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Systematic Review

Effectiveness of transcutaneous electrical nerve stimulation (TENS) modality for treating myofascial pain syndrome: A systematic review and meta-analysis

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Abstract

Introduction: Myofascial pain syndrome (MPS) is a prevalent chronic pain disorder that initiates from myofascial trigger points (MTrPs) in skeletal muscle. This study aimed to systematically review the studies on the efficiency of transcutaneous electrical nerve stimulation (TENS) on MPS.

Methods: The data from PubMed, EMBASE, Web of Science, and Cochrane Central Register of Controlled Trials from the database inception to July 2021 were used. Two reviewers screened the papers independently, and took out the data based on the PRISMA protocol. Information associated with the study was gathered, including glocation, time, author, modality, details of comparisons between groups, duration of treatment, participants' characteristics, and duration of follow-up.

Results: Among 422 articles, a total of 21 articles met the exclusion and inclusion criteria for the study (including 12 trials) and 7 for meta-analysis. The overall estimated effect showed a significant decrease in Visual analog scale (VAS) score in the TENS group compared with the exercise group (MD=-1.60, 95% CI: -2.16 to -1.05, $P<0.00001$). However, there was no significant decrease in pain pressure threshold (PPT) score in the TENS group compared with sham (MD=1.88, 95% CI: -0.62 to 4.38, $P=0.14$) or exercise (MD=0.19, 95% CI: -0.99 to 1.37, $P=0.75$). TENS therapy did not improve the PPT score (MD=0.96, 95% CI: -0.72 to 2.64, $P=0.26$).

Conclusion: The published evidence for the treatment of MPS by TENS has been reviewed. TENS can be utilized as an adjuvant treatment to help alleviate MPS but should not be regarded as a monotherapy.

Introduction

Myofascial pain syndrome (MPS) is a type of chronic pain syndrome that appears in muscles, fascia, or related soft tissues and can be along with apparent emotional disorders or dysfunctions.[1] MPS is a regional pain disorder and a relapsing disease that affects every age group and is characterized by the presence of trigger points (TrPs) within muscles or fascia.[2] The predilection sites of MPS are the neck, shoulders, and back. About 30.0%-93.0% of the patients with musculoskeletal pain are exposed to MPS.[3] Since there are many different treatment options accessible for MPS, treatment strategies should meet the lesion site, course of disease, and individual situation.[4] At present, pharmacologic interventions consist of muscle relaxants such as benzodiazepines, tizanidine, and cyclobenzaprine; Tricyclic antidepressants (TCAs), and topical agents such as diclofenac gel and lidocaine patches, in addition to injection therapy of Botox or lidocaine are frequently used for pain relief in MPS. Other modalities including acupuncture, dry needling, and to a certain extent transcutaneous electrical nerve stimulation (TENS) therapy have been employed to help alleviate the chronic pain in MPS.[5] TENS is the transcutaneous and noninvasive use of electrical stimulation to produce analgesia.[6] It effectively improves pain in patients with MPS, and is theorized for increasing the release of endogenous opiates (enkephalins and β-endorphins), stimulating sensory nerves and gate-control mechanisms,

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modulating autonomic responses, and partly blocking C-fibers for pain relief.[7] Conventional TENS applications were effective in pain relief and range of motion in patients with MPS.[8]

Systematically, we reviewed the information from randomized controlled trials (RCTs) and quasi-RCTs to assess of the efficiency of TENS modality in treating myofascial pain. Understanding the actual benefit of this modality is important clinically since it may help to develop good rehabilitation protocols for chronic MPS circumstances.

Methods

Study design

This systematic review was performed based on the predetermined guidelines presented by the Cochrane Collaboration (2008).[9]

Studies

All RCTs and quasi RCTs were included.

Participants

Inclusion criteria

All relevant studies involved patients with MPS, and sought treatment with the following modality: TENS.

Exclusion criteria

- Articles with no adequate patients (fewer than seven patients)
- All retrospective studies
- Studies with no access to full-text
- Withdrawn trials.

Interventions

TENS (transcutaneous electrical nerve stimulation).

Types of comparisons

The quantitative component of this review was considered placebo, sham controls, and other conventional controls including exercise.

Types of outcomes

Primarily, our objective was to assess the efficiency of TENS in pain relief. Visual analog scale (VAS) was included in valid reliable common scales for pain intensity evaluation and monitoring. The primary outcome was the efficacy of each modality using pain reduction according to the VAS questionnaire and pain pressure threshold (PPT) (using a Pressure Algometer).

Table 1 presents PICOS criteria for exclusion and inclusion of studies.

The strategy of article search

A systematic search was conducted in Cochrane Library, ProQuest, Clinicaltrial.gov, Web of Science, Google Scholar, Ovid, PubMed, and Scopus databases in July 2021. The studies were searched based on the keywords in line with the MeSH glossary. The review search ahead of published or printed articles was performed irrespective of time limitations or language. References accessible in review articles were assessed as further resources. Persian thesis was reviewed by searching the universities' websites. It also tried to search for articles available at conferences. However, no full access was found to the gray literature.

Data collection and analysis

Selecting the studies

The abstracts and titles of all studies recognized by the search approach were read independently by two authors. Once all potentially related articles were retrieved, the full text of each article was independently evaluated by each reviewer for inclusion and then methodological quality and acceptability of selected studies were assessed through the Cochrane appraisal risk of bias checklist. When there was not any consistency, the idea of the third author was considered and agreed upon.

Assessing the risk of bias

The articles were reviewed regarding selection detection, performance bias, reporting, and attrition bias. Also, an assessment was separately performed by two authors in terms of the Cochrane Handbook. The considered items included Random sequence generation (assessing for probable selection bias); allocation concealment (checking for potential selection bias); blinding of participants and personnel (assessing for possible performance bias); blinding of outcome assessment (checking for possible detection bias); selective reporting (checking for reporting bias), incomplete outcome data (assessing for possible attrition bias); and other bias.[10] In all cases, a "low risk" assessment represented a low rate of bias, assessing "high risk" means a high rate of bias, and evaluating "unclear risk" represents the uncertain risk of bias.

Table 1. PICOS criteria for inclusion and exclusion of studies

Parameter	
Participants	Patients with Myofascial pain syndrome
Intervention	Transcutaneous electrical nerve stimulation
Comparator	Placebo, sham or conventional methods including exercise.
Outcomes	Any beneficial effect on Pain reduction (using VAS questionnaire), and pain pressure threshold (using Pressure Algometer)
Study design	Randomized controlled trials (RCTs) or quasi-experimental studies.

Data extraction and management

Data were extracted using a form. Information associated with the study was gathered, including time, author, place, modality, comparison details between groups, treatment duration, follow-up duration, and participants' characteristics. The reports were summarized for studies published more than once, and those published with the most complete information were included in the study. These data were used for the results published only in older versions. All differences between the published versions must be considered. The information needed by the original author was requested via correspondence and the associated data was achieved. Disagreement was resolved through consultation with the third party, who is an expert in this field.

Data analysis

Owing to failure in quasi-experimental articles or complete report data, or a control arm rather than the placebo, sham, or conventional methods, meta-analysis was possible only on 16 articles.

Meta-analysis was performed through Review Manager 5.4.1 statistical software. The findings of the per-protocol analysis were utilized for meta-analysis for intention-to-treat analysis but the results were not reported. Here, all the results were quantitative. Moreover, mean and standard deviation were utilized for analysis before and after the intervention. Using standard deviation and mean changes in each group followed by the intervention in comparison with the baseline, and then, MD changes were calculated with a confidence interval of 95%. In this regard, mean changes from baseline was calculated by this formula:

Mean change = mean of follow-up measurement – mean of baseline measurement

To obtain standard deviation (SD) changes, the previously reported formula was used.[11]

The quantity of heterogeneity amongst the included studies' results was assessed by the I^2 index indicating the variability percentage between studies. A value of more than 50% for this index, represents the higher heterogeneity. Finally, the meta-analysis was reported using a random effect. In addition, for heterogeneity less than 50%, the fixed-effect model was used for analysis. Through the forest plot, pooled results were presented, in case of at least two articles.

Results

Results of the search

In the first phase, 422 articles were collected from databases, and after eliminating the duplicated items, 365 articles remained. Then, the articles were assessed according to the inclusion criteria. Considering non-relevance to this review, 340 were excluded based on the abstract and title. Ultimately, out of 25 articles, 21 were included in systematic review (including 12 trials),[8,12-31] and seven of them for meta-analysis.[8,12,13,15-18] (Figure 1).

Explanation of studies

All of the studies included in this systematic work published from 2002 to 2021, were clinical trials, and included a control group with a parallel arm or cross-over design. Of these, 17 were conducted in Turkey; the others were in India, Iran, South Korea, Taiwan, Thailand, USA, UK, Egypt, etc (Table 2).

Meta-analysis was performed only on seven articles[8,12,13,15-18] (including 12 trials) owing to failure to completely report data or quasi-experimental articles, or a control arm rather than the placebo, sham, or conventional methods,

The outcome measurement tools were VAS, PPT, or both, and a minority of studies used a numeric pain rating scale, Nottingham Health Profile, or neck pain disability index to report their outcomes. Total sessions were varied between 1-30 as well as one to seven sessions per week. The included studies' modification was continuous, biphasic, or Burst/conventional. The frequency (MHz), effective radiating area (ERA) (cm^2), Beam Nonuniformity Ratio (BNR), output (W/cm^2), and duty cycle (%) are summarized in Tables 3 and 4.

Risk of bias in articles

Considering the Cochrane appraisal risk of bias checklist, all of the published articles included in the meta-analysis had moderate or good quality (Figures 2 and 3).

Effectiveness of TENS on pain relief

Fifteen RCTs used the TENS modality in one of the experimental or control arms, or either two different experiments alone in combination with other modalities such as electrical muscle stimulation (EMS), ischemic compression interferential therapy (IFT), or US.[8,12-17,19,20,22,23,25-27,40]

Smania et al, in their study, compared the long, medium, and short-term impacts of peripheral repetitive magnetic stimulation (rMS) and TENS on 53 patients with MPS. Their results indicate that a long-lasting impact of rMS compared to the TENS.[28]

In line with this result, Ardiç et al. compared the TENS and EMS on MPS on 40 patients in three different groups, including TENS + exercise, EMS + exercise, and only exercise. No statistical differences were found in any of the parameters between TENS and EMS groups at any time ($P > 0.05$), indicating that there is no considerable superiority of the two electrotherapies methods on each other in long term evaluation, although the effectiveness of TENS is found immediately followed by treatment.[8] Another RCT was performed by Sahin et al. on the effects of TENS and reported that TENS types were not greater than other MPS treatment groups or placebo.[17]

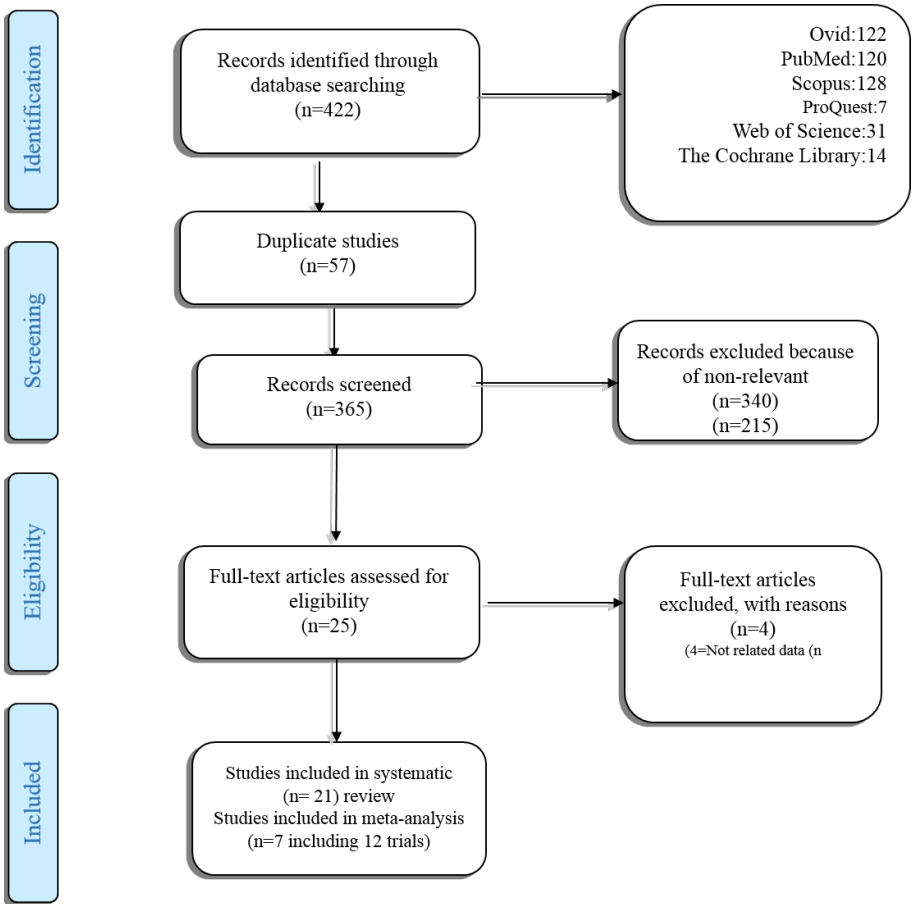

Figure 1. Search and selection process of systematic review

Table 2. Characteristics of the included studies

Author	Year	Type of study	Country	Modality	Control group modality	Case	Control	Mean age	Male	Female
Hou[15]	2002	RCT	Taiwan	Group 1: ischemic compression ± TENS Group 2: exercise ± TENS	Exercise	Group 1: 9 Group 2: 9	21	46.89 ± 14.91 and 51.00 ± 16.19	8	31
Ardiç[8]	2002	RCT	Turkey	Group 1: TENS Group 2: EMS	Exercise	Group 1:15 Group 2:15	10	41.73 ± 8.04 and 42.60 ± 9.40	4	36
Smania[28]	2005	RCT	Italy	TENS	Placebo	18	18	36.56 ± 14.94 and 44.61 ± 16.62	11	25
Gemmell[14]	2010	Double-blind, randomized placebo-controlled trial	UK	TENS	Sham TENS	30	30	24.2-25.6	27	28
Sahin[17]	2011	Randomized, placebo-controlled clinical trial	Turkey	Group 1: conventional TENS Group 2: conventional TENS Group 3: Burst TENS	Sham TENS	Group 1 :19 Group 2: 18 Group 3: 19	19	18-65	35	40
Rodríguez-Fernández[16]	2011	Single blind randomized trial	Spain	TENS	Sham TENS	38	38	18-41	45	31
Ramanathan[19]	2015	RCT	India	US and TENS	Exercise	15	15			
Azatcam[12]	2016	Randomized, controlled, single- blind, prospective study	Turkey	TENS	Exercise	23	23	18-65	21	48
Kim[32]	2016	Single-blind RCT	Korea	US	Exercise (therapeutic inflatable ball)	18	22	67.71 ± 5.65 and 71.15 ± 5.06	5	40

Table 2. Continued.

Author	Year	Type of study	Country	Modality	Control group modality	Case	Control	Mean age	Male	Female
Dissanayake [33]	2016	Single-blind RCT	Sir Lanka	Group 1: TENS Group 2: IFT	Hot pack, active range of motion exercises, myofascial release, and a home exercise program with postural advice	Group 1: 35 Group 2: 35	35	18-55	47	58
Takla[18]	2018	RCT	Egypt	G1: burst-TENS-CT: burst transcutaneous electrical nerve stimulation combined therapy, G2: AMF-CT	Sham TENS	Group 1:23 Group 2:25	22	34.39 ± 5.92 and 34.88 ± 5.67 and 35.18 ± 5.56	30	40
Jeon[34]	2012	RCT	Korea	ESWT	TPI + TENS	15	15	G1:40.86 ± 13.07; G2:45.00 ± 15.46	G1:13; G2:9	G1:2; G2:6
Kim[24]	2014	RCT	Korea	G1: NSAID patch, G2: NSAID patch + TENS, G3: NSAID patch + heating pad, and G4: NSAID patch + topical capsaicin	G1:25; G2:24; G3:25; G4:25	-	-	G1:44.76 ± 12.71; G2:49.17 ± 13.52; G3:47.56 ± 10.67; G4:48.88 ± 11.11	-	-
León-Hernández[25]	2014	RCT	Spain	Needling + TENS	Needling	31	31	26.81 ± 9.63; G2: 23.32 ± 4.77	G1:7; G2:9	G1:24; G2:22
Chalkoo[21]	2015	RCT	India	G1: conventional treatment including muscle relaxants, analgesics, soft diet, and hot fomentations; G2: TENS; G3: combined conventional and TENS treatment	Placebo	each 15	15	17-60	23	37
Amjad [20]	2016	RCT	Pakistan	TENS	US	32	32	G1:32 ± 1; G2:37 ± 9.9	25	39
Rai [27]	2016	RCT	India	G1: TENS; G2:US	control	30;30	30	G1:29.73 ± 8.804; G2:32 ± 10.174; G3:34.93 ± 12.57	6;7;12	24;23;18
Khalifeh [23]	2018	RCT	Iran	G1: TENS + pharmacotherapy; G2: LLLT; G3: sham LLLT		G1:18; G2:19	18	18-60		
Mansourian [26]	2018	RCT	Iran	TENS + medication	LLLT + medication; medication	36	36, 36	21-60	18.54%	81.46%
Chiou [22]	2019	RCT	Taiwan	TENS on the acupuncture point	TENS on trigger point	30	30	G1: 42.13 (12.93); G2: 41.98 (15.04)	G1: 25; G2: 23	G1: 5; G2:7
Gezginaslan [31]	2020	Prospective, randomized, single-blind clinical study	Turkey	ESWT	US, HP, TENS group	49	45	44.2 ± 11.94	16	78

AMF-CT, amplitude modulated frequency combined therapy; LLLT, low-level laser therapy; IFT, interferential therapy; TENS, transcutaneous electrical nerve stimulation; ESWT, extracorporeal shock wave therapy; US, Ultrasound; HP, hot pack; BNR, Beam Nonuniformity Ratio; ERA, effective radiating area; GP, Group

Ramanathan et al compared the impact of conventional physiotherapy (TENS and Ultrasound (US)) with ischemic compression using stretching in MPS treatment. They observed that ischemic pressure was more effective than the conventional method in reducing pain.[19] Rodríguez-Fernández et al showed contrary results with the application of burst-type TENS for ten minutes and concluded a small but statistically significant increase in the PPT over upper trapezius latent myofascial trigger points (MTrPs).[16]

Hou et al, in their RCT on 119 subjects, assessed the immediate effects of physical therapeutic modalities on myofascial pain in the upper trapezius muscle and concluded that therapeutic combinations are most operative for MPS relief like TENS, hot pack plus active ROM and stretch with spray, hot pack plus an active range of motion (ROM) and stretch with spray, as well as, hot pack plus active ROM, interferential current and myofascial release technique.[15]

Gemmell et al compared the results of TENS and sham on 60 MPS patients and observed that TENS was superior to placebo in reducing pain but had no better effect than placebo in improving PPT.[14]

Azatcam et al, in an RCT on 69 MPS patients, compared the effect of TENS + exercise, Kinesio Taping (KT) + exercise, and exercise only on the pain, and revealed a reduction in pain in all groups immediately after treatment and three months after treatment ($P < 0.01$). However, the VAS score was reduced in the KT group in comparison to the control group and TENS ($P = 0.001$),

Table 3. Characteristics of the used modality

Author	Year	Modification	Frequency (MHz)	ERA (cm^2)	BNR	Output (W/cm^2)	Duty cycle%	Total session	Sessions per week
Hou[15]	2002	Biphasic	-	-	-	-	-	14	7
Ardiç[8]	2002	Biphasic	-	-	-	-	-	1	1
Smania[28]	2005	Biphasic	-	-	-	-	-	10	5
Gemmell[14]	2010		-	-	-	-	-	1	1
Sahin[17]	2011	Burst/ conventional	-	-	-	-	-		
Rodríguez-Fernández[16]	2011	Burst	-	-	-	-	-	1	1
Ramanathan [19]	2015	Pulse/burst	1			1.5		30	5
Azatcam[12]	2016	Biphasic						10	5
Kim[32]	2016	Continuous	1	40		1	100	8	2
Dissanayake[33]	2016	Biphasic						8	2
Takla[18]	2018	Group 1: Burst TENS Group 2: AMF TENS	-	-	-	-	-	12	3
Jeon[34]	2012		-	-	-	-	-		
Kim [24]	2014		-	-	-	-	-	2	2
León-Hernández[25]	2014	Conventional	2	-	-	-	-	3	2
Chalkoo[21]	2015	Conventional	10 Htz	-	-	-	-	3	3-day interval
Amjad[20]	2016	Conventional-continuous	1	-	-	1.5	-	12	
Rai[27]	2016	Conventional	-	-		0.73	-	12	3 times every 2 weeks
Khalifeh [23]	2018	-	-	-		200 mW/cm^2	-	10	two times a week
Mansourian[26]	2018	-	-	-		-	-	10	3
Chiou[22]	2019	-	0.6/60 Hz	-	-	-	-	7	Seven consecutive days
Gezginaslan[31]	2020	-	-	-	-	1.5	-	7	Three days interval

AMF, amplitude modulated frequency; TENS, transcutaneous electrical nerve stimulation; ESWT, extracorporeal shock wave therapy; US, Ultrasound; HP, hot pack; BNR, Beam Nonuniformity Ratio; ERA, effective radiating area

and in the TENS group compared to the control group ($P = 0.011$) after treatment. Considering the evaluations after 3 months and, the VAS score was reduced in the TENS group in comparison to the control group ($P = 0.001$), as well as in the KT group than the control group ($P = 0.001$). No considerable differences were found between KT and TENS groups.[12] In line with the influential role of TENS in pain reduction, Dissanayaka showed that TENS with standard care facilitates had better outcomes than IFT.[13] Takla investigated the effect of combination therapy with the application of US and TENS. In their trial, 70 patients underwent the burst-TENS-combined therapy (CT), medium-frequency, low-intensity amplitude modulated frequency (AMF)-CT, or sham-CT control groups. Both combination therapies effectively increased PPT.[18] Other trials reported a better efficacy of TENS in combination with other modalities, including needling,[25] or pharmacotherapies (methocarbamol and naproxen)[23] (fluoxetine, clonazepam, baclofen)[26] in comparison to needling,[25] or low-level laser (LLL) approaches. However, in comparison the TENS,[20,27] the efficacy of US significantly was higher. In addition, TENS on the acupuncture point was accompanied by superior improvement than the TENS on the TrP in pain intensity.[22]

Our meta-analysis included only the studies in which TENS was used only in the intervention arm and compared them with sham, placebo, or exercise. The only combination therapy included in our meta-analysis belonged to the combination therapy of TENS and exercise in the experimental group.[15]

Results of Meta-analysis

Effectiveness of TENS on VAS score

Five RCTs, including seven trials with 214 participants who evaluated the efficacy of TENS compared to placebo or control, sham or exercise, were eligible to be included in the meta-analysis.[8,12,13,15,17] The scale used was VAS. However, one of them had a combination of standard care for the control arm (active ROM exercises, myofascial release, hot pack, and a home exercise program with postural advice), which was not considered in this meta-analysis.[13] The I^2 index represented considerable heterogeneity between studies ($I^2 = 88\%$, P value < 0.0001); thus, a random effect model was utilized to pool the data. A significant reduction was found by the overall estimated effect in VAS score in the TENS group in comparison to the exercise group (MD = -1.60, 95% CI: -2.16 to -1.05, $P < 0.001$). Sahin et al, had three intervention groups: Group 1 received a conventional TENS with a frequency of 100 Hz, 40 μs duration, low amplitude; Group 2 with an

Table 4. The outcomes measure tools and results

Author	Intervention group				Control group			
	VAS (pre)	VAS (post)	PPT (pre)	PPT (post)	VAS (pre)	VAS (post)	PPT (pre)	PPT (post)
Hou[15]	Group 1: 4.69 ± 2.24 Group 2: 4.68 ± 1.28	Group 1: 2.46 ± 1.33 Group 2: 2.43 ± 0.65	Group 1: 2.68 ± 0.75 Group 2: 3.09 ± 1.10	Group 1: 3.39 ± 0.83 Group 2: 3.93 ± 1.03	5.10 ± 1.78	4.33 ± 1.82	3.07 ± 0.96	3.45 ± 1.09
Ardiç[8]	Group 1: 7.40 ± 1.88 Group 2: 7.00 ± 1.20	Group 1: 4.27 ± 2.28 Group 2: 4.13 ± 2.59	Group 1: 2.00 ± 0.76 Group 2: 2.00 ± 0.85	Group 1: 0.80 ± 0.68 Group 2: 1.07 ± 0.59	7.50 ± 1.84	6.50 ± 2.55	2.10 ± 0.74	1.70 ± 0.95
Smania[28]	Range: 40-50	Range:30-40			Range:40-50	Range:40-50		
Gemmell[14]			4.0 ± 1.4	3.51			4.0 ± 1.4	3.55
Sahin[17]	Group 1:7.12 ± 1.87 Group 2:6.15 ± 1.18 Group 3:6.85 ± 1.35	Group 1: 6.85 ± 1.55 Group 2: 6.55 ± 1.42 Group 3: 6.10 ± 2.15			7.56 ± 1.17	6.95 ± 1.15		
Rodríguez-Fernández[16]			2.1 ± 0.5	2.7 ± 0.7			2.2 ± 0.8	2.2 ± 0.8
Ramanathan[19]	7.06 ± 0.798	5.93 ± 0.703			7.13 ± 0.833	3.60 ± 0.828		
Azatcam[12]	7.39 ± 0.66	1.78 ± 0.74	16.75 ± 2.34	24.12 ± 3.02	7.21 ± 0.51	2.95 ± 0.97	16.75 ± 1.94	22.82 ± 3.39
Kim[32]	5.31 ± 1.52	2.67 ± 1.82	2.07 ± 0.70	2.45 ± 0.87	6.15 ± 1.62	3.34 ± 1.95	1.92 ± 0.34	2.50 ± 0.04
Dissanayake[33]	Group 1:69.9 ± 2.8 Group 2:67.2 ± 8.7	Group 1: 45.3 ± 8.4 Group 2: 31.8 ± 6.2			70.3 ± 4.2	17.6 ± 3.1		
Takla[18]			Group 1: 0.27 ± 0.18 Group 2: 0.75 ± 0.16	Group 1: 4.57 ± 0.57 Group 2 :2.73 ± 0.35			0.71 ± 0.16	1.86 ± 0.17
Jeon[34]	6.86 ± 0.90	1.86 ± 0.69	6.86 ± 1.35	12.57 ± 0.72	7.20 ± 1.30	2.80 ± 0.84	6.20 ± 1.92	9.60 ± 2.19
Kim[24]			G1: 2.47 ± 0.83; G2: 2.79 ± 1.41; G3: 2.67 ± 0.74; G4: 2.59 ± 0.89		G1:2.42 ± 1.00; G2:2.94 ± 1.12; G3:3.01 ± 0.82; G4:2.89 ± 0.83			
León-Hernández[25]	4.82 ± 1.83	2.00 (1.00 and 5.00)	1.80 ± 0.90	1.70 (1.18 and 6.75)	4.82 ± 1.91	2.50 (1.00 and 4.00)	1.72 ± 0.81	1.50 (1.15 and 1.87)
Chalkoo [21]	G1: 3.7 (1.05); G2:4.0 (1.07); G3: 5.0 (1.31)	G1: 0.6 (0.91); G2: 1.4 (0.91); G3: 0.1 (0.35)			4.1 (0.64)	4.1 (0.83)		
Amjad [20]	6 times a week for two weeks.							
Rai[27]	240.60 ± 25.75	32.37 ± 13.02			247.87 ± 26.53	20.87 ± 6.35		
Khalifeh [23]	Trapezius: G1: 1.926 ± 1.777; G2: 2 ± 1.763	G1: 1.515 ± 0.812; G2: 1.444 ± 1.423			1.833 ± 2.526	2.666 ± 2.894		
Mansourian[26]	4.13 ± 1.75	4.77 ± 0.27			G1 :4.09 ± 1.76; G2: 2.87 ± 0.98	G1: 4.90 ± 0.27; G2: 5.01 ± 0.27		
Chiou[22]	6.70 (1.18)	2.93 (1.64)			6.20 (1.35)	3.10 (1.42)		
Gezginaslan[31]	8.3 ± 1.2	3.7 ± 1.7			8.1 ± 1.3	6.5 ± 1.2		

acupuncture-like TENS with a frequency of 4 Hz, 250 μs duration, high amplitude; Group 3 with burst TENS with high [100 Hz] and low [2 Hz] frequency, 40 μs, and high amplitude. A control group was treated with electrical stimulation until the patient felt it. The results of subgroup analysis with the control arm of sham TENS showed no statistical difference between the groups (MD: 0.45, 95% CI: -0.21 to 1.12, $P = 0.18$). Also, test for the overall effect of TENS compared to the control arm (either sham or exercise) did not show any significant difference between study groups (MD = -0.67, 95% CI: -1.70 to 0.36, $P = 0.20$). Our results also showed that TENS therapy did not ameliorate patients' pain using the VAS scale (Figure 2).

Effectiveness of TENS on PPT score

Five RCTs involving 222 participants who evaluated the efficacy of TENS compared to placebo or control or sham or exercise were included in the meta-analysis.[8,12,15,16,18,35] The scale used was PPT. The I^2 index showed significant heterogeneity between studies ($I^2 = 99\%$, $P < 0.00001$), and

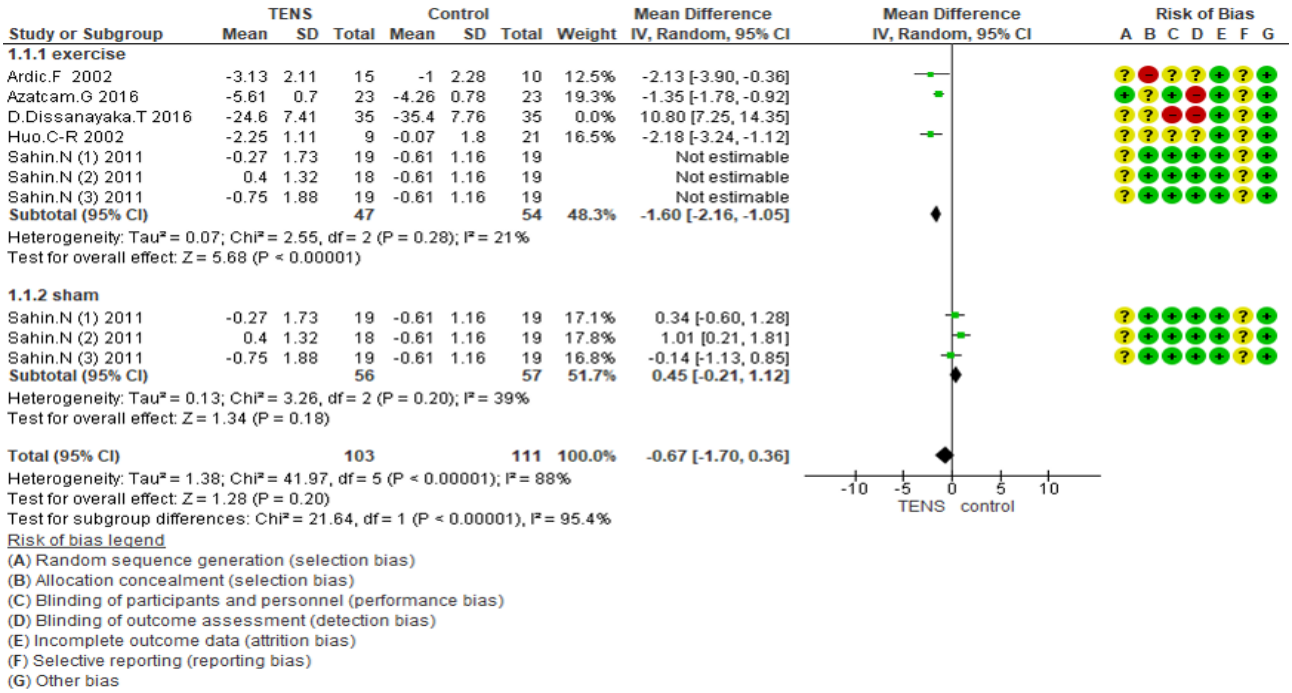

Figure 2. Forest plot of comparison TENS vs. control on VAS score

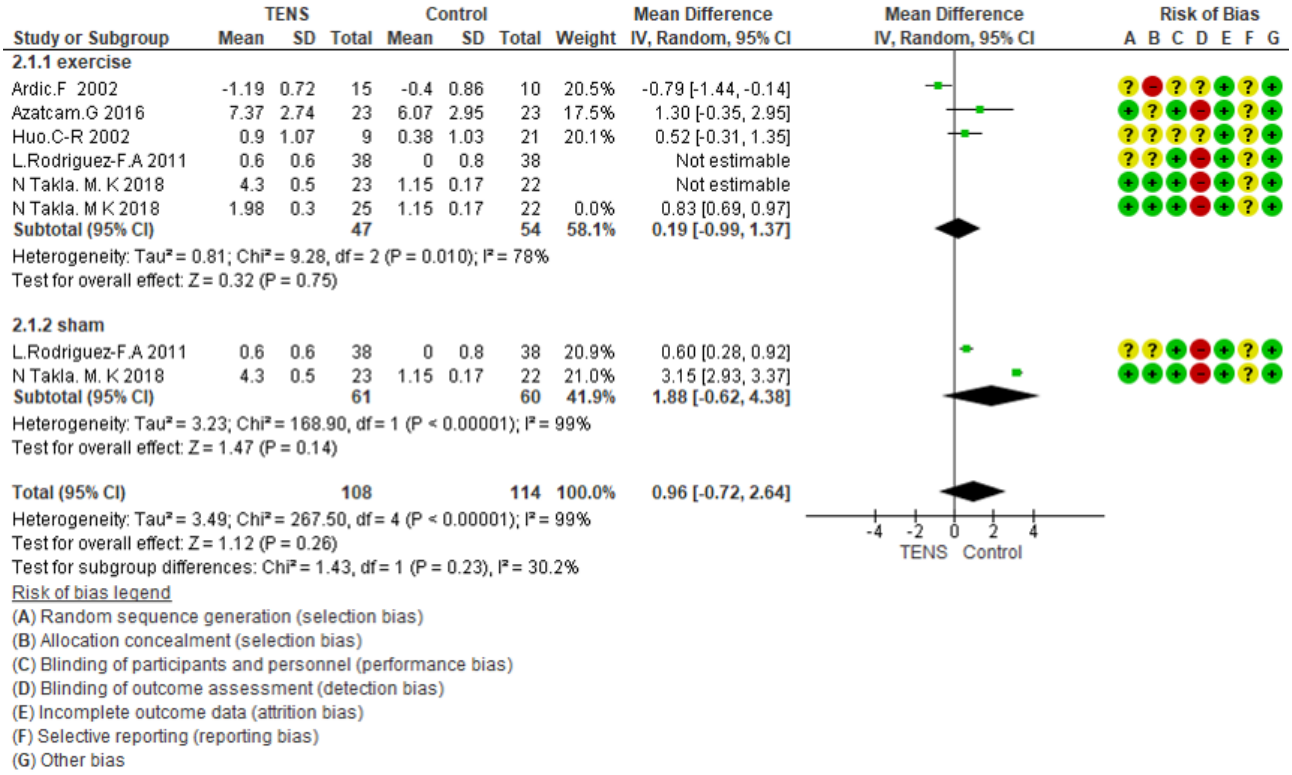

Figure 3. Forest plot of comparison TENS vs. control on PPT score

therefore a random effect model was used to pool the data. The overall estimated effect showed no significant decrease in PPT score in the TENS group compared with sham (MD = 1.88, 95% CI: -0.62 to 4.38, $P = 0.14$) or exercise (MD = 0.19, 95% CI: -0.99 to 1.37, $P = 0.75$). In total, TENS therapy did not improve the PPT score (MD = 0.96, 95% CI: -0.72 to 2.64, $P = 0.26$) (Figure 3).

Discussion

MPS is poorly understood and remains a challenging condition to treat. Effective management of MPS is to diagnose it early, subsequently intensive, protocol-based,

multi-disciplinary rehabilitation applying a combination of medication, rest, physiotherapy, and effective use of various trigger point management techniques. Myofascial pain is typically treated by interventions directed at modifying trigger point sensitivity.[36] The primary objective of treatment is to resolve the pathologic conditions of MPS. Reducing the disability and pain are the secondary treatment objectives.[37] TENS is efficient, safe, and a relatively simple physical modality usually utilized in painful conditions. The TENS devices lead to patients less dependence to analgesics and narcotics.[38] The present work reviewed all available evidence from RCTs and quasi RCTs systematically to summarize the effects of TENS on pain scores in myofascial pain. The use of the TENS in the management of MPS has been well-established, previously. In this regard, a study conducted by Wessberg et al, reported a much higher rate of pain reduction (95%) in patients with myofascial pain.[39] Kruger et al in 1998 determined that in treating chronic pain, the application of TENS has been proposed as a practical adjunct modality.[40] Additionally, it has been reported that 63.6% of patients with myalgia were completely relieved of pain after receiving TENS therapy, while another study reported that 23.3% of patients were pain-free following TENS.[41,42]

To date, data about the comparison of different TENS protocols in the tr0eatment of MPS are limited.[17,18] On the other hand, the studies regarding the efficacy of TENS in the treatment of MPS are conflicting.[7,16,17] Moreover, a recent systematic review also found that TENS is effective for the treatment of MPS.[43] As stated by the present study, TENS is superior to placebo in pain reduction and pain perception improvement. TENS can decrease pain severity and increase pain threshold in MPS patients, as well.

According to the clinical studies using TENS at various frequencies, moderate to high TENS frequencies (20-80 Hz), are most effective to reduce pain intensity regarding high frequencies i.e.,100 Hz or low frequencies < 10 Hz in both clinical and healthy subjects.[44] The findings also showed primary evidence that treatment sessions with durations higher than 15 min have more effectiveness compared to the short-duration sessions.[43]

In general, TENS was beneficial among the noninvasive therapeutic modalities.[37] The difference in pain reduction in the mentioned studies is ascribed to the difference between the samples with regard to variations in biological and social constituents affecting the MPS, along with the stimulation parameters used in the TENS therapy.

Study limitations

Several limitations are present in this study. Only seven studies were included in the meta-analysis. However, all of the included studies were RCTs, and we performed a quality assessment of the risk of bias to overcome this limitation. All studies included in this analysis possessed a relatively small sample size. It must be highlighted that the duration of therapeutic effect and effect sizes are often limited; therefore, real clinical impact should be determined with further large-scaled clinical research.

Conclusion

This manuscript reviewed the main aspects of TENS on pain scores in myofascial pain. Thus, TENS can be utilized as an adjuvant treatment to help alleviate MPS but should not be regarded as a monotherapy. The results of trials were heterogeneous because of large variability within the applied parameters and protocols. The limited sample size and poor quality of these studies highlight and support the need for additional studies with larger numbers of participants, and good quality placebo-controlled trials in this area.

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Competing Interests

There is no conflict of interest.

Ethical Approval

The current study was approved by the Research Ethics Committee of the Tabriz University of Medical Science (No: IR.TBZMED.REC.1400.926).

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