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Effects of Transfer Energy Capacitive and Resistive On Musculoskeletal Pain: A Systematic Review and Meta-Analysis

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Abstract

The use of transfer energy capacitive and resistive (TECAR) therapy to treat musculoskeletal pain has not been clearly established. Hence, this study was conducted to combine the available results. We searched the main databases, including PubMed (January 1950), Web of Knowledge (January 1945), Scopus (January 1980), and ProQuest (January 1983) until December 2021, to find the related studies. Only those studies were included that assessed the pain in participants who received TECAR therapy and compared it with a control group. Using the random effect model, standardized mean difference (SMD) was calculated at a 95% confidence interval (CI). The differences between patients and control group were -1.04 after four weeks of intervention (95% CI: -1.59 to -0.48, I^2=86.9%) and -1.80 after eight weeks (95% CI: -2.15 to -1.46, I^2=87%), which was significant (P<0.001). The intra-group pain comparison before and after two, four, and eight weeks of TECAR therapy obtained SMD levels of -3.96 (95% CI: -5.28 to -2.65, I^2=96.9%), -4.12 (95% CI: -5.98 to -2.26, I^2=97.3), and -5.03 (95% CI: -7.23 to -2.83, I^2=92.2%), respectively. Despite some limitations, our findings may assist clinicians in decision-making about TECAR therapy for the approach to musculoskeletal pain based on evidence-based medicine. **[GMJ.2022;11:e2407]** **DOI:10.31661/gmj.v11i.2407**

Keywords: Musculoskeletal; Pain; Transfer Energy Capacitive

Introduction

Musculoskeletal disorders, also known as cumulative trauma disorders, occur when the pressure applied to the musculoskeletal tissues exceeds their strain tolerance. These injuries are caused over time by the physical activity of muscles, tendons, bones, and joints [1]. These structures may present complications in a range of mild to severe symptoms. Musculoskeletal pain can be confined to one or more widespread origins [2]. Although various treatment options are available, some are disfavoured due to the high cost and/or their side effects [3].

One option is transfer energy capacitive and resistive (TECAR) therapy to reduce muscu-

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loskeletal pain [4]. TECAR therapy employs high-frequency electromagnetic waves (0.3 to 1.2 MHz) [5] and reduces activity-induced spasms and contractions, improves blood flow, and helps muscle oxygenation via hemoglobin activation. Hence, TECAR therapy enhances the body's natural ability to repair tissues and reduce pain [6].

The efficiency of TECAR therapy has been established in reducing pain induced by musculoskeletal disorders [7-10]. The results obtained from a review of this modality demonstrated that TECAR therapy is an effective treatment for knee, shoulder, hip, ankle, spine, and hand pain. Furthermore, it competently improves painful inflammation caused by bone and joint disorders [11]. Another systematic review showed that TECAR therapy is more effective in the treatment of musculoskeletal pain than other modalities [12]. To date, no meta-analysis has been conducted to provide a conclusive result combined with previous findings. Therefore, we performed a meta-analysis to review the combined results of high-quality studies in the literature.

Materials and Methods

Inclusion and Exclusion Criteria

We included randomized controlled trial (RCT), case-control, and cross-sectional studies that assessed the pain in participants who received TECAR therapy regardless of subjects' race, age, gender, publication year, and language. The primary variable investigated in this study was the pain experienced in the leg, shoulder, low back, and femur by patients with musculoskeletal disorders. Also, the pain was assessed by a visual analogue scale (VAS), which measures pain intensity on a scale of 0 to 10. All patients who underwent TECAR therapy received a high-frequency electromagnetic wave (0.3 to 1.2 MHz).

Search Strategy and Sources

The primary databases used to search the studies were PubMed (January 1950), Web of Knowledge (January 1945), Scopus (January 1980), and ProQuest (January 1983) until December 2021. Also, we checked the references list of all relative articles. The following search keywords (Table-1) were used as follow: (TECAR therapy OR capacitive and resistive diathermy OR Hyperthermia, Induced…) AND (Fractures, Bone OR Muscular Disease OR Muscle Disorders OR Muscle Disorder OR pain …).

Study Selection and Data Extraction

After removing the duplicates, all references are imported to EndNote X9 (Clarivate

Table 1. Search Strategies Based on PICO

Variables	Keywords	Synonyms
Population	Musculoskeletal disorders	• Fractures • Bone • Muscular disease • Muscle disorders
Intervention	TECAR therapy	• Capacitive and resistive diathermy • Hyperthermia • Analytical, diagnostic, therapeutic techniques, and equipment category
Comparison	Other treatments for musculoskeletal disease	-
Outcome	Changes in pain and rehabilitation of musculoskeletal patients	• Outcome • Treatment • Patient-relevant outcome • Clinical effectiveness • Treatment effectiveness • Rehabilitation outcome • Treatment efficacy

Analytics, Toronto, Canada). Two researchers independently assessed the title and abstract of all these references to select the related papers. Then, we reviewed the full text of selected articles to ensure that they meet the inclusion criteria. The degree of agreement between the two reviewers was measured, which showed a 79.8% inter-rater reliability in Cohen's kappa coefficient.

We summarized the studies' data related to author name, publication date, country, type of study, age, gender, pathology understudy, evaluation period, sample size, and pain scores before and after therapy in intervention and control groups. The data collected were then entered into an electronic data form. The process of data extraction was performed by two authors independently, and disagreements were solved by taking a consensus-building approach.

Quality Assessment

The quality of included studies was explored using the 5-point score of the Jadad scale [13]. Briefly, the Jadad scale evaluated the quality of the study based on the following items: 1) description of randomization, 2) methods used to generate the sequence of randomization, 3) blinding, 4) method of blinding, and 5) description of withdrawals and dropouts [14]. We categorized the studies into two groups low- (score<4) and high-quality (score≥4). Two authors independently performed the quality assessment, and a consensus was made in the case of disagreement.

Heterogeneity and Reporting Bias

Measuring inconsistency in our meta-analysis, the I^2 statistics test was used to assess heterogeneity quantitatively according to the following equation: $I^2=[(Q\ 2\ df)/Q]\times100$ [15]. A level of I^2 higher than 75% was considered high heterogeneity [16]. Also, we explored heterogeneity using Q-test at a 95% of confidence interval (CI) [17].

Statistical Analysis

Using a standardized mean difference (SMD) method, the intergroup comparisons were made at a 95% CI level. All statistical analyses were carried out by Stata software v.11 (StataCorp, College Station, TX, USA) using a random effect model [18].

Results

A total of 919 articles were found in the initial comprehensive search in databases and selected articles reference list. Out of these, 417 were duplicates. After the title and abstract screening of 502 articles, 13 articles were considered for full-text review (Figure-1). Accordingly, five studies were excluded for the following reasons: one study [6] assessed pain by other scales, such as the Ely test and pelvic tilt instead of VAS; two studies [19, 20] evaluated tissue temperature changes post-TECAR therapy; and two studies were not randomized clinical trial (one case-control study [21] and one cross-sectional study [22]). Finally, eight studies were included in the final analysis [7-10, 23-26].

Studies Characteristics

Totally, 678 participants with a mean age of 49.9±15.24 years were evaluated. As shown in Table-2, five studies [8-10, 23, 25] were conducted in Italy, two in Iran [7, 24], and one in South Korea [26]. The smallest sample size was related to the survey of Kim *et al*. [26] with 22 patients, and the largest was related to the study carried out by Ganzit *et al*. [25] with 327 participants. Subjects in one study [9] suffered from femoral pain. Low back pain (LBP) was the chief complaint in three studies [8, 10, 25], of which two studies [10, 25] investigated athletes suffering from musculoskeletal pain. Participants in another study [8] also had disc herniation. Pain in the knee [23], shoulder [26], and ankle joints [24] were observed in other study populations. One study [7] examined patients with diabetic neuropathy. Pain as the significant variable was measured using VAS in all studies.

Different Therapeutic Approaches for Relief Musculoskeletal Pain

The studies included employed different methods of TECAR therapy for the intervention group (Table-2). The course

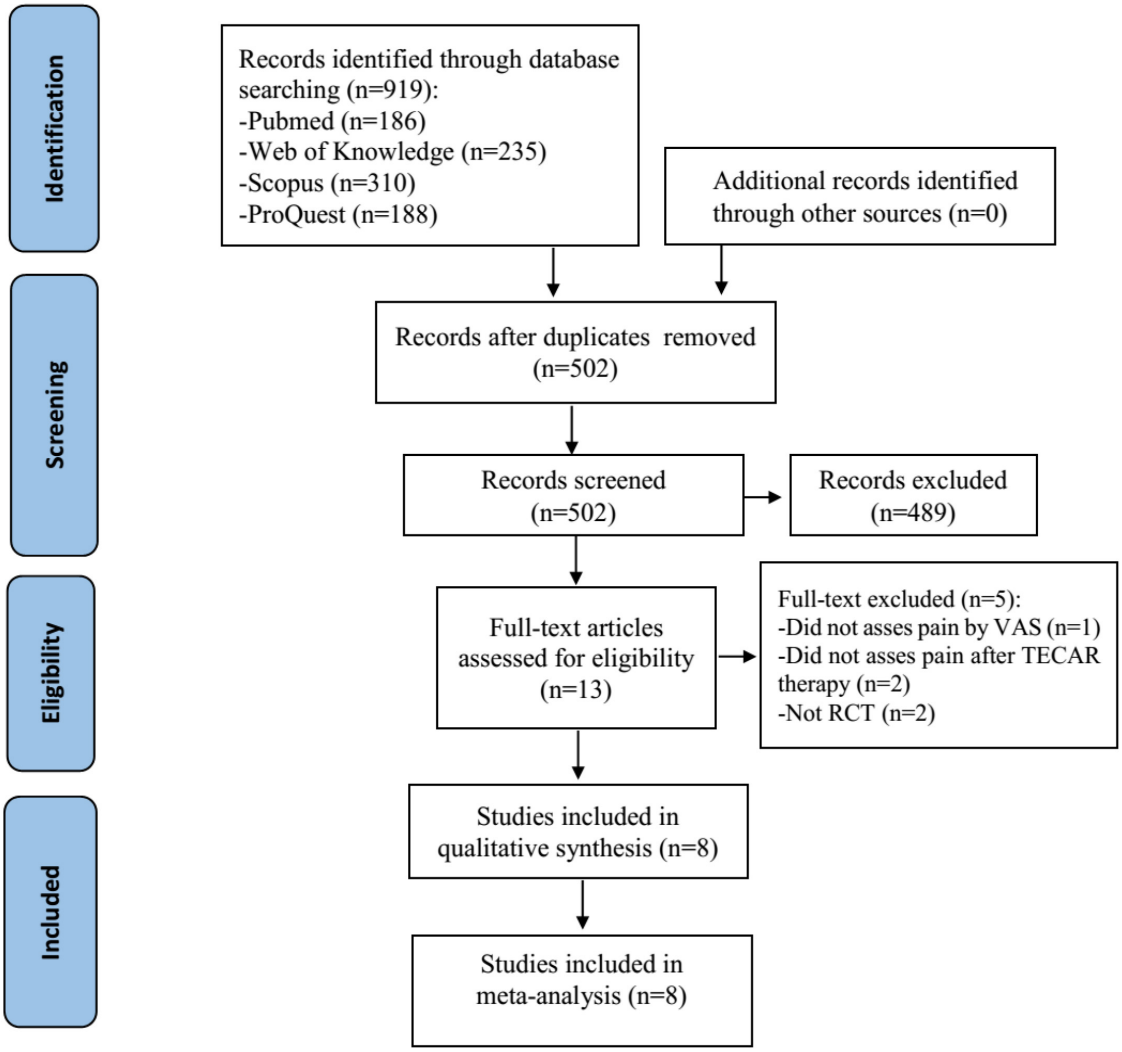

Figure 1. PRISMA flow diagram

of treatment duration varied between two [10, 25], four [7, 23, 24, 26], and eight weeks [8, 9]. Five studies had a control group that underwent other therapies, including laser treatment [8], SonoStim [26], and physiotherapy [24], and the same intervention technique but without energy [7, 23]. In general, all studies were performed to evaluate the effect of TECAR therapy in reducing the symptoms of patients with chronic pain. In addition to pain measurement, motor function post-treatment was assessed in one study [10]. Also, some studies [23, 24, 26] investigated the performance limitation adjunct to the pain variable. Further, the improvement of the symptoms in patients with diabetic neuropathy [7] was examined.

Overall, studies showed a reduction in pain intensity experienced by patients with chronic pain. Regarding Table-2, Tranquilli *et al.* [10] revealed that the patients who underwent TECAR therapy had shorter recovery times and regained normal limb function sooner. In another study [25], TECAR therapy was an effective method for improving bone, muscle, and joint injuries in athletes. Also, TECAR therapy is a better alternative for neuromuscular injuries than other modalities, which are more likely to fail in treatment [25]. Some studies reported the superiority of TECAR therapy over laser therapy [8] and physiotherapy [24]. The comparison between the effects of a deep heating device (HIPER®) and SonoStim showed that both modalities had an almost equal barbaric impact on pain relief and recovered physical activity [26].

Table 2. Characteristics of Studies Included in the Meta-Analysis

Authors	Pathology under study	Time (weeks)	Evaluation method	Sample size	Outcomes		Conclusion
					Control group	Intervention group	
Terranova *et al.* (2008) [9]	Femur	4	VAS	30	No significant reduction	Significant reduction	TECAR therapy was a helpful method for patients with hip fractures.
		8		30	No significant reduction	Significant reduction	
Tranquilli *et al.* (2009) [10]	Musculoskeletal, LBP	2	VAS	116	-	Significant reduction	TECAR was valid for quick and immediate pain reduction, shortened recovery times, adequate and fast resolution of edema, and helpful to prompt recovery of painful contractions.
Ganzit *et al.* (2015) [25]	Musculoskeletal, LBP	2	VAS	327	-	Significant reduction	TECAR therapy is a useful tool in the treatment of sports injuries of the bone, joints, and muscles.
Notarincola *et al.* (2017) [8]	LBP	2	VAS	60	Significant reduction	Significant reduction	TECAR therapy showed statistically better results than laser therapy.
		4	VAS	60	No significant reduction	Significant reduction	
		8	VAS	60	No significant reduction	Significant reduction	
Coccetta *et al.* (2019) [23]	Knee	2	VAS	53	No significant reduction	Significant reduction	Capacitive and resistive electric transfer therapy might be a useful therapeutic option for the conservative management of knee osteoarthritis to reduce pain, stiffness, and functional limitation.
		4	VAS	53	No significant reduction	Significant reduction	
		12	VAS	53	No significant reduction was noted	Significant reduction	
Kim *et al.* (2019) [26]	Shoulder	4	VAS	22	Significant reduction	Significant reduction	The newly developed HIPER-500® for high-frequency deep heat therapy showed similar effects to those of SonoStim® for relieving pain and improving physical performance in the patients.
Niajalili *et al.* (2020) [7]	Leg	4	VAS	24	Significant reduction	Significant reduction	A combination of capacitive TECAR therapy and infrared radiation therapy was suggested as an effective method in improving the symptoms of distal polyneuropathy associated with type 2 diabetes, along with other physiotherapy modalities.
Davari *et al.* (2021) [24]	Leg	2	VAS	46	Significant reduction	Significant reduction	TECAR therapy in patients with lateral ligament sprain of the ankle joint improves the condition of symptoms after an injury, including pain, and it can be used as a complementary treatment along with common therapies.
		4	VAS	46	Significant reduction	Significant reduction	

VAS: Visual analogue scale; **TECAR:** Transfer energy capacitive and resistive; **LBP:** Low back pain

However, HIPER therapy seemed slightly more effective than the other methods [26].

The Role of TECAR Therapy on Musculoskeletal Pain

Figure-2 shows the comparison of pain intensity among patients before TECAR therapy. The pain intensity was not significantly different between groups as the SMD obtained 0.04 (95% CI: -0.21 to 0.29, I^2=44.4%, P=0.43, Figure-2). The SMD between the two groups after two weeks of treatment was -0.38 (95% CI: -1.22 to 0.47, I^2=89.1%), which was not significant (P=0.383, Figure-3). However, the inter-groups differences following four and eight weeks of treatment were -1.04 (95% CI: -1.59 to -0.48, I^2=86.9%) and -1.80 (95% CI: -2.15 to -1.46, I^2=78%), respectively (P<0.05, Figure-3).

Further, inter-control group comparisons were made based on the data obtained before and after the intervention (Figure-4). The subjects of control groups obtained SMD values of -3.13 (95% CI: -5.65 to -0.61, I^2=97%), -2.45 (95% CI: -3.79 to -1.11, I^2=97%), and -1.95 (95% CI: -2.78 to -1.12, I^2=77.8%) in follow-up intervals of two, four, and eight weeks, respectively (Figure-4). Also, inter-intervention group comparisons (Figure-5) revealed that SMD in two weeks after TECAR therapy was -3.96 (95% CI: -5.28 to -2.65, I^2=96.9%), in four weeks was -4.12 (95% CI: -5.98 to -2.26, I^2=97.3), and in eight weeks was -5.03 (95% CI: -7.23 to -2.83, I^2=92.2%). Indeed, TECAR therapy significantly leads to pain resolution (P<0.01, Figure-5).

Subgroup Analysis

Whether the intervention effects vary across subpopulations, we performed subgroup analysis based on the pathology from which the participants suffered. Comparing the pain before and after the intervention, the patients experienced significantly lower pain intensity in the leg after two weeks (SMD=-6.98, 95% CI: -13.74 to -0.22, I^2=98.2%) and in the low back after four weeks (SMD=-3.68, 95% CI: -5.08 to -2.16, I^2=97.4%) of TECAR therapy (P<0.01).

Quality Assessment, Publication Bias, and Heterogeneity of Studies

According to the Jadad scale (Table-3) only one study [23] had a high-quality score. The rest of included studies did not demonstrate the quality measures of randomization,

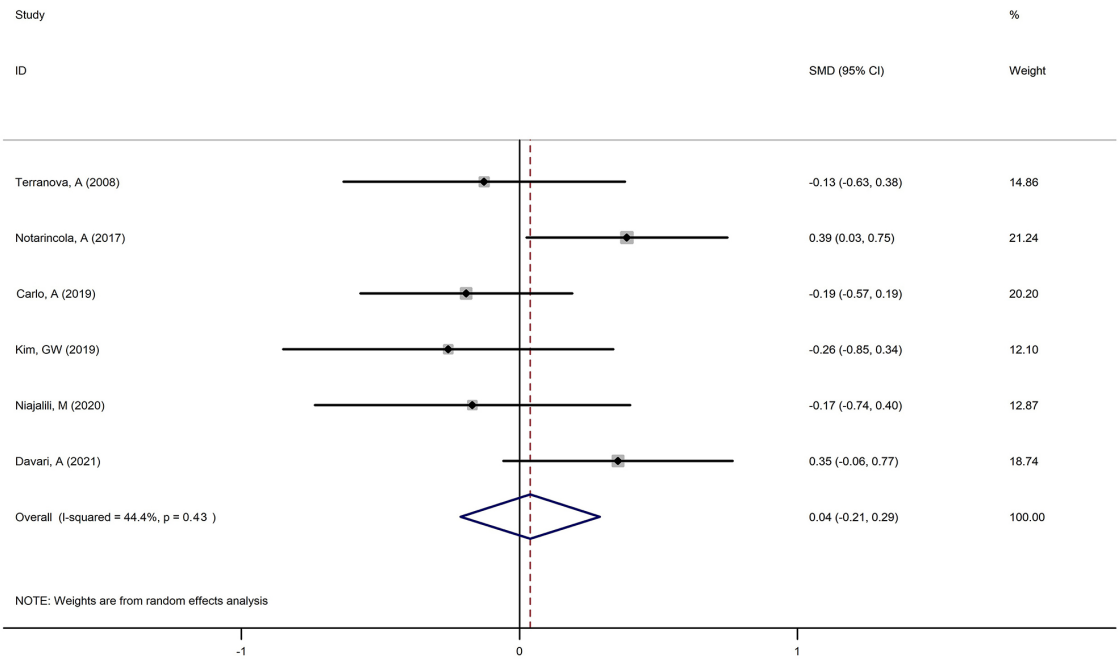

Figure 2. Comparison of pain score between control and intervention groups before TECAR therapy

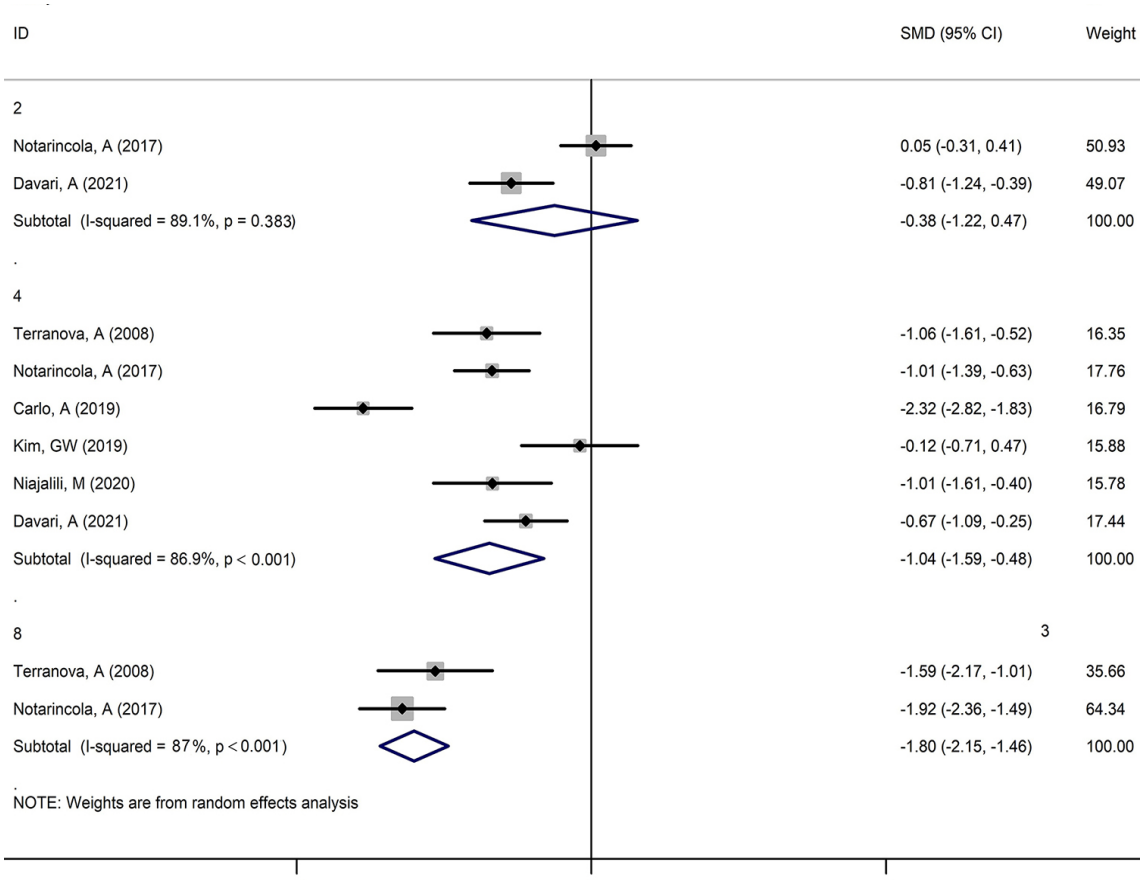

Figure 3. The standardized mean difference (SMD) between control and intervention groups

blinding, and dropout. Table-4 shows the results of Begg and Egger tests for assessing the publication bias. There was no significant publication bias in the inter-group comparison. Based on Q-test analysis, the heterogeneity between the two groups at the intervention intervals of two and four weeks as well as before and after in the intervention group was significant (P<0.05).

Discussion

The present study combined the results of different studies to ascertain the effectiveness of TECAR therapy in reducing pain. For this purpose, all studies that evaluated the pain intensity in patients who received TECAR therapy or did not (control group) before and after the intervention were included. Although the pain intensity was numerically a bit lower before the intervention compared to the control group subjects, this difference was not statistically significant. Therefore, the baseline level of pain was relatively equal in both groups. At different follow-up intervals, the pain intensity was compared before and after intervention in the control group. The control participants showed significantly lower pain intensity in the second, fourth, and eighth weeks' post-intervention compared to baseline pain levels before the intervention. However, the measure of SMD after two weeks was higher than at four and eight weeks, and the intra-group difference of controls was reduced with time. Also, the SMD between before and two, four, and eight weeks after the intervention was significant among patients who underwent TECAR therapy.

Interestingly, SMD in the TECAR therapy group was higher than in the control group, which shows that TECAR therapy has more effectiveness in musculoskeletal pain. In contrast to the control group, the SMD increased after four and eight weeks in the TECAR therapy group. One of the main findings in the current study was an

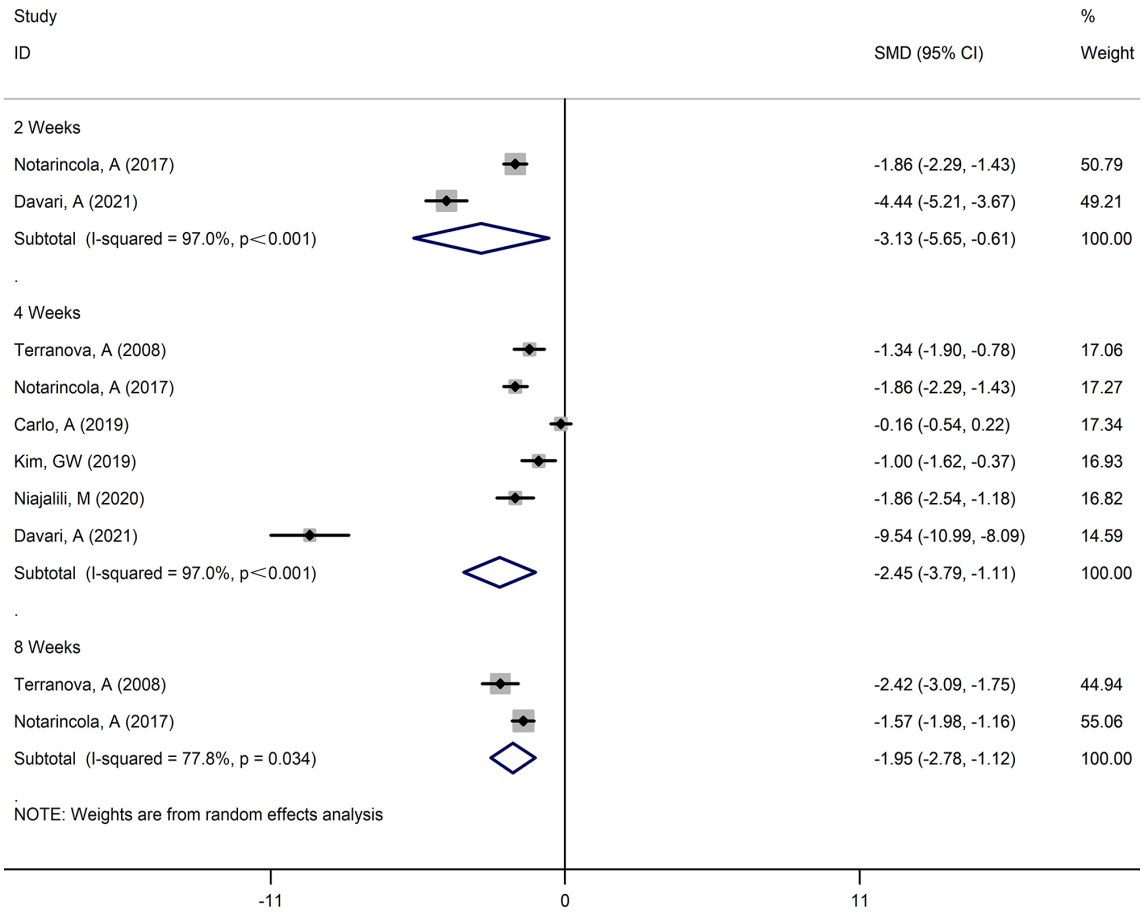

Figure 4. Comparison of pain before and after intervention among the patients in the control group

evaluation of the SMD between the control and TECAR therapy groups. This comparison showed that patients who received TECAR therapy experienced significantly lower pain levels than the control group after four and eight weeks' post-intervention. Based on these results, it seems that TECAR therapy is the more effective treatment choice for musculoskeletal pain.

TECAR therapy is a complementary method for joint pain treatment and is a valuable tool for physiotherapists, and it does not interfere with other therapies [27]. In addition to physiotherapy, TECAR is used in several other fields, such as orthopedic, rheumatic, and aesthetic vascular areas [25], and the fact that recovery time noticeably decreases is its main advantage. Owe to three important physiological effects of TECAR therapy; its major therapeutic applications are as follows: antispastic, analgesic, and metabolic stimulants. Also, the adjunction of TECAR therapy causes a rapid improvement of the acute inflammatory process and return of muscle strength in comparison with other combination therapies.

In addition, three studies were conducted on LBP [8, 10, 25] and two on leg pain [7, 24]. Other studies [9, 23, 26] were performed on the shoulder, femur, and knee. The similarity of methodology in the studies reviewed allowed us to combine the results. Further, subgroup analysis was carried out in two or more studies concerning patients' underlying pathology. This analysis compared the subgroups of LBP (two weeks after TECAR therapy) and leg pain (four weeks after TECAR therapy). The results showed that the pain was significantly lower two weeks after the intervention than at baseline. Patients with leg pain demonstrated the highest SMD [7] after four weeks of treatment compared to baseline leg pain. In consistence, TECAR therapy was also influential on LBP. Notarnicola *et al.* [8] reported that TECAR and laser therapies significantly

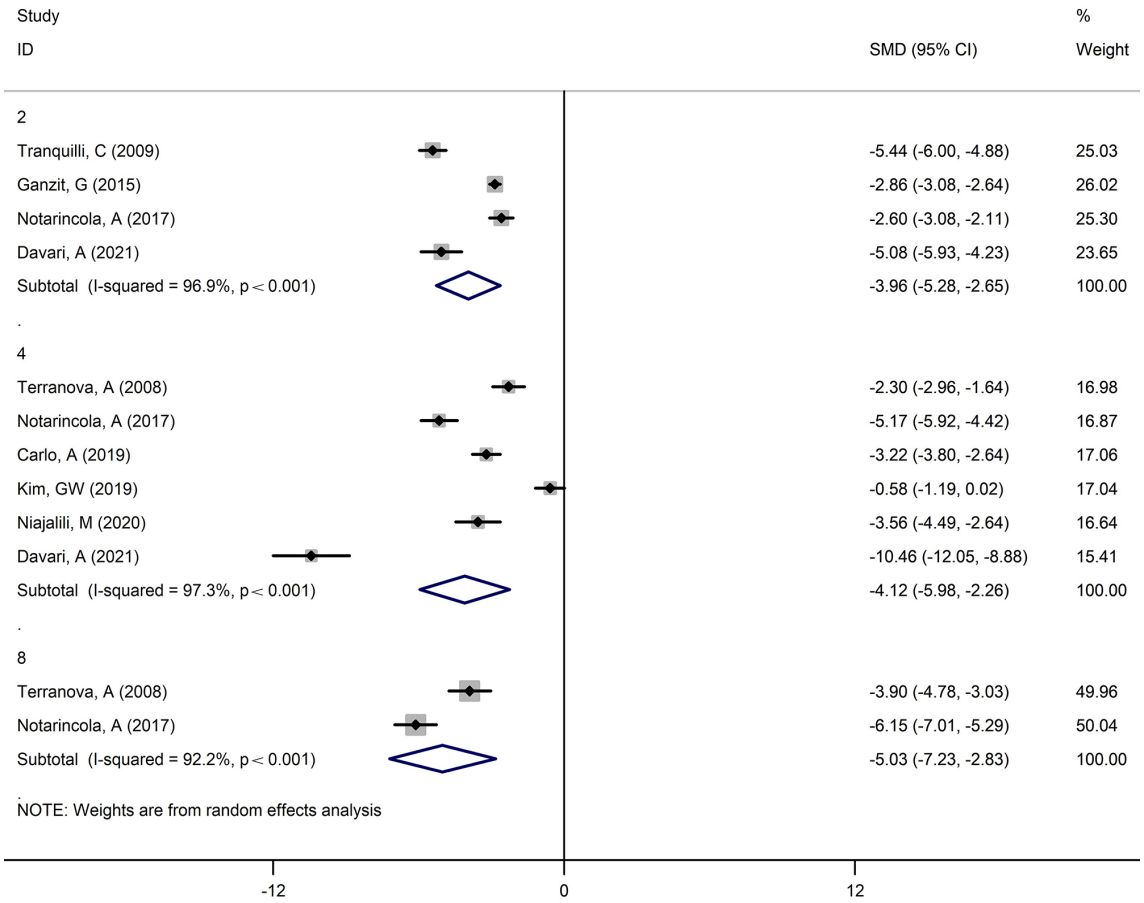

Figure 5. Comparison of pain score before and after intervention in the TECAR therapy group

affect LBP. However, TECAR therapy was more effective than laser in pain relief over time [8]. Improvement progress over time can be explained by the biological effects of treatment, including anti-edema and anti-inflammatory effects, muscle relaxant effect in paravertebral, endorphin secretion, and increasing cellular metabolism [8]. In another study [28], considerable improvement in pain of patients who underwent a combination of TECAR and massage therapies was observed, while the massage therapy was not effective alone. Hence, it suggested that TECAR therapy is helpful in LBP management [28]. Therefore, TECAR therapy simultaneously reduces these disorders' complications from the initial moments of rehabilitation by reducing the severity of LBP in the acute stage with different techniques [28]. Also, Terranova *et al*. showed that pain and edema decreased considerably after TECAR therapy [9]. Also, TECAR therapy has a more noticeable and immediate analgesic effect compared with the transcutaneous electrical nerve stimulation method [29]. TECAR therapy was also compared with cryoultrasound therapy. Costantino *et al*. reported that cryoultrasound therapy had a better impact than TECAR therapy, but the difference showed no statistical significance [27]. Ultimately, it may be inferred that TECAR therapy is an effective method for musculoskeletal pain.

It seems that TECAR therapy is an excellent complementary treatment along with other manual physiotherapy techniques. Therefore, the rehabilitation protocol improves with the synergistic effect between TECAR treatment and physiotherapy. Thus, it results in higher satisfaction for both patients and physiotherapists. Our study had some limitations. Indeed, only a limited number of studies met our inclusion criteria; hence, we could not assess the subgroup analysis based on pathology. Also, the majority of included studies have low quality; thus, information

Table 3. Quality Assessment Score Based On Jadad Scale

Domains	Terranova *et al.*	Tranquilli *et al.*	Ganzit *et al.*	Notarincola *et al.*	Coccetta *et al.*	Kim *et al.*	Niajalili *et al.*	Davari *et al.*
Was the study described as randomized?	+1	0	0	0	+1	0	0	0
Was the method of randomization appropriate?	-1	-1	0	-1	0	0	-1	0
Did the methodology include a blinding technique?	+1	0	0	+1	+1	0	0	+1
Was the method of blinding appropriate?	0	-1	0	0	0	0	0	-1
Was there a description of withdrawals and dropouts?	0	0	0	0	0	0	0	0
Was there a clear description of the inclusion/exclusion criteria?	+1	+1	+1	+1	+1	+1	+1	0
Did the authors describe in the method how to assess the adverse effects?	0	0	0	0	0	0	0	0
Did the study provide explanations for statistical analysis?	+1	+1	+1	+1	+1	+1	0	+1
Total point	3	0	2	2	4	2	0	1

Table 4. Publication Bias Assessment

Comparisons	*Begg	*Egger
Between two groups before the treatment	0.313	0.901
Between two groups after the treatment		
2 weeks	0.317	0.483
4 weeks	0.652	0.996
8 weeks	0.602	0.673
Before and after treatment in the intervention group		
2 weeks	0.497	0.556
4 weeks	0.543	0.836
8 weeks	0.174	0.774

* P-value was calculated at 95

bias was not avoidable.

Conclusion

Our findings provide appropriate evidence for the efficacy of TECAR therapy on musculoskeletal pain. Therefore, TECAR therapy can serve as a complementary treatment along with physiotherapy.

Conflict of Interest

The authors declared that they have no conflict of interest.

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