A Survey of the Effects of Electrical Stimulation on Pain in Patients with Knee Osteoarthritis

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Abstract. Objective: To determine whether electrical stimulation therapy is effective at reducing pain in people with knee osteoarthritis.

Methods: Various literatures on the treatment of pain in osteoarthritis of knee joint with electrical stimulation were searched. According to the title and abstract, the search records were independently screened, and the author, study design, study population, type of electrical stimulation, evaluation criteria, results and other information were extracted.

Results: Ten randomized controlled trials involving 405 patients diagnosed with knee osteoarthritis found that both TENS and NMES had a positive effect on the analgesic effects of knee arthritis, but further work is still needed to clarify the long-term treatment effect of electrical stimulation in terms of knee arthritis pain.

Conclusion: TENS treatment is more effective than NMES treatment in relieving joint pain in people who have KOA. In future studies, In future studies, the experimental analysis of the same parameter of TENS is needed to determine better methods of pain relief.

Keywords: Electrical stimulation · knee osteoarthritis · TENS · NMES · pain

1 Introduction

Knee osteoarthritis (KOA) is the most common disease in arthritis. Its main symptoms are knee pain and knee stiffness, which inconvenience people to move, and can even lead to functional disability [1] in severe cases. Globally, the majority of its patients are senior citizen [2]. The onset factors of osteoarthritis include damage to the articular cartilage inside the joint, which produces a variety of symptoms including joint pain, knee swelling, bone spur formation and reduced range of motion, so that the development of muscle weakness, mobility, and even disability, seriously, et al.affecting the normal life of the elderly [3].

The pain and exercise loss caused by knee osteoarthritis bring a lot of constant to people's lives, so how to better treat the problem of knee osteoarthritis has been much concerned. From the type of treatment, although there are drug therapy, non-drug therapy, invasive intervention and physical therapy [4], the therapeutic effect is not satisfactory, so pain therapy is the most concerned and feasible treatment method at present [5].

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Electrical stimulation (ES), as a non-invasive treatment, delivers various stimuli from the skin surface by placing electrodes on the skin to increase muscle strength, reduce joint stiffness and muscle spasm [6, 7], so as to play a role in pain relief, and has been put into use in several fields and has achieved remarkable results, like rehabilitation therapy. It has different types of use in relieving knee osteoarthritis pain, including TENS, NMES, IFC, PES, NIN, etc. [8]. In practical applications, TENS and NMES are the most common, so this paper takes them as examples to analyze the effectiveness of electrical stimulation in treating pain for patients who have knee osteoarthritis.

The treatment method of TENS is proposed by Melzack and based on the "Gate-Control Theory", and because of its pain-relieving function, it is often used to treat knee osteoarthritis pain [9–11]. Literature search showed that TENS had a positive effect on knee osteoarthritis when it was used in randomized controlled trials [8, 12, 13].Neuromuscular electrical stimulation (NMES) works by stimulating nerves and/or muscles with electrodes to induce muscle contraction, which can increase muscle load and improve muscle strength through electrical induced contraction [14], thus relieving pain. Studies have shown that NMES can promote the strength of the quadriceps muscle, resulting in effective pain relief [15, 16].The review provided strong evidence that both TENS and NMES have a role in pain relief, howeve, the article also has some limitations, and the specific efficacy of the two still need to be further discussed [8, 17, 18].

Therefore, this systematic review of electrical stimulation therapy is aimed to analyze the role of TENS and NMES in reducing pain in patients with KOA. Through a review of the available literature, we speculate that TENS is more useful than NMES treatment in treating KOA pain.

2 Methods

First, the literature search was conducted on the CNKI, PubMed, ScienceDirect, and Web of science databases as of December 2022. Keywords searched include "electrical stimulation", "transcutaneous electrical nerve stimulation", "neuromuscular electrical stimulation", "knee osteoarthritis" and "pain".

Next, the literature was screened by identifying whether the title and abstract of the paper met the requirements. Finally, the English randomized controlled trial (RCT) from 2004 to 2020 was selected. These studies included studies in which TNES or NMES were combined with other therapy and TENS or NMES were compared with other treatments. Experiments in which patients had undergone knee replacement surgery were excluded. Studies using other electrical stimuli and studies using implantable electrodes were also excluded.

3 Result

A total of 10 randomized controlled trials (RCTs) were selected for systematic analysis, and the study methods of these 10 experiments were summarized [19–28]. As shown in Table 1.

Table 1. Study methods.

Author	Study design	Type of electrical stimulation	Outcome Measures for pain	Particiapants / Groups	Treatment Duraiton	Parameters	Conclusion
Arslan (2020)	*RCT*	*NMES*	*VAS WOMAC*	*38 participant Groups: NMES + physiotherapy:21, physiotherapy:17*	*Five times a week for two weeks (ten sessions)*	*Frequency: 100Hz Pulse width: 60 ms Duration: 20 min*	*In terms of pain, NMES provided no additional benefit to patients*
Matsuse (2019)	*RCT*	*NMES*	*KOOS*	*20 participants Groups: NMES + vc: 10, TENS: 10*	*Twice a week for twelve weeks (twenty-four sessions)*	*Frequency: 40 Hz Pulse width: 2.4–22.6 ms Duration: 30min Burst duty cycle: 10% Pulse duration: 200μs*	*NMES is effective for obese women with knee pain*
Rabe (2018)	*RCT*	*NMES*	*KOOS*	*35 participants Groups: NMES + vc:17, LLRT:18*	*Twice a week for twelve weeks (twenty-four sessions)*	*Frequency: 40 Hz Pulse width:2.4–22.6 ms Duration: 20 min Burst duty cycle: 10% Pulse duration: 200 μs*	*NMES can effectively relieve pain in women with knee osteoarthritis*
Palmieri-Smith (2010)	*RCT*	*NMES*	*WOMAC*	*30 participants Groups: NMES: 16, Standard of care: 14*	*Three times a week for four weeks (twelve sessions)*	*Frequency: 50Hz Intensity: vary*	*Women treated with NMES had less pain and were more able to function*
Rosemffet (2004)	*RCT*	*NMES*	*VAS WOMAC*	*26 participants Groups: FES: 8, exercise program: 10, FES + exercise program: 8*	*Three times a week for eight weeks (twenty-four sessions)*	*Frequency: 25 Hz Intensity: 60-80 mA Duration: 30 min*	*FES may be a useful treatment for patients who have KOA*
Sajadi (2020)	*RCT*	*TENS*	*VAS*	*105 participants Groups: TENS: 53, Leech therapy: 52*	*Five times a week for three weeks (fifteen sessions)*	*Frequency: 40 - 150 Hz Intensity: vary Duration: 20 min*	*Patients receiving TENS had significant analgesic effects*

(*continued*)

Table 1. (*continued*)

Author	Study design	Type of electrical stimulation	Outcome Measures for pain	Particiapants / Groups	Treatment Duraiton	Parameters	Conclusion
Khan (2018)	*RCT*	*TENS*	*VAS*	*60 participants Groups: TENS:30, NSAID + ADL:30*	*Three times a week for six weeks (eighteen sessions)*	*Frequency: 80 Hz Intensity: 10-30 mA Duration: 20 min*	*TENS is more effective at relieving pain than medication*
Kanako (2018)	*RCT*	*TENS*	*VAS*	*50 participants Groups: TENS:25, Sham-TENS:25*		*Frequency: 1-250 Hz Pulse width: 60 μs*	*TENS effectively reduces pain, particularly in preradiographic knee OA*
Cherian (2016)	*RCT*	*TENS*	*VAS*	*36 participants Groups: TENS:18, physical therapy:18*	*Six weeks*	*Pulse duration: 48-400 μs*	*TENS provided more pain relief than standard treatments*
Chen (2013)	*RCT*	*TENS*	*VAS*	*50 participants Groups: TENS:23, HA injection:27*	*Three times a week for four weeks (twelve sessions)*	*Pulse width: 200 μs Intensity: vary Duration: 20 min*	*TENS treatment provides more pain relief than HA injection*

3.1 Participants Studied

In total, 405 patients with KOA participated in the ten studies. All patients enrolled in the randomized trial were recruited from a clinical setting and were voluntary participants. All patients included in the study had imaging evidence of knee osteoarthritis (Kellgren and Lawrence scales > Level 1) or clinical evidence of knee osteoarthritis. There were no specific gender ratios or age requirements in any of the experiments.

3.2 Treatment Approaches

In Table 1, the types of electrical stimulation, parameter Settings and experiment time used in ten randomized experiments were summarized. Only one experiment did not report the experiment time, and all the experiments had different parameters. n different experiments, the choice of equipment model and manufacturer is different; Different requirements for the placement of equipment; The number Settings for the same parameter are also different.

3.3 Outcome Measures

In ten randomized trials, pain severity of knee OA was measured mostly by VAS and WOMacs, with only two trials using KOOS as a measure.

VAS (visual analogue scale) is a scale to measure the pain degree of patients. It reflects the pain degree of patients in the form of numbers. Using a 10cm straight line

or ruler, the patient is asked to select a number between 0 and 10 to indicate his pain level, with 0 being "no pain" and 10 being "as much pain as possible".

WOMAC is often used to measure knee pain, stiffness, and physical function in patients with knee OA, it includes 3 subscales, 24 items. Patients are asked to rate the items in relation to their condition, with higher scores indicating more severe symptoms, the most limiting, and poorer health [29, 30].

KOOS(Knee Injury and Osteoarthritis Outcome Score) is a questionnaire to evaluate the therapeutic effect of knee injury and osteoarthropathy mainly through patient self-assessment management. It includes pain, symptoms, activity ability of daily living, sports and recreation ability, and quality of life related to knee joint. Patients need to score it based on their own conditions. The lower the score, the better the treatment effect.

4 Discussion

Ten studies investigated the treatment impact of electrical stimulation (TENS and NMES) on pain in people with KOA. By analyzing the literature, it is found that electrical stimulation plays an positive role in the therapeutic effect of pain, and the therapeutic effect of TENS on pain is significant.

TENS is a common analgesic method. In a randomized trial of the TENS studied, TENS was used to treat painful conditions in KOA. The different data provided by the five selected random experiments indicate that TENS was significantly effective in treating pain, whether compared with other forms of electrical stimulation, conventional therapy or medication. TENS, whether in the form of electrode patches or portable wearables, is always effective in pain treatment for patients who have KOA. NMES is a type of physical therapy commonly used to treat knee osteoarthritis. In the randomized trial of NMES studied, NMES were used to treat pain and motion recovery in knee osteoarthritis. Different evidence from five randomized trials indicated that NMES alone or in combination with other ttreatments can slow down the pain level in patients with KOA. However, some experiments have shown that the therapeutic effect of NMES on pain is not so obvious as that of TENS, so long-term experiments should be carried out for observation.

TENS, which uses electrical stimulation to relieve pain, has advanced in many types since it was first proposed by Melzack and has received many applications in the field of pain management, including knee pain management [31]. When TENS is in use, electrodes stimulate the pain-sensing nerve tissue to keep it in a state of continuous excitation, thereby increasing the pain threshold due to fatigue (pain nerves become desensitized); At the same time, TENS stimulation on the nerve can also promote the dilation of blood vessels near the knee joint and accelerate blood circulation, so it has a good analgesic effect, which can be seen in a short time. The physical characteristics of NMES, such as current frequency, waveform and wave width, are more suitable for stimulating muscle contraction than analgesia. Different strength of muscle contraction can be used to improve muscle strength, muscle facilitation, joint motion and other functions, and can also indirectly activate nerve tissue, which can improve neuromuscular efficiency to some extent. Therefore, NMES is more effective than TENS in the recovery of knee motor ability. TENS works better than NMES for pain relief.

One limitation of this paper is that it is possible that all included articles based their treatment protocols on previously published similar treatment guidelines, which means that another studies or all treatment approaches may have been overlooked. Another limitation of this paper is the inconsistency of the electrical stimulation parameters used and the lack of uniformity in the published literature. In the ten experiments studied, the frequency ranges from 25-250Hz, and the frequency ranges from 40-80Hz; Pulse widths vary from 2-60ms; Pulse duration, duty cycle and experiment time are not uniform, so it is not possible to group the experiment according to the setting of equipment parameters, and it is not possible to conduct quantitative analysis of the experiment. Therefore, the analysis of electrical stimulation in this paper is qualitative. It is hoped that future studies can include more Settings of parameters equivalent to the frequency, so as to better analyze experimental results and better determine treatment methods.At the same time, in future experimental studies, longer follow-up and research should be used to better evaluate the treatment effect and safety of electrical stimulation.

5 Conclusions

In summary, we analyzed the therapeutic effects of different types of electrical stimulation on osteoarthritis pain in the knee joint. Studies have shown that both TENS and NMES have positive analgesic effects on knee arthritis, but the best analgesic effect is TENS. In future studies, it is necessary to increase the experimental analysis of TENS with the same parameters to determine better methods of pain relief.

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