REVIEW

Nr 2022;12 (2):191-198

Transcutaneous Electrical Stimulation (TENS) Parameters in Individuals with Fibromyalgia: a Systematic Review with Meta-Analysis

G. Batista de Aguiar[1], T. K. Bloot[1], A. E. Rauber Pilonetto[1], M. R. Buzanello Azevedo[1], D. P. Artioli[2], G. R. Flor Bertolini[1]

[1] *Universidade Estadual do Oeste do Paraná (Unioeste), Cascavel, Paraná, Brazil*
[2] *Fundação Lusíadas (Unilus), Santos, São Paulo, Brazil*

CORRESPONDING AUTHOR:
Gladson Ricardo Flor Bertolini
Universidade Estadual do Oeste do Paraná (Unioeste),
Universitaria St 2069
Cascavel, Paraná, Brazil
E-mail: gladsonricardo@gmail.com

DOI:
10.32098/mltj.02.2022.13

LEVEL OF EVIDENCE: 1A

SUMMARY

Background. Fibromyalgia is a non-inflammatory condition characterized by widespread musculoskeletal pain in conjunction with a large number of specific areas of the body that are hypersensitive and painful to touch. Transcutaneous electrical nerve stimulation (TENS) is a potential non-pharmacological treatment for pain control in patients with fibromyalgia. Therefore, the present study aimed to conduct a systematic review of the literature to verify the therapeutic parameters of the application of TENS in people with fibromyalgia.

Methods. This systematic review was performed according to the criteria established for the Preferred Reporting Items for Systematic Reviews and Meta-Analysis - PRISMA.

Results. The application of TENS in patients with fibromyalgia is effective for the reduction of pain when associated with therapeutic exercises in relation to patients who perform the exercise alone. However, not enough studies with similar results were found to associate the effects of TENS application on quality of life, the impact of the disease, fatigue, and depression, but the meta-analyses carried out did not show advantages for the intensity of pain at rest.

Conclusions. There is great variability in the parameters observed in the use of TENS in individuals with fibromyalgia, which generates the need for more primary studies that aim to establish optimal parameters for this condition.

KEY WORDS

Electric stimulation therapy; fibromyalgia; pain measurement; physical therapy modalities; transcutaneous electric nerve stimulation.

INTRODUCTION

Fibromyalgia is a non-inflammatory condition characterized by widespread musculoskeletal pain, usually, the pain tends to be continuous, but the intensity can vary depending on factors such as stress, physical activity, and the weather (1, 2). Other symptoms described are morning stiffness, muscle spasm, fatigue, poor sleep quality, headaches, depression, and irritable bowel syndrome (3). Women are more affected, and the occurrence of the disease increases with the aging. However, the causes of fibromyalgia are not well delineated, presenting characteristics similar to neuropathic pain, including changes in the central nervous system (CNS) (4–6). Chronic pain also interferes in the psychological functions, altering their emotional states and consequently affecting their quality of life (7–9).

There are no definitive treatments for fibromyalgia, so the minority of patients experience clinically relevant benefits from various interventions, pharmacological and non-phar-

macological. Pharmacologic treatment generally is done with so-called nonconventional analgesics such as antidepressants, duloxetine, and amitriptyline (10, 11) or antiepileptic drugs such as gabapentin and pregabalin (12, 13). Among nonpharmacological therapies, there are several physiotherapeutic interventions. Some of the therapies are: acupuncture; manual therapy; kinesiotherapy; hydrotherapy; and electrotherapy. Electrotherapy has been shown to be a viable procedure that can provide considerable pain relief and improve patient quality of life (14–17).

Transcutaneous electrical nerve stimulation (TENS) is a potential nonpharmacological treatment for pain control in patients with fibromyalgia. TENS consists of the transcutaneous application of a low-frequency, pulsed electric current that has a biphasic waveform, symmetrical or asymmetrical and balanced. This characteristic provides the stimulation of nerve receptors and has a component of direct current equal to zero. TENS is performed by applying electrodes to intact skin, with the objective of stimulating nerve fibers, activating central ascending and/or descending inhibitory mechanisms, and reducing excitatory signals in the posterior horn of the spinal cord. Furthermore, its low cost, portability, and ease of autonomy by the patient, in addition to the absence of significant adverse effects, can justify the application of TENS in people who suffer from central sensitization processes, such as in cases of fibromyalgia (18–21)

Given the relevance of the application of TENS in individuals with fibromyalgia, the objective of this study was to perform a systematic review of the literature to verify the therapeutic parameters of the application of TENS in individuals with fibromyalgia, targeting the physical and psychological context, when therapy was compared with a placebo group or with the application of other forms of therapy, in addition to the effectiveness of this form of therapy in reducing pain at rest by meta-analysis.

MATERIALS AND METHODS

The systematic review was conducted according to the criteria established for the conduct of reviews, Preferred Reporting Items for Systematic Reviews and Meta-Analysis – PRISMA (22).

Eligibility and study selection criteria

Electronic databases were used: National Library of Medicine (PubMED), Cochrane, Google Academic, Physiotherapy Evidence Database (PEDro), and Latin American and Caribbean Literature on Health Sciences (LILACS), searching for articles related to the effects of transcutaneous electrical nerve stimulation on individuals with fibromyalgia, searched in the periods June to August 2021.

The searches were conducted with the terms “fibromyalgia”, “transcutaneous electrical nerve stimulation” and “effects”, correlating them with “and” to form the combinations.

Inclusion and exclusion criteria

Inclusions criteria: linical trials, that had TENS as an intervention on individuals with fibromyalgia were included, of both genders. Studies with transcutaneous electrical nerve stimulation administered as a single treatment or in combination with other treatments were also included.

Exclusion criteria: case reports, studies that did not determine the dose of TENS, were not available in full, involving children, animals, and individuals with other conditions not related to fibromyalgia were excluded

The analysis of the selected articles was performed by two reviewers, who independently determined the eligibility of the study. In situations of disagreement about the inclusion of the study, a third evaluator was responsible for the insertion or not of the article in this review. The same procedure was used in the evaluation of the internal validity of the studies, using the PEDro scale (23).

Regarding the sequence of steps for the selection of articles, first the identification and selection of articles was carried out, then the eligibility was carried out in which the inclusion and exclusion criteria were applied, and finall , the inclusion of articles that fit the methodology of this revie .

Data analysis

Data were described qualitatively and the main information (authors, type of intervention, application parameters, and other variables analyzed) was shown in tables. Clinical heterogeneity was assessed by two authors and meta-analysis was performed where both agreed that study participants, interventions, and outcomes were sufficiently similar. The results of clinically and statistically homogeneous studies were meta-analyzed using Review Manager software (RevMan 2011). Meta-analysis was conducted using the inverse variance method for continuous outcomes. A random-effects model was used. The heterogeneity in the data was verified by Chi^2 and I^2 and the significance level was set at 5%. The results were separated according to comparison mode, control/placebo group or other form of therapy.

RESULTS

Selected studies

The database search resulted in 151 studies, of which 143 articles were excluded after analysis by the researchers because they were duplicated in databases or did not meet the methodological criteria reported in this review (**figure 1**).

The present review included eight randomized clinical trials that addressed the application of TENS in patients with fibromyalgia. The sample size in the studies ranged from 10 to 301 individuals of both genders, aged 18 to 76 years.

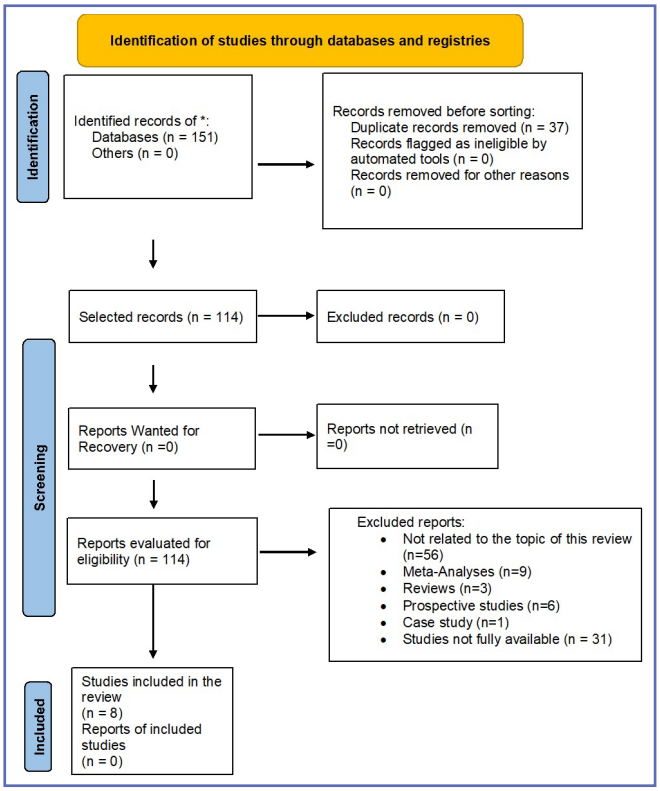

Figure 1. Flowchart according to the PRISMA method.

Parameters

The search checked the application parameters and the effects caused in patients who underwent therapy with TENS alone or with TENS associated with other therapies, compared to a placebo group or a group undergoing other types of therapy.

In relation to the electrostimulation characteristics of the 8 analyzed studies, it was possible to observe some similarities with respect to the application of TENS (**table I**).

The studies used frequencies equal to or higher than 60 Hz, with the exception of Silva *et al.* (24) who used a frequency of 15 Hz and Lauretti *et al.* (25), in which the frequency ranged from 2 to 100 Hz. Regarding phase duration, it was applied between 150-200 µs, with the exception of Yuksel *et al.* (26) who applied a phase duration of 100 ms and Jamison *et al.* (27) who applied 290 µs. Regarding intensity, 3 studies used the maximum tolerated by the patient (28–30) and 3 studies used intensity according to the patient's sensitivity, that is, the intensity was applied until the patient felt a constant tingling throughout the application time without causing discomfort or contraction (24, 26, 27). The study by Lauretti *et al.* (25) was the only one to specify the application intensity at 60 mA. The study by Castro-Sánchez *et al.* (31) did not report the intensity, but was the only one to present the application of a current with a pulse frequency of 100 Hz and a burst of 2 Hz. The time of each session ranged from 10 to 60 minutes. Only Dailey *et al.* (29) performed a single session to evaluate the immediate effects of TENS.

There were similarities regarding the positioning of the electrodes on the trapezius, supraspinatus, gluteus, cervicothoracic region and lower back. Only in the study by Jamison e*t*

Table I. TENS application parameters.

Parameters for the application of TENS	Silva *et al.* (21)	Carbonario *et al.* (22)	Dailey *et al.* (23)	Yuksel et al. (24)	Dailey *et al.* (25)	Lauretti *et al.* (26)	Jamison *et al.* (27)	Castro-Sánchez *et al.* (28)
Frequency (Hz)	15	150	100	70	2-125	2-100	60-100	100
Phase Duration (µs ou ms)	150 µs	150 µs	200 µs	100 ms	200 µs	200 µs	290 µs	200 µs
Intensity	Strong, but comfortable	Intensity maximum tolerated	Intensity maximum tolerated	Strong, but comfortable	Intensity maximum tolerated	60 mA	Strong, but comfortable	Not specifie
Session duration (minutes)	40	30	30	20	30	20	60	10
Positioning two eletrodes (bilaterally)	Trapezius, Supra-spinatus, Gluteal region	Trapezius, Supra-spinatus,	Cervical and lumbosacral region	Thoracic region (T2/T6)	Cervical and lumbosacral region	C7 or L5 Region	Top of the calf	Trapezius, latissimus dorsi, gluteus, tibialis anterior

al. (27) were electrodes applied to the upper calf region and only one of the studies also applied the anterior region of the anterior region of the electrodes to the latissimus dorsi and tibialis anterior region (31).

Regarding the type of electrodes, none of the articles specify the size and material used, with the exception of the work by Jamison *et al*. (27), which describes the use of 4 hydrogel pads, with a surface area of 60 cm^2 for the application of TENS. Furthermore, only the study by Castro-Sánchez *et al*. (31) reports the application of 32 mm diameter electrodes in the most painful region of the patient.

Table II shows the information concerning the scores obtained by the 8 selected clinical trials according to the PEDro scale.

Outcomes

Pain

In six analyzed studies, a significant decrease in pain was observed compared to a placebo group. In addition, Silva *et al*. (24) demonstrated that a group treated with TENS showed superior effects than a group treated with hydrotherapy. The study by Castro-Sánchez *et al*. (31) demonstrated that both dry needling therapy and TENS therapy can reduce pain in patients with fibromyalgia. In the study by Yuksel *et al*. (26), TENS treatment was found to result in a significant decrease in pain intensity, as in well as acupuncture application, demonstrating that there was no superiority between the techniques.

Table II. Classification of studies according to the PEDro scale.

PEDro scale	Silva *et al..,* 2008	Carbonario *et al..,* 2013	Dailey *et al..,* 2020	Dailey *et al..,* 2013	Yuksel *et al..,* 2019	Lauretti *et al.,* 2013	Jamison *et al.,* 2021	Sánchez *et al..,* 2020
1. Eligibility Criteria	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Random distribution	1	0	1	1	1	1	1	1
3. Secret allocation of subjects	0	0	1	1	0	0	1	1
4. Initial similarity between the groups groups	1	1	1	1	1	1	1	1
5. "Blinding" of the subjects	1	0	0	0	0	1	1	0
6. "Blinding" of therapists	0	0	0	0	0	0	0	0
7. "Evaluator "Blinding	1	0	1	1	0	1	1	1
8. Measurements obtained in more than 85% of the subjects	1	1	1	1	1	1	1	1
9. Intention-to-treat analysis analysis	0	0	0	0	0	0	0	0
10. Intergroup comparisons	0	1	1	1	1	1	1	1
11. Measures of precision and variability	1	1	1	1	1	1	1	1
Total score	7/10	5/10	8/10	8/10	6/10	8/10	9/10	8/10

One study combined TENS with exercise programs. A reduction in muscle pain was reported when TENS was added (28) and in the same study, a reduction in pain and an increase in pain thresholds to pressure, not observed in the group that performed exercise alone, was observed. Four studies evaluated the effectiveness of TENS on fatigue and, in all, a decrease was shown compared to the placebo group (25, 28–30). The impact of disease was also evaluated in two studies (27, 30) and only in the study by Jamison *et al.* (27), was there a reduction in the impact of disease in patients who used TENS for 3 months.

Quality of life

Quality of life was evaluated in 4 studies (24, 26, 28, 30), although improved in the study by Silva *et al.* (24) it was not superior compared to the group that underwent hydrotherapy. However, both groups presented values that corresponded to the presence of depression before the intervention and, after treatment, both presented values that did not correspond to the presence of depression. Reduced depression was also observed through the application of TENS in the study by Carbonario *et al.* (28), when compared to the placebo group.

Flexibility

Flexibility was evaluated in two studies (24, 29), which did not show significant differences with respect to the control group. In relation to the PEDro scale presented in **table II**, all studies presented a score equal to or greater than 5 points, indicating that most articles reached at least half of the total score. The scoring of this scale was designed to observe the internal validity of its results.

Meta-analysis

Meta-analysis was conducted and the use of TENS did not show any advantages, when the variable was the intensity of pain at rest, compared to the control/placebo group (**figure 2 A**) or even other forms of therapy (dry needling and hydrotherapy) (**figure 2 B**), but there was great heterogeneity in the data, verified by Ch ^{2} and I^2.

DISCUSSION

The results of this systematic review demonstrated that the application of TENS in patients with fibromyalgia is effective in reducing pain, which is the main objective of TENS, and can be explained by gate control theory and activation of descending analgesic mechanisms (19, 21, 32, 33).

The present study found that the application of TENS associated with therapeutic exercises seems to have a greater effect in relation to patients who performed the exercise alone. Studies have shown that the application of TENS associated with exercises contributes to increased pain tolerance, both through the release of opioids in the CNS (34–37). Furthermore, TENS can act on the adaptation to therapeutic exercise, making it more comfortable, reducing its initial adverse effects, and improving compliance (25, 38). None of the studies showed adverse effects with the application of TENS, reinforcing that the therapy is also safe.

In one of the studies, the researchers guided the patients to apply TENS at home, which promoted similar effects

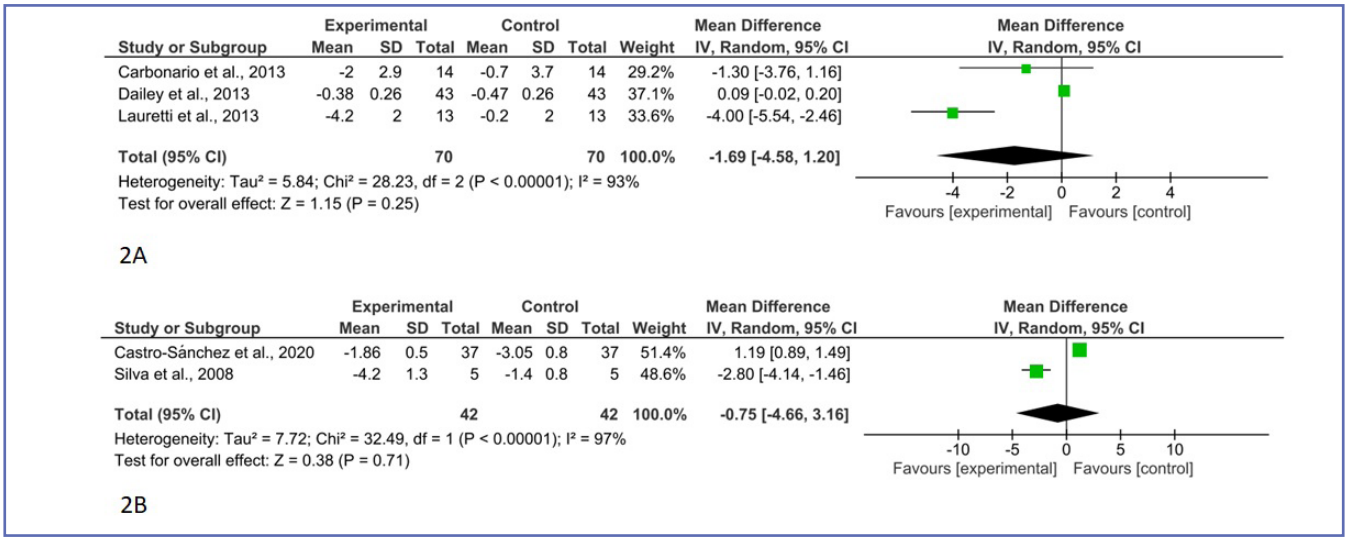

Figure 2. Forest graphs, with analysis of the articles in which the use of TENS was compared with control/placebo group **(A)**, as well as comparison between TENS and other therapeutic modalities (dry needling and hydrotherapy) **(B)**. In both cases no advantages of using TENS therapy to reduce pain intensity at rest were seen.

to application in the clinical environment. In this study, therapy with active TENS in the lower back or cervical region showed improvement in pain relief and the results were even more positive when 2 devices were applied simultaneously in the lumbar and cervical regions (25). Therefore, this review highlights the importance of using TENS in the home environment, especially in people with chronic pain. Effects of TENS on fatigue, quality of life, impact of illness, depression reduction, and flexibility gain were not evaluated in all studies, and the results shown were not similar. Thus, there was an inconclusive result regarding these effects on patients with fibromyalgia

Knowledge of the proper parameters of TENS are essential for an adequate analgesic effect (21). With this, it was observed that pain reduction was achieved with a high or maximum intensity tolerated by the patient, indicating that there may be a type of modulation after applying an irritating stimulus. This can be explained through diffuse noxious inhibitory control, which occurs when the response-to a painful stimulus is inhibited by another noxious stimulus. Even with these findings, most of the articles brought the intensity determined by the patients who participated in the study, and one of the studies did not show the intensity. Therefore, more research is needed to numerically standardize an intensity that could cause beneficial effects. There was no consensus on frequency and phase duration, but analgesic effects were observed in all parameters applied, at high or low frequencies and longer or shorter phase durations. As for the area of application, it was observed in the study by Lauretti *et al*. (25) that the analgesic effects were greater when applied simultaneously in two areas (lumbar and cervical).

Through the analysis of the studies, it can be observed that the minimum time of application of TENS therapy was 10 minutes in addition, it seems that the analgesic effects are achieved after several treatment sessions. However, Dailey *et al*. (29) evaluated the effects of a single 30-minute session and were able to achieve an immediate reduction in pain and fatigue. In addition, the duration of the treatment effect on patients is unknown, demonstrating that all studies evaluated only the short-term effects of TENS.

CONCLUSIONS

The present study presented the effects of TENS on pain and on parameters such as quality of life, fatigue, impact of the disease, and depression in individuals with fibromyalgia. It was found to reduce pain when associated with a therapeutic exercise program. However, not enough studies with similar results were found to associate the effects of TENS application with quality of life, disease impact, fatigue, and depression. The meta-analyses conducted pointed to the absence of advantages of using TENS when the variable under study was pain at rest. Moreover, the application differences in the application parameters point to the need for continuity in studies that seek to register an optimal parameter of this therapy.

FUNDINGS

The funds for conducting the study were borne by the authors themselves.

DATA AVAILABILITY

The data remain under the care of the authors.

CONTRIBUTIONS

All authors contributed to the design and data analysis. GBA, TKB, AERP: databases searching and writing. MRBA, DPA, GRFB: terms searching and critical review of the study.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. Neumeister MW, Neumeister EL. Fibromyalgia. Clin Plast Surg 2020;47(2):203–13.
2. Sarzi-Puttini P, Giorgi V, Marotto D, Atzeni F. Fibromyalgia: an update on clinical characteristics, aetiopathogenesis and treatment. Nat Rev Rheumatol 2020;16(11):645-60.
3. Wolfe F, Walitt BT, Häuser W. What is fibromyalgia, how is it diagnosed, and what does it really mean? Arthritis Care Res (Hoboken) 2014;66(7):969-71.
4. Wolfe F, Brähler E, Hinz A, Häuser W. Fibromyalgia prevalence, somatic symptom reporting, and the dimensionality of polysymptomatic distress: Results from a

survey of the general population. Arthritis Care Res 2013;65(5):777–85.
5. D'Agnelli S, Arendt-Nielsen L, Gerra MC, *et al.* Fibromyalgia: Genetics and epigenetics insights may provide the basis for the development of diagnostic biomarkers. Mol Pain 2019;15:174480691881994.
6. Mantia R, Di Gesù M, Vetro A, Mantia F, Palma S, Iovane A. Shortness of filum terminale represents an anatomical specific feature in fibromyalgia: A nuclear magnetic resonance and clinical study. Muscles Ligaments Tendons J 2015;5(1):33–7.
7. Atzeni F, Talotta R, Masala IF, *et al.* One year in review 2019: fibromyalgia. Clin Exp Rheumatol 2019;37 Suppl 116(1):3-10.
8. Häuser W, Fitzcharles M-A. Facts and myths pertaining to fibromyalgia. Dialogues Clin Neurosci 2018;20(1):53–62.
9. Schachter CL, Busch AJ, Peloso PM, Sheppard MS. Effects of short versus long bouts of aerobic exercise in sedentary women with fibromyalgia: A randomized controlled trial. Phys Ther 2003;83(4):340–58.
10. Sultan A, Gaskell H, Derry S, Andrew RA. Duloxetine for painful diabetic neuropathy and fibromyalgia pain: Systematic review of randomised trials. BMC Neurol 2008;8:29.
11. Lunn MPT, Hughes RAC, Wiffen PJ. Duloxetine for treating painful neuropathy, chronic pain or fibromyalgia. Cochrane Database Syst Rev 2014;2014(1):CD007115.
12. Moore RA, Straube S, Wiffen PJ, Derry S, McQuay HJ. Pregabalin for acute and chronic pain in adults. Cochrane database Syst Rev 2009;2009(3):CD007076.
13. Wiffen PJ, Derry S, Moore RA, *et al.* Antiepileptic drugs for neuropathic pain and fibromyalgia - an overview of Cochrane reviews. Cochrane Database Syst Rev 2013;2013(11):CD010567.
14. Araújo FM, DeSantana JM. Physical therapy modalities for treating fibromyalgia. F1000Res. 2019;8:F1000 Faculty Rev-2030.
15. Lorena SB de, Lima M do CC de, Ranzolin A, Duarte ÂLBP. Effects of muscle stretching exercises in the treatment of fibromyalgia: A systematic review. Rev Bras Reumatol 2015;55(2):167–73.
16. Maffei ME. Fibromyalgia: Recent advances in diagnosis, classification, pharmacotherapy and alternative remedies. Int J Mol Sci 2020;21(21):7877.
17. Sosa-Reina MD, Nunez-Nagy S, Gallego-Izquierdo T, Pecos-Martín D, Monserrat J, Álvarez-Mon M. Effectiveness of therapeutic exercise in fibromyalgia syndrome: A systematic review and meta-analysis of randomized clinical trials. Biomed Res Int 2017;2017:2356346.
18. Wu L-C, Weng P-W, Chen C-H, Huang Y-Y, Tsuang Y-H, Chiang C-J. Literature review and meta-analysis of trans-cutaneous electrical nerve stimulation in treating chronic back pain. Reg Anesth Pain Med 2018;43(4):425–33.
19. Johnson MI, Jones G. Transcutaneous electrical nerve stimulation: current status of evidence. Pain Manag 2017;7(1):1–4.
20. Leemans L, Elma Ö, Nijs J*, et al.* Transcutaneous electrical nerve stimulation and heat to reduce pain in a chronic low back pain population: a randomized controlled clinical trial. Brazilian J Phys Ther 2021;25(1):86–96.
21. Mokhtari T, Ren Q, Li N, Wang F, Bi Y, Hu L. Transcutaneous electrical nerve stimulation in relieving neuropathic pain: Basic mechanisms and clinical applications. Curr Pain Headache Rep 2020;24(4):14.
22. Liberati A, Altman DG, Tetzlaff J, *et al.* The PRISMA state-ment for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explana-tion and elaboration. J Clin Epidemiol 2009;62(10):e1–34.
23. Cashin AG, McAuley JH. Clinimetrics: Physiotherapy Evidence Database (PEDro) Scale. J Physiother. 2020;66(1):59.
24. Silva TFG da, Suda EY, Marçulo CA, Paes FH da S, Pinheiro GT. Comparison of transcutaneous electrical nerve stimulation and hydrotherapy effects on pain, flexibility and quality of life in patients with fibromyalgia. Fisioter e Pesqui 2008;15(2):118–24.
25. Lauretti GR, Chubaci EF, Mattos AL. Efficacy of the use of two simultaneously TENS devices for fibromyalgia pain. Rheumatol Int 2013;33(8):2117–22.
26. Yüksel M, Ayaş Ş, Cabıoğ lu MT, Yılmaz D, Cabıoğ lu C. Quantitative data for transcutaneous electrical nerve stimulation and acupuncture effectiveness in treatment of fibromyalgia syndrome. Evidence-based Complement Altern Med 2019;2019:9684649.
27. Jamison RN, Edwards RR, Curran S, *et al.* Effects of wearable transcutaneous electrical nerve stimulation on fibromyalgia: A randomized controlled trial. J Pain Res 2021;14:2265-82.
28. Carbonario F, Matsutani LA, Yuan SL, Marques AP. Effectiveness of high-frequency transcutaneous electrical nerve stimulation at tender points as adjuvant therapy for patients with fibromyalgia. Eur J Phys Rehabil Med. 2013;49(2):197-204.
29. Dailey DL, Rakel BA, Vance CGT, *et al.* Transcutaneous Electrical Nerve Stimulation (TENS) reduces pain, fatigue, and hyperalgesia while restoring central inhibition in primary fibromyalgia. Pain 2013;154(11):2554–62.
30. Dailey DL, Vance CGT, Rakel BA, *et al.* Transcutaneous electrical nerve stimulation reduces movement-evoked pain and fatigue: A randomized, controlled trial. Arthritis Rheumatol 2020;72(5):824–36.
31. Castro-Sánchez AM, Garcia-López H, Fernández-Sánchez M, *et al.* Benefits of dry needling of myofascial trigger points on autonomic function and photoelectric plethysmography in patients with fibromyalgia syndrome. Acupunct Med 2020;38(3):140–9.
32. Zhang R, Lao L, Ren K, Berman BM. Mechanisms of acupuncture-electroacupuncture on persistent pain. Anesthesiology 2014;120(2):482–503.
33. Sluka KA, Lisi TL, Westlund KN. Increased release of serotonin in the spinal cord during low, but not high, frequency transcutaneous electric nerve stimulation in rats with joint inflammation. Arch Phys Med Rehabil 2006;87(8):1137–40.
34. Goodin BR, McGuire LM, Stapleton LM, *et al.* Pain catastrophizing mediates the relationship between self-re-

ported strenuous exercise involvement and pain ratings: Moderating role of anxiety sensitivity. Psychosom Med 2009;71(9):1018–25.
35. Landmark T, Romundstad PR, Borchgrevink PC, Kaasa S, Dale O. Longitudinal associations between exercise and pain in the general population--the HUNT pain study. PLoS One 2013;8(6):e65279.
36. Naugle KM, Naugle KE, Fillingim RB, Riley JL. Isometric exercise as a test of pain modulation: Effects of experimental pain test, psychological variables, and sex. Pain Med (United States) 2014;15(4):692–701.
37. Sato KL, Sanada LS, Rakel BA, Sluka KA. Increasing intensity of TENS prevents analgesic tolerance in rats. J Pain 2012;13(9):884–90.
38. Mi J, Ls C, Gp H, Jones G, Ca P. Transcutaneous electrical nerve stimulation (TENS) for fibromyalgia in adults (Review). Cochrane Database Syst Rev 2017;2017(10):CD012172.