Transcutaneous Electrical Nerve Stimulation (TENS) In Chronic Low Back Pain Management: Principles, Applications, And Future Directions

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Abstract. TENS represents a non-invasive and cost-efficient approach to alleviating chronic lower back pain, providing a viable alternative to pharmaceutical treatments. This article explores the principles, applications, and effectiveness of TENS in managing chronic lower back pain. TENS operates by delivering painless electrical currents to activate nerves beneath the skin's surface, providing flexible and customizable pain relief. It has shown promise in reducing reliance on nonsteroidal anti-inflammatory drugs (NSAIDs) and opioids, thus mitigating potential side effects associated with prolonged medication use. However, the long-term efficacy of TENS remains a subject of debate, and individual differences may influence its effectiveness. This article reviews the existing literature, highlighting the positive impact of TENS on short-term pain relief, especially in the context of lower back pain. Additionally, it discusses variations in research quality and methodology, emphasizing the need for larger-scale trials and personalized treatment plans to enhance its long-term effectiveness. In summary, TENS demonstrates considerable promise as a safe and non-invasive therapeutic choice for addressing chronic lower back pain. While questions remain regarding its long-term efficacy, TENS offers an alternative for patients seeking pain relief without the side effects associated with medication. Future research should focus on personalized approaches and comprehensive studies to further elucidate its role in chronic pain management and improve patients' quality of life.

Keywords: Non-invasive treatment; transcutaneous electrical nerve stimulation; pain management, personalized therapy; chronic low back pain.

1. Introduction

TENS is a program used to activate and stimulate nerves under skin tissues with painless electrical currents. It can be any kind of device that transports electrical currents to reach under the dermal surface. TENS is mainly used for pain relief in replacement for other options like drugs. Usually, TENS devices are easily obtained by being non-positional and it is a relatively cheaper option for treatments compared to long-term prescription drugs for pain relief. These devices consist of a main pulse generator along with a battery that connects to electrodes to deliver pulses through the surface of the skin. Through the hand-held battery and pulse generator, the user can change the level, frequency, duration, and pattern of electrical stimulation [1].

Additionally, TENS has exhibited noteworthy potential in mitigating chronic lower back pain. Lower back pain is a prevalent health concern, frequently arising from diverse factors such as muscle tension, spinal conditions, and enduring lifestyle choices. Patients often seek various methods to alleviate the discomfort associated with lower back pain, and TENS offers a non-invasive, cost-effective, and efficient alternative. By applying electrical stimulation to the nerve regions in the lower back, TENS can alleviate lower back pain without the need for medication, thereby enhancing the quality of life for patients [2].

In this article, we will delve into the application of TENS as a therapeutic approach for addressing chronic lower back pain, placing a specific emphasis on its underlying principles, practical applications, and efficacy. We will delve into how TENS reduces lower back pain by activating subcutaneous nerves and discuss its role in rehabilitation and pain management. Through an in-depth examination of the therapeutic efficacy of TENS, we aim to provide more treatment options for individuals suffering from chronic lower back pain, assisting them in overcoming pain and regaining comfort and freedom in their lives.

2. How TENS works

The usage of TENS as mentioned is mainly for pain relief. The electrodes for converting the electric currents should be placed around the pain area should be placed around the pain area. The two polar will transfer currents and deliver to the nerves which are usually not reach for conventional treatment methods. TENS devices therefore provide a more flexible treatment for relieving pain with eglectable side effects. The correct usage of TENS can effectively eliminate possible such as allergic reactions and muscle discomfort. Consultants with medical providers are recommended beforehand of usage for effective prevention of TENS treatments [3]. Pain control function of TENS is mainly conveyed through two main aspects, Gate control and endorphin release as accompaniment for Gate control.

To start with gate control theory of pain in order to relive pain. The central nervus system receives to review through different "gate" of signals retrieved [4]. Thus, the status of the "gate" are controlled by three major factors, non-painful nerve fibers (A-beta fibers), painful nerve fibers (A-delta and C fibers), and sensory information processed by brain. The system of TENS targets mainly the A-beta fibers, the non-painful nerve fibers, that deliervers to central nervus system painless actions. The electrodes send low frequency electrics waves to stimulate to activate the fibers, therefore achieving purpose of closing the gate.

As accompanyment to gate control theory, the release of Endorphins caused by TENS's mechanism, provides addition pain relief support. Endorphins, as a natural pain lifting chemical produced by the body, are activated by the eclectic shock delivered by the electrodes of TENS. Addition to relieving pain with its own characteristics, Endorphins inhibites the reception of pain from opioid receptors of spinal cords [5]. With the electric wave similar to pain signals, endorphins are generated, due to activation by transferred TENS waves up to spinal cords, in the brain and spreads throughout. Thereby, the endorphins are able to active inhibitory nerve cells to prevent signals delivered to opioid receptors, relieving pain as a result [6].

2.1. Different Types of TENS

2.1.1. Comparison between Conventional TENS, Acupuncture-like TENS (AL-TENS), and Intense TENS

Conventional TENS is commonly used and serves the basic function of transmitting electric currents through the surface of the skin. Conventional TENS typically employs low-intensity pulse signals and a low-frequency shock pattern. Generally, conventional TENS is classified by a stimulation frequency of more than 100 Hz, an intensity of 10–30 mA, and a pulse duration of 50–100 ms [7]. Among these three factors, only the stimulation frequency is considered high, while the intensity is low, and the pulse duration is classified as short. Conventional TENS is less aggressive and only reaches a shallow level beneath the skin's surface. Certain frequency and intensity settings can be adjusted to reach deeper tissues and activate more nerves compared to low-intensity settings.

2.1.2. Acupuncture-like TENS (AL-TENS)

Acupuncture-like TENS originates from conventional TENS with the main difference being the placement of electrodes [1]. Taking inspiration from acupuncture, specific acupoints are targeted in AL-TENS. Electrodes are placed on these special acupoints, allowing the currents to flow similarly

to acupuncture needles. TENS eliminates the need for needles, and the currents are usually programmed with specific stimulation frequencies, intensities, and pulse durations. This programming simulates acupuncture while providing pain relief, improving circulation, and relaxing muscles. The main difference between AL-TENS and conventional TENS is the specific placement of currents on the required acupoints for treatment.

3. Clinical Applications of TENS

3.1. TENS intervention

The TENS intervention entails administering pulsed electrical currents generated by a standard TENS device. These currents are applied to the intact surface of the skin through the use of surface electrodes, with the option to target either the exact pain site or nerve bundles located in proximity to the site of pain.

3.2. Treatment Outcome

Johnson et al. conducted a comprehensive meta-analysis of 381 studies to assess the efficacy of TENS in pain relief [8]. In most cases, patients who underwent TENS treatment experienced a reduction in pain ranging from 30% to 50%. Data analysis led to the conclusion that TENS therapy is effective when applied directly to patients in the short term. TENS has been proven to be an effective method for patient use.

3.3. Adverse Effects

Regarding potential adverse effects, Deyo, R.A., et al. reported that approximately one-third of the participants experienced minor skin irritation at the electrode placement site [9]. Interestingly, these adverse effects occurred with similar frequency in both the TENS and placebo groups. Notably, one participant who had been randomized to the placebo group developed severe dermatitis four days after initiating therapy, leading to their withdrawal from the trial.

4. Advantages

4.1. Reducing the Use of NSAIDs

TENS offers an alternative to traditional pain medications, potentially reducing the reliance on opioids or NSAIDs, which can have adverse effects with prolonged use. Historically, NSAIDs have been the go-to method for relieving low back pain (LBP), affirming their efficacy. Nevertheless, the utilization of NSAIDs increases the likelihood of patients developing chronic back pain [10]. A study conducted by Parisien, M., et al. indicates that NSAIDs can disrupt the normal biological repair process in humans [11]. By employing TENS to alleviate inflammation around the lower back, we can minimize the potential side effects resulting from excessive NSAID usage.

4.2. Effective for Short-Term Therapy

As previously mentioned, TENS has been proven effective in most cases; however, it's important to emphasize its suitability for "short-term" use. Research by Marchand, S., et al. reveals that patients treated with TENS for one week versus those treated for three months or more did not exhibit significant differences [12]. This indicates that TENS is most effectively employed within a multidisciplinary approach for managing low back pain, rather than serving as the sole or prolonged treatment. Furthermore, as per Khadilkar, A., et al., TENS therapy significantly reduces pain and improves performance on the majority of standardized tests of physical capacity [2]. Transcutaneous electrical nerve stimulation should be considered when seeking short-term pain relief. Nevertheless, scientific support for TENS during long-term LBP therapy is lacking.

5. Disadvantages

5.1. Insufficient Scientific Support

When considering the use of TENS for long-term treatments, it lacks the necessary reliability to convince everyone. According to a study conducted by Khadilkar, A., et al., which involved 324 patients with chronic low back pain randomly assigned to one of four treatment groups, TENS therapy was observed to be as effective as a placebo [2]. Similarly, research by Deyo, R.A., et al. indicates that TENS does not provide greater benefits than a placebo and does not seem to offer any additional advantage over exercise alone for patients with chronic low back pain [9]. These studies, taken together, suggest that TENS may not be an effective solution for addressing issues related to low back pain.

5.2. Potential for Allergic Reactions

Although TENS is commonly used for treatment, it may trigger allergies in certain cases. According to a case study conducted by Weber-Muller, F., et al., a fifty-year-old patient reported eczematous lesions after TENS treatment [13]. Deeper analysis uncovered several potential contributors to allergic reactions, including the presence of propylene glycol in the electrode gel, the use of mercaptobenzothiazole rubber in the electrodes, and the metallic components of the electrodes containing nickel. For individuals who are sensitive or allergic to these substances, alternative methods are advisable.

5.3. Risk for Certain Population Groups

Administering an electrical current to muscles via electrodes, TENS has the potential to generate electromagnetic interference with pacemakers and implanted cardioverter defibrillators, necessitating cautious application. According to Badger, J., P. Taylor, and I. Swain's study regarding a similar method to TENS, these methods appear relatively safe in small-scale studies [14]. Nevertheless, as the author recommends, caution should be exercised when using FES in patients with pacemakers and ICDs until additional research is conducted. Furthermore, for the treatment of lower back pain using TENS, further research is necessary to ensure patient safety.

6. Future Outlook and Recommendations

6.1. Future Research Directions

6.1.1 Larger-Scale Clinical Trials

To thoroughly assess the effectiveness of TENS across diverse types of chronic low back pain patients, it is imperative to conduct larger-scale multicenter clinical trials. These trials can further confirm the role of TENS in pain management and identify which patient groups are most likely to benefit from TENS therapy.

6.1.2 Mechanistic Studies

Gaining a precise understanding of the influence of TENS on the nervous system and pain perception is paramount. Future research endeavors may delve into the impact of TENS on neurotransmitters, brain activity, and neural plasticity, facilitating a more profound comprehension of the underlying mechanisms of TENS.

6.1.3 Personalized Treatment

Since individual differences in pain perception and response can be significant, future research can focus on developing personalized TENS treatment plans tailored to individual patients' needs. This may involve customization based on genetic, neurobiological, or physiological factors.

6.1.4 Long-Term Effectiveness Studies

Current research on TENS primarily focuses on short-term effects. Subsequent research can explore the long-term efficacy of TENS in managing pain for individuals with chronic low back pain. This will help determine whether TENS can be a viable option for long-term treatment.

6.2. Clinical Practice Recommendations

6.2.1 Individualized Treatment Plans

When using TENS to treat chronic low back pain patients, consider developing individualized treatment plans. This should take into account the patient's medical history, type of pain, and pain severity to determine the most appropriate TENS parameter settings.

6.2.2 Patient Education

Healthcare professionals should educate patients on how to use TENS devices correctly, including proper electrode placement and parameter adjustments. Patients should be informed that TENS is a short-term pain management method and may need to be combined with other treatment modalities.

6.2.3 Long-Term Effects Monitoring

For patients undergoing TENS therapy, regular monitoring of their pain status and assessment of the long-term effects of treatment are essential. If TENS therapy fails to maintain pain relief over the long term, a reevaluation of the treatment plan is necessary.

6.2.4 Safety Precautions

When administering TENS therapy, healthcare professionals should be mindful of potential allergic reactions or patients with medical devices such as pacemakers. Ensuring the safety of the treatment is critical to patient well-being.

7. Conclusion

In conclusion, TENS holds potential as a low-risk, non-invasive treatment option for addressing chronic low back pain. In the short term, TENS can provide effective pain relief and reduce reliance on medications, especially NSAIDs. Additionally, TENS can serve as an adjunctive therapy, improving patients' quality of life.

However, it is crucial to acknowledge that certain research findings raise concerns regarding the long-term effectiveness of TENS, particularly in the context of extended treatment for chronic low back pain. Some studies propose that the efficacy of TENS might fluctuate due to individual variances, and the literature still harbors some debate on this matter. Furthermore, variations in research quality and methodology among the reviewed studies may impact our assessment of TENS.

Despite these limitations, TENS retains its potential value as a non-invasive, low-risk treatment modality for managing chronic low back pain. Multiple studies have provided support for the pain relief effects of TENS, especially in the short term. For patients who are unsuitable for or prefer to avoid pharmaceutical interventions, TENS provides a viable alternative.

The future of TENS in the treatment of chronic low back pain demands additional exploration, especially through larger-scale trials and personalized approaches. This research will empower healthcare professionals to make informed treatment recommendations and ultimately enhance the quality of life for patients.

Authors Contribution

All the authors contributed equally, and their names were listed in alphabetical order.

References

[1] Johnson M. Transcutaneous Electrical Nerve Stimulation: Mechanisms, Clinical Application and Evidence . Rev Pain, 2007, 1(1): 7-11.

[2] Khadilkar A, Milne S, Brosseau L, et al. Transcutaneous electrical nerve stimulation (TENS) for chronic low-back pain . Cochrane Database Syst Rev, 2005, (3): Cd003008.

[3] Teoli D, An J. Transcutaneous Electrical Nerve Stimulation [M]. StatPearls. Treasure Island (FL); StatPearls Publishing Copyright © 2023, StatPearls Publishing LLC. 2023.

[4] Melzack R, Wall P D. Pain mechanisms: a new theory . Science, 1965, 150(3699): 971-9.

[5] Sluka K A, Deacon M, Stibal A, et al. Spinal blockade of opioid receptors prevents the analgesia produced by TENS in arthritic rats . J Pharmacol Exp Ther, 1999, 289(2): 840-6.

[6] Kalra A, Urban M O, Sluka K A. Blockade of opioid receptors in rostral ventral medulla prevents antihyperalgesia produced by transcutaneous electrical nerve stimulation (TENS) . J Pharmacol Exp Ther, 2001, 298(1): 257-63.

[7] Lund I, Lundeberg T, Kowalski J, et al. Gender differences in electrical pain threshold responses to transcutaneous electrical nerve stimulation (TENS) . Neurosci Lett, 2005, 375(2): 75-80.

[8] Johnson M I, Paley C A, Jones G, et al. Efficacy and safety of transcutaneous electrical nerve stimulation (TENS) for acute and chronic pain in adults: a systematic review and meta-analysis of 381 studies (the meta-TENS study) . BMJ Open, 2022, 12(2): e051073.

[9] Deyo R A, Walsh N E, Martin D C, et al. A controlled trial of transcutaneous electrical nerve stimulation (TENS) and exercise for chronic low back pain . N Engl J Med, 1990, 322(23): 1627-34.

[10] Van Der Gaag W H, Roelofs P D, Enthoven W T, et al. Non-steroidal anti-inflammatory drugs for acute low back pain . Emergencias, 2022, 34(1): 66-7.

[11] Parisien M, Lima L V, Dagostino C, et al. Acute inflammatory response via neutrophil activation protects against the development of chronic pain . Sci Transl Med, 2022, 14(644): eabj9954.

[12] Marchand S, Charest J, Li J, et al. Is TENS purely a placebo effect? A controlled study on chronic low back pain . Pain, 1993, 54(1): 99-106.

[13] Weber-Muller F, Reichert-Penetrat S, Schmutz J L, et al. [Contact dermatitis from polyacrylate in TENS electrode] . Ann Dermatol Venereol, 2004, 131(5): 478-80.

[14] Badger J, Taylor P, Swain I. The safety of electrical stimulation in patients with pacemakers and implantable cardioverter defibrillators: A systematic review . J Rehabil Assist Technol Eng, 2017, 4: 2055668317745498.