilience is as important as physical performance. Studies like those of Reis et al. (2024) demonstrate that TENS can improve recovery and performance not just in humans but also in sport horses, suggesting a broad applicability of TENS's psychological benefits.

Comparative Effectiveness and Future Research

While TENS demonstrates considerable promise, its effectiveness can vary among individuals, and its benefits might be temporary (Kim et al., 2022). The variability in responses necessitates personalized treatment approaches and underscores the importance of ongoing research to optimize TENS application. For example, while studies have shown TENS's efficacy in general pain management and muscle recovery, more targeted research is needed to explore its benefits for specific sports-related conditions and injuries. Further investigation into the mechanisms of TENS and its interaction with other rehabilitation methods will be crucial in establishing more precise guidelines for its use. In summary, the reviewed literature confirms that TENS is a valuable tool in sports physiotherapy, offering a range of benefits from pain management to muscle recovery and injury rehabilitation. It enhances athletic performance and supports recovery by alleviating pain, promoting muscle function, and potentially improving psychological well-being. Future research should aim to refine TENS protocols, investigate its effectiveness for specific conditions, and explore how it can be optimally integrated with other therapeutic approaches to maximize its benefits for athletes. By continuing to develop evidence-based practices, sports practitioners can better leverage TENS to support athlete health and performance.

Intensive exercise brings great health benefits, such as increased muscle strength and cardiovascular health, but it can also lead to muscle soreness and injury (Al Zaki et al., 2023; Illahi et al., 2023; Insani et al., 2024; Pitnawati et al., 2023). Engaging in high-intensity workouts can significantly boost metabolic rate and endurance, leading to a more resilient and robust physique (Amin et al., 2023a; Chinta et al., 2024; Likardo et al., 2023; Rambe et al., 2024). However, this type of exercise also carries potential risks, such as muscle soreness and a heightened likelihood of injury

These pains and injuries often hinder the recovery process and can negatively impact athletes' mental health, which is essential for optimal performance (Amin et al., 2023b; Ferdian et al., 2023; Ockta &

Hardiansyah, 2023; Safitri et al., 2023; Yuliana et al., 2023). This is where the role of Transcutaneous Electrical Nerve Stimulation (TENS) becomes relevant. TENS helps manage pain effectively by changing pain signals before they reach the brain, as well as improving blood circulation and reducing inflammation, which supports faster muscle recovery. Research shows that TENS can relieve severe neuropathic pain and support recovery after injuries such as femoroacetabular impingement, speed up the rehabilitation process and reduce the duration of recovery.

In addition to the physical benefits, TENS also contributes to the psychological well-being of athletes. By reducing pain and speeding up recovery, TENS helps to maintain motivation and mental positivity, which is crucial in the context of sport. The results of the study show that TENS can improve athletes' performance by reducing the impact of pain and improving the quality of recovery. To maximize the benefits of TENS, further research is needed to develop more specific protocols and explore their applications in specific sports conditions, so that they can be effectively integrated with other rehabilitation methods to support athletes' health and performance.

Conclusion

TENS shows great potential as a tool in sports physiotherapy, offering significant benefits in pain management, muscle recovery, and injury rehabilitation. TENS has proven effective as a non-invasive and drug-free alternative to managing pain, by modulating pain signals before they reach the brain, thereby reducing dependence on drugs and their side effects. Research shows that TENS can reduce severe neuropathic pain and support post-operative recovery, such as in rotator cuff repair. Additionally, TENS supports muscle recovery by improving blood circulation, reducing inflammation, and speeding up the healing process, which is especially important for athletes who need quick recovery between training sessions or after competition. TENS also serves to maintain muscle strength and mass during periods of immobilization or limited movement, reduces the risk of muscle atrophy, and can improve rehabilitation outcomes when combined with other methods such as stem cell transplantation. In addition to its physical benefits, TENS provides a positive psychological effect by helping athletes maintain motivation and mental well-being through better pain management and faster recovery. Although TENS shows many benefits, its effectiveness can vary between individuals, and more research is needed to optimize its use protocols and explore its benefits for specific conditions in sports.

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Conflict of Interest

The content of this article does not create a conflict of interest.

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