Complementary Therapies in Medicine 47 (2019) 102188

Contents lists available at ScienceDirect

Complementary Therapies in Medicine

journal homepage: www.elsevier.com/locate/ctim

Effects of thermotherapy and transcutaneous electrical nerve stimulation on patients with primary dysmenorrhea: A randomized, placebo-controlled, double-blind clinical trial

Aline Fernanda Perez Machado[a,*], Monica Rodrigues Perracini[a], Érika Patrícia Rampazo[b], Patricia Driusso[b], Richard Eloin Liebano[b]

[a] Masters and Doctoral Programs in Physical Therapy, Universidade Cidade de São Paulo (UNICID), São Paulo, SP, Brazil
[b] Physical Therapy Department, Universidade Federal de São Carlos (UFSCar), São Carlos, SP, Brazil

ARTICLE INFO

Keywords:
Dysmenorrhea
Pelvic pain
Transcutaneous electrical nerve stimulation
Termotherapy

ABSTRACT

Objectives: To evaluate the effects of thermotherapy and transcutaneous electrical nerve stimulation (TENS) on pain intensity, pressure pain threshold (PPT) and conditioned pain modulation (CPM) in patients with primary dysmenorrhea (PD).
Design: A randomized, placebo-controlled, double-blind clinical trial.
Setting: Physiotherapy Department of the Universidade Cidade de São Paulo, São Paulo (Brazil).
Interventions: Eighty-eight dysmenorrheic women were randomly allocated into four groups: Thermotherapy + TENS(n = 22), Thermotherapy(n = 22), TENS(n = 22) and Placebo(n = 22). Thermotherapy was applied by microwave diathermy (20 min), and TENS (200 μs, 100 Hz, 30 min), into the lower abdomen both.
Main outcome measures: Pain intensity was measured using the numeric rating scale (NRS) and the McGill Pain Questionnaire (Br-MPQ). PPT and CPM were recorded from women's abdominal and lumbar. The evaluation was done in 5 times: baseline, after 20, 50, 110 min and 24 h from intervention.
Results: There was a significant decrease in the NRS for Thermotherapy + TENS *vs*. TENS, for Thermotherapy *vs*. TENS and for Placebo, after 20 min; for Thermotherapy *vs*. TENS and for Placebo, after 110 min and 24 h. Abdome PPT increased in the Thermotherapy + TENS *vs*. TENS and Placebo, after 50 min; for Thermotherapy + TENS *vs*. Placebo and for Thermotherapy *vs*. Placebo, after 110 min. No changes in lumbar PPT and CPM were observed.
Conclusions: The use of thermotherapy reduced NRS compared to the TENS and Placebo after 20, 110 min and 24 h. Thermotherapy demonstrated an increase in the PPT in the abdomen after 50 and 110 min and decreased the Br-MPQ scores after 110 min in patients with PD.

1. Introduction

Primary dysmenorrhea (PD) is the most common gynecological disorder during menacme. It is a pain caused by menstrual cramps, located in the lower abdomen, extending to the lower back of the spine and radiating to the medial region of the thighs.[1–4] It affects about 50% of women of reproductive age, and between 10 and 15% the presence of pain is strong enough to interfere with the activities of daily living.[1,2,4,5] In the United States, dysmenorrhea has been the main reason for school and work absenteeism.[1,6] In the United Kingdom, 45 to 97% of the female population reports dysmenorrhea.[7] The pain lasts for about 8 to 72 h, which begins during or a few days before the menstrual period[2,5] and tends to disappear after about 2 days or with the end of menstruation.[1,2,5,8,9] It is believed that the main mechanism causing menstrual pain is the excessive production and release of prostaglandins by the endometrium during menstruation, mainly derived from cyclooxygenase-2 activity. Prostaglandins indirectly cause pain in menstrual cramps by stimulating the nociceptors, promoting increased uterine contractility causing visceral pain and increasing uterine pressure. Still, uterine contraction may induce hypoxia and local ischemia, causing

Abbreviations: TENS, transcutaneous electrical nerve stimulation; PPT, pain pressure threshold; CPM, conditioned pain modulation; PD, primary dysmenorrhea (PD); NRS, numeric rating scale (NRS); Br-MPQ, Brazilian version of the McGill Pain Questionnaire

* Corresponding author at: Universidade Cidade de São Paulo (UNICID), Cesário Galeno St., 448/475, 03071-000, São Paulo, SP, Brazil.
E-mail addresses: lifpm@yahoo.com.br, machado.lifpm@gmail.com (A.F.P. Machado).

https://doi.org/10.1016/j.ctim.2019.08.022
Received 27 March 2019; Received in revised form 6 August 2019; Accepted 27 August 2019
Available online 28 August 2019
0965-2299/

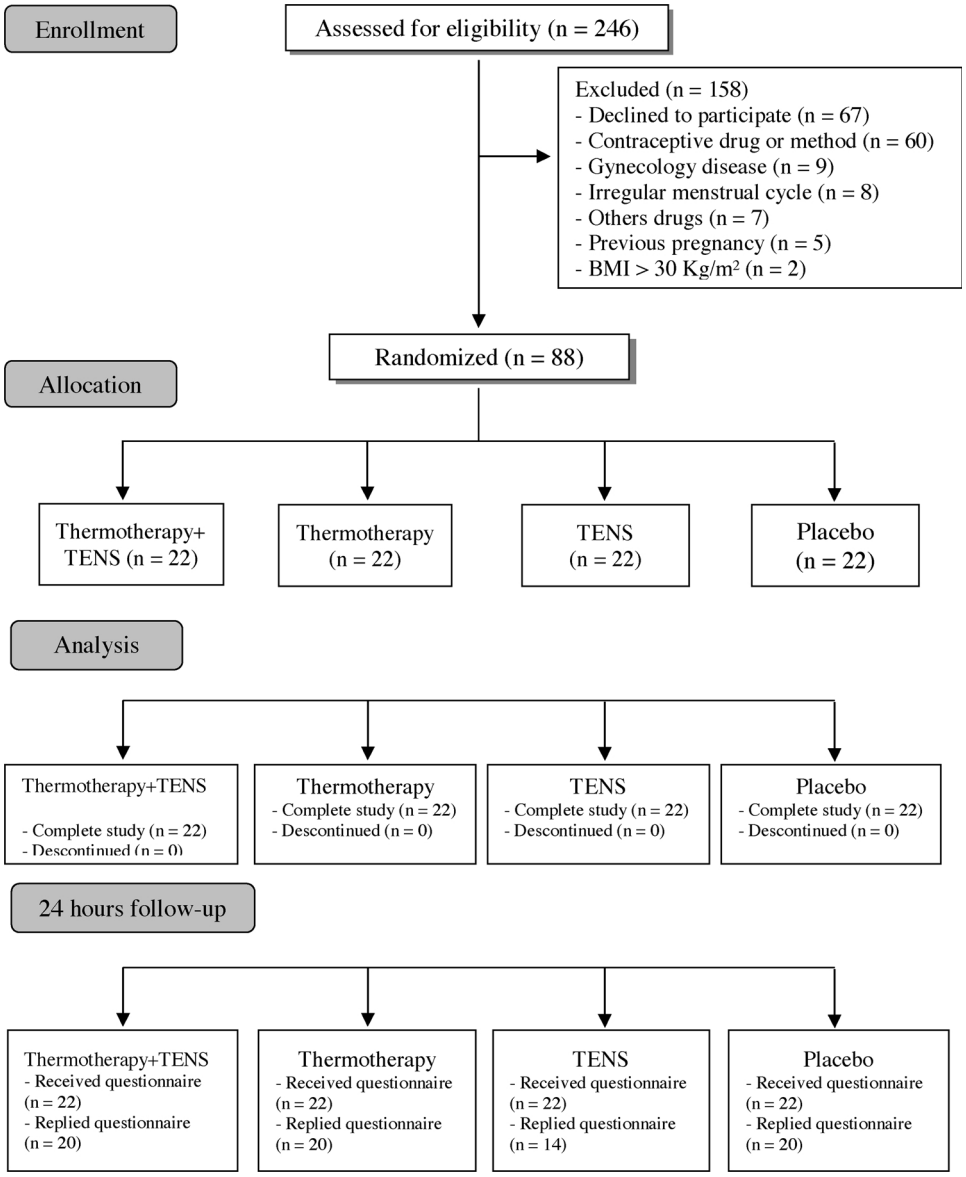

Fig. 1. Consort flow for the study.
Legend: Thermotherapy + TENS: active microwave diathermy and active transcutaneous electrical nerve stimulation group, Thermotherapy: active microwave diathermy and placebo transcutaneous electrical nerve stimulation group, TENS: placebo microwave diathermy and active transcutaneous electrical nerve

muscle spasms, which increases pain. [2,9–16]

The use of non-pharmacological and minimally invasive therapies has been recommended in the treatment of PD symptoms. Among the therapeutic possibilities, the following stand out: acupuncture,[17–20] massage,[21–25] physical exercises,[22,25–28] superficial thermotherapy[16,25,29–33] and deep,[34,35] and Transcutaneous Electrical Nerve Stimulation (TENS).[3,8,9,13,29,33,36–43] Despite the various options, the systematic review by Kannan, Claydon [12] points out that the use of thermotherapy and TENS to promote decreased PD should be considered.[12,29]

Thermotherapy consists of the therapeutic use of heat that can be applied by means of superficial and deep heat. Superficial thermotherapy is widely used in clinical practice and its effect on pain reduction is similar or superior when compared with anti-inflammatories and analgesics, and with physical activities.[5,16,25,30–32] One of the forms of deep thermotherapy is by microwave diathermy since heat promotes vasodilation and increases local blood flow, which can influence the transmission of painful impulses and reduce the level of nociceptive stimulation, removing prostaglandins and reducing spasm, hypoxia and local ischemia.[16,29–33] It is believed that as a result of microwave diathermy reaching deeper tissues, it is suggested that it has a direct action in the uterus, promoting a more potent analgesic action when compared to superficial thermotherapy. However, the use of microwave diathermy still presents a certain limitation due to lack of scientific basis[34,35].

TENS consists of the generic application of electrical currents transmitted by electrodes through the surface of the skin to stimulate the peripheral nerves producing various physiological effects, the main one being analgesia.[44–46] It is known that the main analgesic mechanism of TENS occurs by the activation of opioid receptors in the central and peripheral nervous system, with the δ-opioid receptors being activated in the high frequency TENS and the μ-opioid receptors in the low frequency. The use of TENS in PD especially causes a vasodilation in the area of the dermatome via axonal reflex, which suggests a decrease in uterine muscle ischemia through increased blood flow in the corresponding area.[29,37,47] TENS is well known and widely used to promote beneficial effects on pain relief for PD. [3,8,9,12,13,29,33,36–42]

Thermotherapy and TENS were used alone and associated with

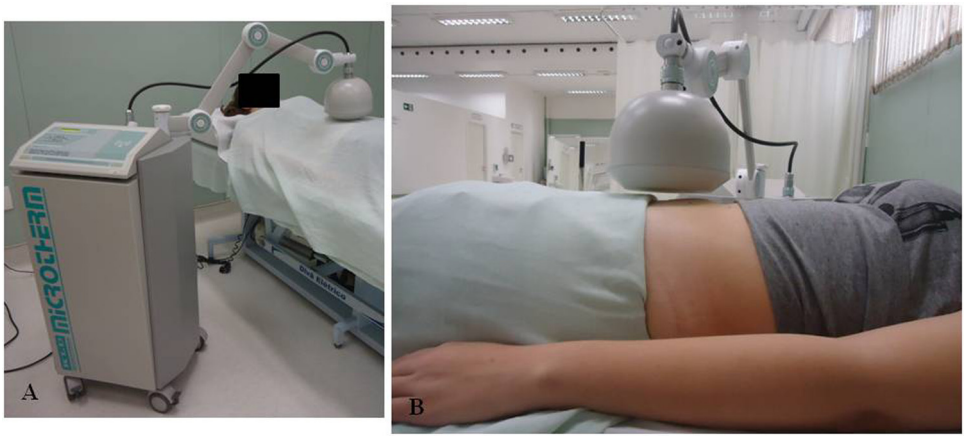

Fig. 2. (A) Microwave diathermy application with patient in supine position. **2. (B).** Reflector directed towards the pelvis at 5 cm further from the surface of the skin.

other therapies in the management of PD. Only Lee et al.[33] studied the effects of the combination of TENS followed by thermotherapy and concluded that the combination was effective in relieving PD pain. Recently, Igwea et al.[29] published a systematic review confirming that the use of TENS and thermotherapy tended to promote pain reduction in PD as well as medications. Considering that TENS has an effect on pain modulation by activating central and peripheral analgesic mechanisms[3,8,9,13,29,33,36–43] and that heat changes blood flow, favoring the removal of prostaglandins and promoting relaxation of muscle spasm, [16,25,29–33] the hypothesis of the present study is that the association of both encompasses different analgesic mechanisms to improve PD. Therefore, the design of the present study has great relevance for investigating the effect of microwave diathermy and the association between microwave diathermy and TENS for the treatment of PD.[29] Therefore, the objective was to evaluate the effects of thermotherapy and TENS on pain intensity, pressure pain threshold and conditioned pain modulation in patients with PD.

2. Methods

The present was a randomized, placebo-controlled, double-blind clinical trial that evaluated the effects of thermotherapy and TENS on patients with PD (RBR-5QKCK4). The study was approved and conducted at the —— (approved number: 41518815.4.0000.0064). The present trial was prospectively registered at the Brazilian Clinical Trials Registry (ReBEC) (registry number: RBR-5QKCK4). The methodological steps of the study are described in detail in the published protocol by Machado et al. (2017).[48] The design is in compliance with the Consolidated Standards of Reporting Clinical Trials statement (CONSORT) (Fig. 1). All patients agreed to participate by providing their free and informed consent before participating in the trial.

2.1. Simple size

The sample calculation was estimated considering a difference of 2 points and a standard deviation (SD) of 1.96 on the numeric rating scale (NRS) between groups (Ative and Placebo). Using a significance level of .05 and power of .80, a sample size of 88 subjects was calculated for the present study.

2.2. Inclusion and exclusion criteria

Nullipara dysmenorrheic women between the ages of 18 and 44 years, practicing physical activities ≤ 2 times a week, body mass index (BMI) ≤ 29.9 Kg/m^2, with regular menstrual cycle and experiencing PD with pain levels of ≥ 3 on the NRS were selected for the present study. Exclusion criteria were patients using hormonal contraceptive, anti-inflammatory and/or analgesic drugs for the treatment of dysmenorrhea or any other disorder, prior use of microwave diathermy or TENS. Patients with any chronic diseases, such as diabetes and/or rheumatoid arthritis, and/or gynecological diseases (polycystic ovary syndrome, endometriosis, adenomyomatosis, uterine fibroids), or malignant or benign neoplasm; patients with metal implants, heart disease and/or use of pacemakers, hypoesthesia or anesthesia in abdominal region, and patients in risk for developing epilepsy were also excluded from the study.

2.3. Randomization

Participants were randomized into four groups after the evaluation. Allocation concealment was ensured by the use of sequentially numbered, opaque, sealed envelopes.[49] The envelopes were stored in a safe cabinet that only the allocation investigator had access to and were opened immediately prior to the intervention.

All groups were submitted to active or placebo thermotherapy followed by active or placebo TENS. The Thermotherapy + TENS group was submitted to the application of thermotherapy followed by TENS, both active. The Thermotherapy group was submitted to active thermotherapy and placebo TENS. The TENS group was submitted to placebo thermotherapy and active TENS. The Pacebo group was submitted to both placebo thermotherapy and TENS. The devices were calibrated prior to the beginning of the study.

2.4. Thermotherapy procedure

The thermotherapy was applied by a microwave diathermy device (Microtherm - KLD®, Amparo, São Paulo, Brazil). For the groups that received active thermotherapy (Thermotherapy + TENS and Thermotherapy groups), the intensity was measured when the patient referred the same thermal sensation, i.e. moderate heat. Each patient remained in a supine position while a reflector was directed towards the lower abdomen at 5 cm from the surface of the skin, for 20 min (Fig. 2A and B). The placebo microwave therapy was applied using the same unit, but the intensity was not adjusted.

2.5. TENS procedure

The use of TENS was conducted with a Neurodyn Portable TENS (IBRAMED®, Amparo, São Paulo, Brazil) (Fig. 3A). The generator emits asymmetric, balanced, biphasic pulses. The active unit applied high frequency TENS (continuous mode, 100 Hz, 200μs pulse duration) at a strong but comfortable intensity, as dictated by each subject for 30 min

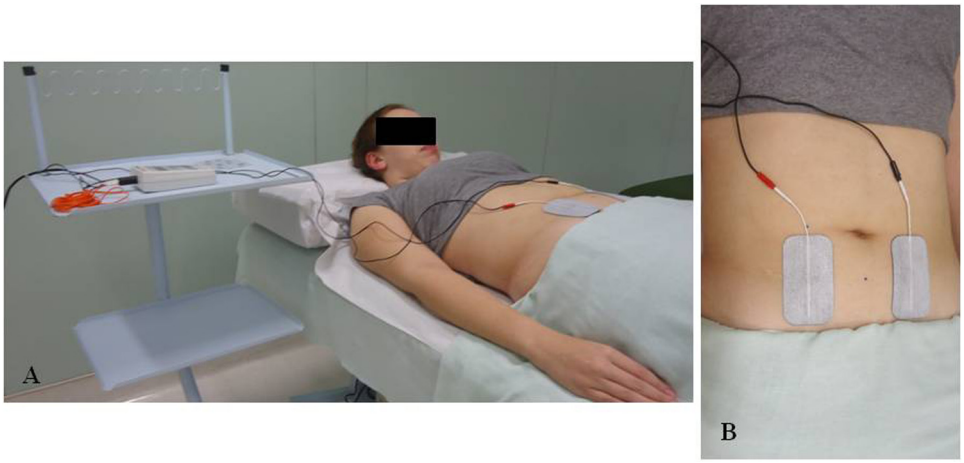

Fig. 3. (A) TENS application. **3. (B)** Electrodes position.

to the lower abdomen. The placebo TENS was applied using a placebo unit that was identical in appearance to the active unit. Two self-adhesive electrodes (ValuTrode®, 9 × 5 cm) were placed on both sides of the abdomen, at level T10 - T11 (Fig. 3B).

2.6. Outcome measures

The patients who agreed to participate in the research were initially evaluated according to the inclusion and exclusion criteria. Those eligible for the study were accompanied by a researcher until menstruation occurred. Patients and the researcher communicated via WhatsApp®. From day 1 to day 3 of menstruation, the patient presented menstrual cramps and was referred to the clinic for treatment. A baseline survey was then carried out before the intervention by means of anamnesis to collect data regarding the participants' personal and medical information. After obtaining consent, the selected patient was randomly assigned to a group. When each procedure was finished, the patient was submitted to an evaluation.

The patient was evaluated immediately after intervention with active or placebo thermotherapy (after 20 min from baseline) and after intervention with active or placebo TENS (after 50 min from baseline). Patient was placed in a supine position and remained at rest for 60 min after the end of the TENS application. When the time was completed, another evaluation was done (after 110 min from baseline) and the patient left the clinic. The patient was instructed to follow their daily routine. The following day, she answered a questionnaire (prepared and sent via WhatsApp®) about pain and possible drug intake or use of alternative pain relief methods used in the last 24 h (after 24 h). Fig. 4 shows the experimental protocol timeline.

Pain intensity was evaluated at all moments with the use of different assessment instruments: pain intensity using the NRS (baseline, after 20 min, 50 min, 110 min and 24 h), a pressure algometry to measure pressure pain threshold (PPT) (baseline, after 20 min, 50 min and 110 min), the McGill Pain Questionnaire (MPQ) to identify type of pain (Br-MPQ) and a conditioned pain modulation (CPM) test (baseline and after 110 min).

2.7. Pain intensity

To evaluate pain intensity, an 11-point numeric rating scale (NRS) was used, where 0 (zero) represents no pain and 10 (ten) represents the most intensive pain imaginable. Patients were instructed to mark along the line at the appropriate point of the scale.

2.8. Pressure pain threshold (PPT)

The PPT was measured by a blind evaluator using a Somedic® digital algometer (Somedic Inc., Hörby, Sweden), which was calibrated prior to the beginning of the study. Initially, two measures were performed in the extensor muscles of the dominant forearm so the patients could familiarize with the equipment. A preliminary study on reliability was conducted by the evaluator recording three points of each of the sites evaluated by the PPT in ten healthy patients at two different moments (with a 48 h interval). The intra-evaluator reliability for PPT was analyzed using the intraclass correlation coefficient (ICC). For the abdomen, the intra-evaluator value of reliability was 0.842 (95% CI 0.365 to 0.961) for evaluator 1; 0.769 (95% CI 0.069 to 0.943) for evaluator 2. For the lumbar spine, it was 0.947 (95% CI 0.785 to 0.987) for evaluator 1 and 0.753 (95%CI 0.004 to 0.939) for evaluator 2. The inter-evaluator value of reliability for the abdomen was 0.842 (95% CI 0.538 to 0.957) in the first evaluation and 0.919 (95% CI 0.762 to 0.978) post 24 h. For the lumbar spine, it was 0.871 (95% CI 0.623 to 0.965) in the first evaluation and 0.865 (95% CI 0.605 to 0.964) post 24 h.

For the PPT measurements, the algometer (with a 1 cm^2 wide rubber tip) was pressed against the skin in a perpendicular angle at a constant

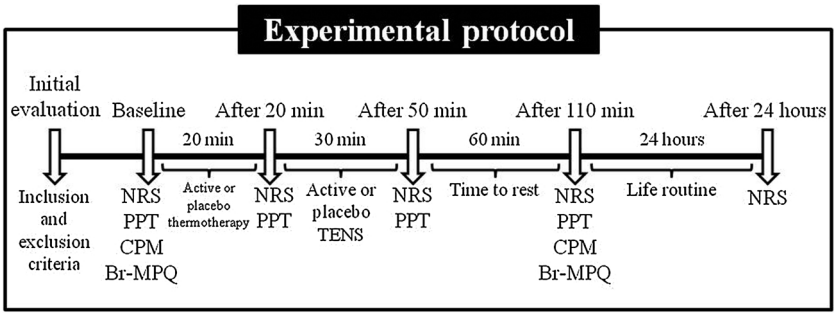

Fig. 4. Experimental protocol timeline.
Legend: Thermotherapy + TENS: active microwave diathermy and active transcutaneous electrical nerve stimulation group, Thermotherapy: active microwave diathermy and placebo transcutaneous electrical nerve stimulation group, TENS: placebo microwave diathermy and active transcutaneous electrical nerve stimulation group, NRS: numeric rating scale, PPT: pressure pain threshold, CPM: conditioned pain modulation, Br-MPQ: McGill Pain Questionnaire.

Fig. 5. PPT points.

slope of 30 kPa/s. The patients were instructed to press the button at the first feeling of change from pressure to pain. PPTs were measured at 6 algometry points marked over the umbilical region and the lumbar spine using a pen. The patient was positioned in a supine position for the measurement of points 1 to 5 on the abdomen, and then in ventral decubitus for point 6 in the lumbar region. The measures expressed in kPa were collected three times from each point according to the reliability tested prior to the beginning of the study, with 30 s apart between measures. The mean values of the points were used considering points 1–5 as "Abdomen", and point 6 as "Lumbar spine"[50] (Fig. 5).

2.9. Conditioned pain modulation (CPM)

A cold water bath was used to induce pain and trigger the CPM response. The conditioned stimulus was the immersion of the hand into cold water on the side ipsilateral to the most painful site. Pain intensity was measured after 30 s of ice immersion of the hand using the NRS as well as that of the menstrual cramps. PPT was recorded 30 s after immersion at the lowest pain threshold.[51] The hand was immersed into an ice water container for the CPT at 5.06 °C (0.88) at baseline and at 4.81 °C (0.85) after 110 min.

2.10. McGill pain questionnaire (Br-MPQ)

The Br-MPQ was developed by Melzack (1975)[52] and translated and adapted into the Brazilian Portuguese language (Br-MPQ)[53]. The MPQ contains 78 pain descriptors assigned to 20 categories within sensory, affective, evaluative and miscellaneous subclasses. The descriptors are assigned an intensity value in each of 20 sections, starting at one for the word with the least pain value. Scoring is *via* a Pain Rating Index (PRI) for each subclass and a total PRI. The number of words chosen (NWC) can also be used.

The NWC (range 0–20) is the sum score of the total number of descriptors that the participant chooses which may be no more than 20. PRI corresponds to the sum of values attributed to each word chosen from the questionnaire. It includes PRI-Total (PRI-T; score 0–78), PRI-Sensory (PRI-S; score 0–42), PRI-Affective (PRI-A; score 0–14), PRI-Evaluative (PRI-E; score 0–5), and PRI-Miscellaneous (PRI-M; score 0–17). For both the PRI and NWC, the higher the score the more severe the pain.

2.11. Statistical analysis

The mean difference adjusted for comparison between groups for the NRS, PPT, CPM and for the domains of the Br-MPQ was calculated using a linear mixed model. This longitudinal analysis included the intervention effects for the groups (Thermotherapy + TENS, Thermotherapy, TENS and Placebo), the evaluation periods and for the group interaction *vs* time. Data were expressed as mean, standard deviation, mean difference and p-value. Chi-square tests were used to make comparisons between categorical variables such as the investigation for blinded assessor. Data were analyzed using the SPSS software (v. 19; SPSS Inc; Chicago, IL). The level of significance was set at $p \leq 0.05$.

3. Results

In the present study, 246 patients were evaluated according to the eligibility criteria. Of these, 158 patients were excluded. Eighty-eight patients were included in the study and received the physiotherapeutic intervention. Each of the 4 groups (Thermotherapy + TENS, Thermotherapy, TENS and Placebo) were comprised of 22 patients, and 100% completed the intervention. However, after 24 h, the sample loss was 16%, totaling 74 patients in the final analysis: Thermotherapy + TENS (n = 20.9%), Thermotherapy (n = 20.9%), TENS (n = 14.3%) and Placebo (n = 20.9%) (Fig. 1). The socio-demographic and gynecologic characteristics of patients, which are separated by groups, are listed in Table 1. There was no significant difference between groups at baseline.

3.1. Pain intensity

The average pain intensity measured by the NRS at baseline was similar for the four groups. After 20 min, there was a significant decrease in the Thermotherapy + TENS *vs* TENS (p = 0.05), and in the Thermotherapy *vs.* TENS (p = 0.01) and *vs.* Placebo (p = 0.05). After 110 min and 24 h, there was a statistically significant decrease in the Thermotherapy *vs.* TENS (p = 0.05 and p = 0.01, respectively) and *vs.* the Placebo (p = 0.05 and p = 0.01, respectively). These findings suggest that the use of thermotherapy had reduced the pain intensity compared to the TENS and Placebo after 20, 110 min and 24 h after the use of thermotherapy (Table 2 and Fig. 6).

After 24 h, 18.1% (n = 4) of the patients in the TENS group, 13% (n = 3) in the Thermotherapy + TENS and 9% (n = 2) in the Placebo group used medication for pain relief. One patient in the TENS group used a hot water bag. For the Thermotherapy, none of the patient had to use any type of pain reliever after intervention.

3.2. Pressure pain threshold (PPT)

The PPT values were significantly higher for the abdomen in 3 groups of the present study (Thermotherapy + TENS, Thermotherapy and TENS) and for the lumbar spine in all groups. After 50 min, the PPT values were significantly higher for the abdomen in the Thermotherapy + TENS *vs.* TENS (p = 0.02) and *vs.* the Placebo (p = 0.01) groups. Finally, after 60 min, the PPT values were significantly higher in the Thermotherapy + TENS *vs.* the Placebo (p = 0.01) and the Thermotherapy *vs.* the Placebo groups (p = 0.01). There was no statistically significant difference for the PPT in the evaluation periods for the lumbar spine in all groups (Table 2 and Fig. 7).

3.3. Conditioned pain modulation (CPT)

There was no statistically significant change in all groups regarding the menstrual cramps during the CPT (Table 2).

Table 1
Characteristics of patients in the baseline.

Characteristics	Groups				p value
	Thermotherapy + TENS (n = 22)	Thermotherapy (n = 22)	TENS (n = 22)	Placebo (n = 22)	
Age (years old)	21.6 ± 2.75	21.6 ± 3.77	22.2 ± 4.72	23 ± 3.99	0.609
BMI (Kg/m^2)	23.1 ± 3.17	25.1 ± 4.45	24.8 ± 4.22	24.8 ± 5.12	0.403
Race					
White	18 (81.8%)	15 (68.2%)	10 (45.5%)	15 (68.2%)	0.111
Black	2 (9.1%)	5 (22.8%)	8 (36.4%)	5 (22.8%)	
Others	2 (9.1%)	2 (9.1%)	1 (18.1%)	1 (9%)	
Marital status					
Single	19 (86.4%)	21 (95.5%)	20 (90.9%)	22 (100%)	0.316
Married	3 (13.6%)	1 (4,5%)	2 (9.1%)	0 (0%)	
Schooling					
Complete college	5 (22,8%)	5 (22.8 %)	5 (22,8%)	2 (9.1%)	0.611
Incomplete college	16 (72,7%)	12 (54.5%)	13 (59,1%)	12 (77.3%)	
Complete high school	1 (4.5%)	4 (18.2%)	3 (13.6%)	3 (13.6%)	
Incomplete high school	0 (0%)	1 (4.5%)	1 (4.5%)	0 (0%)	
Age of menarche (years)	12.3 ± 1.96	12.5 ± 1.40	11.9 ± 1.67	12 ± 1.65	0.602
Period of cramps (years)	9 ± 3.73	9.3 ± 4.83	10.3 ± 4.08	8.8 ± 4.56	0.862
Day of menstrual cycle	2 ± 0.69	1.6 ± 0.56	1.6 ± 0.64	1.9 ± 0.52	0.216
NRS (0-10)	5.9 ± 1.9	6.1 ± 1.6	6.1 ± 2.1	6.3 ± 1.8	0.886
PPT Abdome (kPa)	130.6 ± 57.9	101.4 ± 47.4	118.0 ± 33.7	134.8 ± 64.2	0.153
PPT Lumbar (kPa)	241.2 ± 144.8	163.5 ± 61.2	186.1 ± 68.4	193.9 ± 90.7	0.066
Br-MPQ					
NWD (0-20)	16.00 ± 4.12	16.41 ± 2.91	16.09 ± 3.69	16.23 ± 3.25	0.982
Sensory (0-41)	9.27 ± 3.27	9.14 ± 1.42	8.55 ± 1.68	8.82 ± 2.15	0.708
Affective (11-15)	4.23 ± 1.95	4.09 ± 1.31	4.32 ± 1.73	4.18 ± 1.59	0.858
Evaluative (0-5)	1.55 ± 1.10	1.55 ± 1.06	1.18 ± 0.50	1.50 ± 1.01	0.528
Miscellaneous (0-18)	3.64 ± 1.73	3.18 ± 0.91	2.77 ± 1.15	3.41 ± 1.14	0.701
Total (0-78)	18.45 ± 6.23	17.95 ± 2.97	16.82 ± 3.69	17.82 ± 4.89	0.247
CPM (PPT difference, kPa)	31.6 ± 31.9	29.0 ± 38.0	35.1 ± 46.6	31.4 ± 41.1	0.392

Legend: Thermotherapy + TENS: active microwave diathermy and active transcutaneous electrical nerve stimulation group, Thermotherapy: active microwave diathermy and placebo transcutaneous electrical nerve stimulation group, TENS: placebo microwave diathermy and active transcutaneous electrical nerve stimulation group, ± standard deviation, BMI: body mass index, NRS: numeric rating scale, PPT: pressure pain threshold, kPa: kilopascal, CPM: conditioned pain modulation, Br-MPQ: McGill Pain Questionnaire, NWD: number of words chosen.

3.4. McGill pain questionnaire

The baseline score after 110 min was statistically lower in the following domains between the Thermotherapy *vs.* Placebo: "NWD" ($p = 0.01$), "Affective" ($p = 0.04$), "Evaluative" ($p = 0.05$) and "Total" ($p = 0.02$); "Sensory" between the Thermotherapy *vs.* TENS ($p = 0.04$); "Affective" ($p = 0.04$) and "Total" ($p = 0.05$) between the Thermotherapy + TENS *vs.* Placebo (Table 3).

4. Discussion

The results showed that when pain intensity was evaluated by means of NRS, the application of thermotherapy reduced pain intensity compared to the TENS and placebo after 20 and 110 min and 24 h following intervention. The combined (thermotherapy plus TENS) was more effective than the TENS after 20 min, reinforcing the use of thermotherapy because this time evaluation was after the thermotherapy used. In this moment, the TENS group had not been submitted to any intervention because the microwave diathermy was inactive. Our findings have demonstrated that the use of thermotherapy had positive effects on reducing pain immediately after the intervention with heat up to 24 h after.

Considering that thermotherapy can be applied in many different ways,[29,32] the microwave therapy was the treatment of choice in the present study because the electromagnetic waves produces heat deep inside the tissues than other modalities. It was believed that the use of thermotherapy plus TENS would be more effective for pain relief when compared to the use of these devices separately, considering that each therapy method has different mechanisms of analgesia for PD.[3,8,9,13,16,25,29–33,36–43] However, for the pain intensity, it should be highlighted that the use of thermotherapy has significantly reduced the pain intensity, considering that the combination of thermotherapy plus TENS has produced beneficial effects only after 20 min, which was conducted immediately after the use of microwave diathermy and before TENS. Therefore, heat was shown to be more effective than TENS in pain reduction in PD. These findings corroborate the recent systematic review which demonstrates thermotherapy showing more moderate effect sizes.[25]

Vance et al. (1996)[34] were the first investigators to propose the use of microwave diathermy as an effective treatment for reducing pain in a patient with PD. In 2017, Sindole and Hande[35] evaluated the effectiveness of microwave diathermy and aerobic exercise (3 times a week, for 8 weeks) in reducing the pain intensity and improving the quality of life in females with PD compared to only exercises. However, the procedures used in this particular study lack details, and therefore, may compromise the reproducibility of results and possible comparisons with the current findings.

The combination and the comparison of TENS with other therapies for the treatment of cramping pelvic pain have been recommended for reduction of pain intensity and improvement of quality of life in women with PD.[29,33] The use of TENS with ibuprofen has demonstrated reduction of pain compared to the placebo or control group.[13] When compared to the use of non-steroidal anti-inflammatory, TENS has provided fast pain relief without significant changes in the uterine activity.[37] TENS seems to be more effective than verapamil and equally effective as naproxen.[36] Tugay et al. (2007)[8] reported that TENS and

Table 2
Mean (SD) for NRS, PPT and CPM outcomes at all evaluations for each group and adjusted mean difference (p value) between groups.

Outcomes	Mean (SD)				Ajusted mean difference between groups (p value)					
	Thermotherapy + TENS (n = 22)	Thermotherapy (n = 22)	TENS (n = 22)	Placebo (n = 22)	Thermotherapy + TENS *vs* MWD	Thermotherapy + TENS *vs* TENS	Thermotherapy + TENS *vs* Placebo	Thermotherapy *vs* TENS	Thermotherapy *vs* Placebo	TENS *vs* Placebo
NRS (0-10)										
Baseline	5.9 ± 1.9	6.1 ± 1.6	6.1 ± 2.1	6.3 ± 1.8	—	—	—	—	—	—
After 20 min	3.2 ± 1.7	3.2 ± 2.1	4.7 ± 2.5	4.6 ± 2.2	0.2 (0.66)	−1.2 (0.05*)	−0.9 (0.12)	−1.5 (0.01*)	−1.2 (0.05*)	0.2 (0.66)
After 50 min	1.4 ± 2.1	2.0 ± 2.0	2.4 ± 2.0	3.0 ± 2.7	−0.3 (0.56)	−0.7 (0.21)	−1.1 (0.08)	−0.4 (0.51)	−0.7 (0.24)	−0.3 (0.61)
After 110 min	1.5 ± 1.9	0.7 ± 2.4	1.9 ± 1.8	2.1 ± 2.6	−1.1 (0.08)	−0.1 (0.82)	−0.1 (0.82)	−1.2 (0.05*)	−1.2 (0.05*)	−0.0 (0.99)
Ev-24h	1.2 ± 2.1	0.3 ± 0.7	2.1 ± 2.3	2.2 ± 2.3	−1.1 (0.07)	−0.7 (0.28)	−0.5 (0.40)	−1.8 (0.01*)	−1.7 (0.01*)	0.1 (0.78)
PPT Abdome (kPa)										
Baseline	130.6 ± 57.9	101.4 ± 47.4	118.0 ± 33.7	134.8 ± 64.2	—	—	—	—	—	—
After 20 min	147.5 ± 70.0	120.0 ± 45.3	124.5 ± 36.9	136.9 ± 80.3	−1.7 (0.88)	10.4 (0.36)	14.7 (0.19)	12.0 (0.28)	16.4 (0.15)	4.3 (0.70)
After 50 min	169.8 ± 70.7	127.3 ± 56.1	131.9 ± 41.3	138.8 ± 71.4	13.3 (0.24)	25.3 (0.02*)	35.1 (0.01*)	12.1 (0.29)	21.8 (0.05)	9.7 (0.39)
After 110 min	162.2 ± 69.5	126.9 ± 50.3	129.6 ± 38.3	129.2 ± 63.7	6.0 (0.59)	20.0 (0.07)	37.1 (0.01*)	14.0 (0.22)	31.1 (0.01*)	17.1 (0.13)
PPT Lumbar (kPa)										
Baseline	241.2 ± 144.8	163.5 ± 61.2	186.1 ± 68.4	193.9 ± 90.7	—	—	—	—	—	—
After 20 min	250.0 ± 158.8	167.7 ± 84.3	184.4 ± 57.4	194.6 ± 109.8	4.5 (0.81)	10.5 (0.58)	8.1 (0.67)	5.9 (0.75)	3.5 (0.85)	−2.4 (0.90)
After 50 min	281.1 ± 162.3	189.3 ± 83.5	204.1 ± 69.9	218.5 ± 108.9	14.1 (0.46)	21.9 (0.25)	15.4 (0.42)	7.7 (0.68)	1.2 (0.94)	−6.5 (0.73)
After 110 min	272.5 ± 150.9	200.8 ± 80.4	203.5 ± 74.0	213.9 ± 101.1	−6.0 (0.75)	13.9 (0.47)	11.3 (0.55)	19.9 (0.30)	17.3 (0.37)	−2.6 (0.89)
CPM (PPT difference, kPa)										
Baseline	31.6 ± 31.9	29.0 ± 38.0	35.1 ± 46.6	31.4 ± 41.1	—	—	—	—	—	—
After 110 min	41.4 ± 45.0	24.1 ± 25.8	29.9 ± 25.2	30.5 ± 29.7	14.6 (0.30)	15.0 (0.29)	10.7 (0.45)	0.34 (0.98)	−3.9 (0.78)	−4.3 (0.76)

Legend: SD – standard desviation, Thermotherapy + TENS: active microwave diathermy and active transcutaneous electrical nerve stimulation group, Thermotherapy: active microwave diathermy and placebo transcutaneous electrical nerve stimulation group, TENS: placebo microwave diathermy and active transcutaneous electrical nerve stimulation group, NRS: numeric rating scale, PPT: pressure pain threshold, CPM: conditioned pain modulation, After 20 min: evaluation after microwave diathermy, After 50 min: evaluation after transcutaneous electrical nerve stimulation, After 110 min: evaluation after rest during 60 min, After 24 h: evaluation after 24 h, *: significant difference.

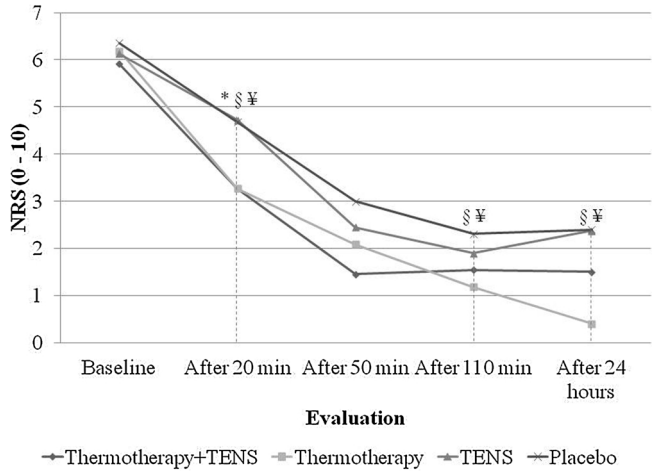

Fig. 6. Pain intensity by NRS in all groups.
Legend: Thermotherapy + TENS: active microwave diathermy and active transcutaneous electrical nerve stimulation group, Thermotherapy: active microwave diathermy and placebo transcutaneous electrical nerve stimulation group, TENS: placebo microwave diathermy and active transcutaneous electrical nerve stimulation group, NRS: numeric rating scale, *: Thermotherapy + TENS *vs* TENS (p = 0.05) after 20 min, §: Thermotherapy *vs.* TENS (p = 0.01, after 20 min; p = 0.05, after 110 min; and p = 0.01, after 24 h); ¥: Thermotherapy *vs.* Placebo (p = 0.05, after 20 min; p = 0.05, after 110 min; p = 0.01, after 24 h).

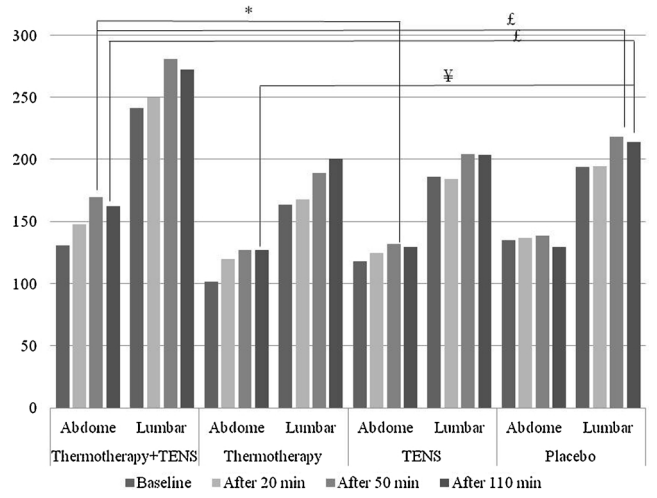

Fig. 7. PPT values for the abdome and lumbar spine in all groups.
Legend: Thermotherapy + TENS: active microwave diathermy and active transcutaneous electrical nerve stimulation group, Thermotherapy: active microwave diathermy and placebo transcutaneous electrical nerve stimulation group, TENS: placebo microwave diathermy and active transcutaneous electrical nerve stimulation group, PPT: pressure pain threshold, *: Thermotherapy + TENS *vs.* TENS (p = 0.02) after 50 min, £: Thermotherapy + TENS *vs.* Placebo (p = 0.01, after 50 min; p = 0.01, after 110 min), ¥: Thermotherapy *vs.* Placebo (p = 0.01) after 110 min.

interferential current appeared to be effective in PD and free from the potentially adverse effects of analgesics. Lee et al. (2015)[33] were the first to demonstrate that the combination of high frequency TENS and thermotherapy provided pain relief in women with moderate to severe PD.

The present is the first randomized, placebo-controlled, double-blind clinical trial that evaluated the effects of thermotherapy and TENS on patients with PD. There is insufficient literature available toallow comparison of our findingswith the findings of others. Unlike other studies that have shown positive effects for the use of TENS, the design proposed here was that all patients would first receive 20 min of microwave diathermy active or placebo followed by 30 min of active or placebo TENS. This protocol resulted in significant reduction of pain immediately after 60 min and 24 h of thermotherapy. No patient was submitted to TENS prior to thermotherapy. This may have affected the effect of TENS, considering that the NRS decreased with the use of thermotherapy, and the potential effect of TENS may have been reduced. In contrast, Lee et al. (2015) applied the protocol using TENS followed by thermotherapy. The effects of TENS cannot be compared to those of the present study because no evaluations were made after the use of each therapy.[33]

The proposed study design included various forms of pain assessment, unlike prior studies. To date, the literature is consistent with the beneficial effect of TENS on relieving pain in women with PD, which has been evidenced by clinical trials that measured their findings using the NRS. It is believed that the emission of thermotherapy by microwave diathermy has promoted beneficial effects for pain relief of PD. This can be explained by the vascular reactions induced by the increased blood flow in the area, resulting in intravascular vascular leakage induced by histamine, *bradykinin* and prostaglandin. Consequently, this blood flow increases tissue oxygenation and relaxes the uterine contraction.[31]

Regarding the PPT in the abdomen, it is believed that the higher PPT values in the abdomen obtained in the Thermotherapy and Thermotherapy + TENS groups was caused by the decrease of sensitivity in the deep tissue by mechanisms of central spinal hyperexcitability, which is recurrent in women with moderate to severe menstrual pain, promoting a local hyperalgesia[50]. Considering the use of PPT in CPM, there was no significant difference with regards to the assessment of PPT performed during the cold pressor test. The results showed that it had no effect on the CPM paradigm. The available literature is still insufficient to enable comparisons of these findings. However, the lowest PPT values were determined for the abdomen and the highest PPT values for the lumbar spine corroborated our study results. Until now there have been no scientific studies of the effect of any therapy or medication on PPT.

Non-pharmacological therapeutic strategies can be safe and effective for the treatment of pain in patients with PD. Further clinical trials should be developed to investigate the effects of the combined use of thermotherapy and TENS, proposing the reversal use of such resources and including more than a single menstrual cycle. Currently, women are active in the labor market, with so many appointments and deadlines to keep that sometimes it is difficult to find time for treatments. Thus, the proposed use of a practical, easy-to-handle, low-cost and self-applied device based only on previous instructions can be a good way to prove the effects of alternative therapies.

5. Conclusion

The use of thermotherapy reduced pain intensity compared to the TENS and placebo after 20, 110 min and 24 h. Thermotherapy alone or associated with TENS compared to the placebo demonstrated an increase in the pressure pain threshold in the abdomen after 50 and 110 min after treatment. Thermotherapy and the combination of thermotherapy and TENS decreased the Br-MPQ scores when compared to the TENS and placebo after 110 min in patients with PD.

Disclaimer

Not applied.

Sources of support

The authors report no conflict of interest.
There is no financial support for the research.

Table 3
Mean (SD) for McGill Questionnaire (Br-MPQ) domains at baseline and after 110 min for each group and adjusted mean difference (p value) between groups.

Br-MPQ	Mean (SD)				Ajusted mean difference between groups (p value)					
	Thermotherapy + TENS (n = 22)	Thermotherapy (n = 22)	TENS (n = 22)	Placebo (n = 22)	Thermotherapy + TENS *vs* MWD	Thermotherapy + TENS *vs* TENS	Thermotherapy + TENS *vs* Placebo	Thermotherapy *vs* TENS	Thermotherapy *vs* Placebo	TENS *vs* Placebo
NWD (0-20)										
Baseline	16.00 ± 4.12	16.41 ± 2.91	16.09 ± 3.69	16.23 ± 3.25	—	—	—	—	—	—
After 110 min	4.64 ± 5.17	3.55 ± 5.7	6.23 ± 6.84	8.25 ± 7.66	1.5 (0.45)	−1.5 (0.456)	−3.3 (0.09)	−3.0 (0.13)	−4.8 (0.01*)	1.8 (0.35)
Sensory (0-41)										
Baseline	9.27 ± 3.27	9.14 ± 1.42	8.55 ± 1.68	8.82 ± 2.15	—	—	—	—	—	—
After 110 min	2.59 ± 2.95	2.09 ± 3.13	3.77 ± 3.90	3.91 ± 3.99	0.3 (0.74)	−1.9 (0.09)	−1.7 (0.11)	−2.2 (0.04*)	−2.1 (0.06)	−0.1 (0.90)
Affective (11-15)										
Baseline	4.23 ± 1.95	4.09 ± 1.31	4.32 ± 1.73	4.18 ± 1.59	—	—	—	—	—	—
After 110 min	0.50 ± 1.01	0.36 ± 1.09	0.95 ± 1.56	1.77 ± 2.83	3.6 (1.00)	−0.3 (0.57)	−1.3 (0.04*)	−0.3 (0.57)	−1.3 (0.04*)	0.9 (0.14)
Evaluative (0-5)										
Baseline	1.55 ± 1.10	1.55 ± 1.06	1.18 ± 0.50	1.50 ± 1.01	—	—	—	—	—	—
After 110 min	0.64 ± 0.73	0.27 ± 0.46	0.45 ± 0.51	0.86 ± 0.89	0.3 (0.27)	−0.2 (0.58)	−0.2 (0.40)	−0.5 (0.10)	−0.6 (0.05*)	0.1 (0.78)
Miscellaneous (0-18)										
Baseline	3.64 ± 1.73	3.18 ± 0.91	2.77 ± 1.15	3.41 ± 1.14	—	—	—	—	—	—
After 110 min	1.09 ± 1.44	0.82 ± 1.50	1.09 ± 1.38	1.68 ± 1.84	−0.1 (0.70)	−0.8 (0.07)	−0.8 (0.09)	−0.6 (0.16)	−0.6 (0.19)	−0.0 (0.92)
Total (0-78)										
Baseline	18.45 ± 6.23	17.95 ± 2.97	16.82 ± 3.69	17.82 ± 4.89	—	—	—	—	—	—
After 110 min	4.82 ± 5.59	3.45 ± 5.75	6.27 ± 6.94	8.45 ± 8.99	0.8 (0.69)	−3.0 (0.16)	−4.2 (0.05*)	−3.9 (0.07)	−5.1 (0.02*)	1.1 (0.59)

Legend: Thermotherapy + TENS: active microwave diathermy and active transcutaneous electrical nerve stimulation group, Thermotherapy: active microwave diathermy and placebo transcutaneous electrical nerve stimulation group, TENS: placebo microwave diathermy and active transcutaneous electrical nerve stimulation group, NWD: number of words chosen, After 110 min: evaluation after rest during 60 min, *significant difference.

Declaration of Competing Interest

There are no conflicts of interest.

References

1. De Sanctis V, Soliman A, Bernasconi S, et al. Primary dysmenorrhea in adolescents: prevalence, impact and recent knowledge. *Pediatric Endocrinol Rev.* 2015;13(2):512–520.
2. Proctor M, Farquhar C. Diagnosis and management of dysmenorrhoea. *BMJ.* 2006;332(7550):1134–1138.
3. Lewers D, Clelland JA, Jackson JR, Varner RE, Bergman J. Transcutaneous electrical nerve stimulation in the relief of primary dysmenorrhea. *Phys Ther.* 1989;69(1):3–9.
4. Harlow SD, Campbell OM. Epidemiology of menstrual disorders in developing countries: a systematic review. *BJOG.* 2004;111(1):6–16.
5. Latthe PM, Champaneria R, Khan KS. Dysmenorrhoea. *BMJ Clin Evid.* 2011;2011.
6. Hillen TI, Grbavac SL, Johnston PJ, Straton JA, Keogh JM. Primary dysmenorrhea in young Western Australian women: prevalence, impact, and knowledge of treatment. *J Adolesc Health.* 1999;25(1):40–45.
7. Latthe P, Latthe M, Say L, Gulmezoglu M, Khan KS. WHO systematic review of prevalence of chronic pelvic pain: a neglected reproductive health morbidity. *BMC Public Health.* 2006;6:177.
8. Tugay N, Akbayrak T, Demirturk F, et al. Effectiveness of transcutaneous electrical nerve stimulation and interferential current in primary dysmenorrhea. *Pain Med.* 2007;8(4):295–300.
9. Proctor ML, Smith CA, Farquhar CM, Stones RW. Transcutaneous electrical nerve stimulation and acupuncture for primary dysmenorrhoea. *Cochrane Database Syst Rev.* 2002(1):CD002123.
10. Polat A, Celik H, Gurates B, et al. Prevalence of primary dysmenorrhea in young adult female university students. *Arch Gynecol Obstet.* 2009;279(4):527–532.
11. Daniels SE, Talwalker S, Torri S, Snabes MC, Recker DP, Verburg KM. Valdecoxib, a cyclooxygenase-2-specific inhibitor, is effective in treating primary dysmenorrhea. *Obstet Gynecol.* 2002;100(2):350–358.
12. Kannan P, Claydon LS. Some physiotherapy treatments may relieve menstrual pain in women with primary dysmenorrhea: a systematic review. *J Physiother.* 2014;60(1):13–21.
13. Dawood MY, Ramos J. Transcutaneous electrical nerve stimulation (TENS) for the treatment of primary dysmenorrhea: a randomized crossover comparison with placebo TENS and ibuprofen. *Obstet Gynecol.* 1990;75(4):656–660.
14. Maia J, Hugo Maltez A, Studard E, Zausner B, Athayde C, Coutinho E. Effect of the menstrual cycle and oral contraceptives on cyclooxygenase-2 expression in the endometrium. *Gynecol Endocrinol.* 2005;21(1):57–61.
15. Dawood MY. Primary dysmenorrhea: advances in pathogenesis and management. *Obstet Gynecol.* 2006;108(2):428–441.
16. Akin M, Price W, Rodriguez Jr G, Erasala G, Hurley G, Smith RP. Continuous, low-level, topical heat wrap therapy as compared to acetaminophen for primary dysmenorrhea. *J Reprod Med.* 2004;49(9):739–745.
17. Shi GX, Liu CZ, Zhu J, Guan LP, Wang DJ, Wu MM. Effects of acupuncture at Sanyinjiao (SP6) on prostaglandin levels in primary dysmenorrhea patients. *Clin J Pain.* 2011;27(3):258–261.
18. Choi EM, Jiang F, Longhurst JC. Point specificity in acupuncture. *Chin Med.* 2012;7:4.
19. Smith CA, Armour M, Zhu X, Li X, Lu ZY, Song J. *Acupuncture for dysmenorrhoea.* The Cochrane Library; 2016.
20. Smith CA, Crowther CA, Petrucco O, Beilby J, Dent H. Acupuncture to treat primary dysmenorrhea in women: a randomized controlled trial. *Evid Based Complement Altern Med.* 2011;2011:612464.
21. Apay SE, Arslan S, Akpinar RB, Celebioglu A. Effect of aromatherapy massage on dysmenorrhea in Turkish students. *Pain Manag Nurs.* 2012;13(4):236–240.
22. Azima S, Bakhshayesh HR, Kaviani M, Abbasnia K, Sayadi M. Comparison of the effect of massage therapy and isometric exercises on primary dysmenorrhea: a randomized controlled clinical trial. *J Pediatr Adolesc Gynecol.* 2015;28(6):486–491.
23. Demirturk F, Erkek ZY, Alparslan O, Demirturk F, Demir O, Inanir A. Comparison of reflexology and connective tissue manipulation in participants with primary dysmenorrhea. *J Altern Complement Med.* 2016;22(1):38–44.
24. Sut N, Kahyaoglu-Sut H. Effect of aromatherapy massage on pain in primary dysmenorrhea: a meta-analysis. *Complement Ther Clin Pract.* 2017;27:5–10.
25. Armour M, Smith CA, Steel KA, Macmillan F. The effectiveness of self-care and lifestyle interventions in primary dysmenorrhea: a systematic review and meta-analysis. *BMC Complement Altern Med.* 2019;19(1):22.
26. Motahari-Tabari N, Shirvani MA, Alipour A. Comparison of the effect of stretching exercises and mefenamic acid on the reduction of pain and menstruation characteristics in primary dysmenorrhea: a randomized clinical trial. *Oman Med J.* 2017;32(1):47–53.
27. Geneen LJ, Moore RA, Clarke C, Martin D, Colvin LA, Smith BH. Physical activity and exercise for chronic pain in adults: an overview of Cochrane Reviews. *Cochrane Database Syst Rev.* 2017;4 CD011279.
28. Brown J, Brown S. *Exercise for dysmenorrhoea.* The Cochrane Library; 2010.
29. Igwea SE, Tabansi-Ochuogu CS, Abaraogu UO. TENS and heat therapy for pain relief and quality of life improvement in individuals with primary dysmenorrhea: a systematic review. *Complement Ther Clin Pract.* 2016;24:86–91.
30. Chaudhuri A, Singh A, Dhaliwal L. A randomised controlled trial of exercise and hot water bottle in the management of dysmenorrhoea in school girls of Chandigarh, India. *Indian J Physiol Pharmacol.* 2013;57(2):114–122.
31. Navvabi Rigi S, Kermansaravi F, Navidian A, et al. Comparing the analgesic effect of heat patch containing iron chip and ibuprofen for primary dysmenorrhea: a randomized controlled trial. *BMC Womens Health.* 2012;12:25.
32. Potur DC, Komurcu N. The effects of local low-dose heat application on dysmenorrhea. *J Pediatr Adolesc Gynecol.* 2014;27(4):216–221.
33. Lee B, Hong SH, Kim K, et al. Efficacy of the device combining high-frequency transcutaneous electrical nerve stimulation and thermotherapy for relieving primary dysmenorrhea: a randomized, single-blind, placebo-controlled trial. *Eur J Obstet Gynecol Reprod Biol.* 2015;194:58–63.
34. Vance AR, Hayes SH, Spielholz NI. Microwave diathermy treatment for primary dysmenorrhea. *Phys Ther.* 1996;76(9):1003–1008.
35. Sindole NM, Hande D. Effect of microwave diathermy and aerobic exercise in females with primary dysmenorrhea. *Imperial J Interdiscip Res.* 2017;3(2).
36. Lundeberg T, Bondesson L, Lundstrom V. Relief of primary dysmenorrhea by transcutaneous electrical nerve stimulation. *Acta Obstet Gynecol Scand.* 1985;64(6):491–497.
37. Milsom I, Hedner N, Mannheimer C. A comparative study of the effect of high-intensity transcutaneous nerve stimulation and oral naproxen on intrauterine pressure and menstrual pain in patients with primary dysmenorrhea. *Am J Obstet Gynecol.* 1994;170(1 Pt 1):123–129.
38. Kaplan B, Peled Y, Pardo J, et al. Transcutaneous electrical nerve stimulation (TENS) as a relief for dysmenorrhea. *Clin Exp Obstet Gynecol.* 1994;21(2):87–90.
39. Kaplan B, Rabinerson D, Pardo J, Krieser RU, Neri A. Transcutaneous electrical nerve stimulation (TENS) as a pain-relief device in obstetrics and gynecology. *Clin Exp Obstet Gynecol.* 1997;24(3):123–126.
40. Wang SF, Lee JP, Hwa HL. Effect of transcutaneous electrical nerve stimulation on primary dysmenorrhea. *Neuromodulation.* 2009;12(4):302–309.
41. Lauretti GR, Oliveira R, Parada F, Mattos AL. The new portable transcutaneous electrical nerve stimulation device was efficacious in the control of primary dysmenorrhea cramp pain. *Neuromodulation.* 2015;18(6):522–526 discussion 522-527.
42. Bai HY, Bai HY, Yang ZQ. Effect of transcutaneous electrical nerve stimulation therapy for the treatment of primary dysmenorrheal. *Medicine.* 2017;96(36):e7959.
43. Schiotz HA, Jettestad M, Al-Heeti D. Treatment of dysmenorrhoea with a new TENS device (OVA). *J Obstet Gynaecol.* 2007;27(7):726–728.
44. Nnoaham KE, Kumbang J. WITHDRAWN: transcutaneous electrical nerve stimulation (TENS) for chronic pain. *Cochrane Database Syst Rev.* 2014(7):CD003222.
45. Johnson MI, Paley CA, Howe TE, Sluka KA. Transcutaneous electrical nerve stimulation for acute pain. *Cochrane Database Syst Rev.* 2015(6):CD006142.
46. Johnson MI, Jones G. Transcutaneous electrical nerve stimulation: current status of evidence. *Pain Manag.* 2017;7(1):1–4.
47. Melzack R, Wall PD. Pain mechanisms: a new theory. *Science.* 1965;150(3699):971–979.
48. Perez Machado AF, Perracini MR, Saraiva Cruz, et al. Microwave diathermy and transcutaneous electrical nerve stimulation effects in primary dysmenorrhea: clinical trial protocol. *Pain Manag.* 2017;7(5):359–366.
49. Doig GS, Simpson F. Randomization and allocation concealment: a practical guide for researchers. *J Crit Care.* 2005;20(2):187–191 discussion 191-183.
50. Bajaj P, Bajaj P, Madsen H, Arendt-Nielsen L. A comparison of modality-specific somatosensory changes during menstruation in dysmenorrheic and non dysmenorrheic women. *Clin J Pain.* 2002;18(3):180–190.
51. Yarnitsky D, Bouhassira D, Drewes AM, et al. Recommendations on practice of conditioned pain modulation (CPM) testing. *Eur J Pain.* 2015;19(6):805–806.
52. Melzack R. The McGill Pain Questionnaire: major properties and scoring methods. *Pain.* 1975;1(3):277–299.
53. PIMENTA CAdMT, Jacobsen Manoel. Questionário de dor McGill: proposta de adaptação para a língua portuguesa. *Rev esc enferm USP.* 1996;30(3):10 [online].