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ORIGINAL ARTICLE

Pulsed Electromagnetic Field and Exercises in Patients With Shoulder Impingement Syndrome: A Randomized, Double-Blind, Placebo-Controlled Clinical Trial

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Abstract

Objective: To evaluate the effects of pulsed electromagnetic field (PEMF) and exercises in reducing pain and improving function and muscle strength in patients with shoulder impingement syndrome (SIS).

Design: Double-blind, randomized controlled trial with a 3-month posttreatment follow-up.

Setting: Outpatient rehabilitation of a public hospital.

Participants: Patients (N = 56) between 40 and 60 years of age, with a diagnosis of SIS, were randomly assigned to receive active PEMF (n = 26; mean age, 50.1y) or placebo PEMF (n = 30; mean age, 50.8y).

Interventions: After 3 weeks of active or placebo PEMF, both groups performed the same program of exercises that focused on shoulder strengthening.

Main Outcome Measures: A visual analog scale, the University of California/Los Angeles shoulder rating scale, the Constant-Murley shoulder score, and handheld dynamometry for muscle strength were used as outcome measures at baseline (pretreatment), at 3 weeks (after active or placebo PEMF), at 9 weeks (postexercise), and at 3 months posttreatment.

Results: Patients in the active PEMF group had a higher level of function and less pain at all follow-up time frames compared with baseline ($P<.05$). However, the placebo PEMF group had increased function and reduced pain only at the 9-week and 3-month follow-ups ($P<.05$)—that is, after performing the associated exercises. For the shoulder dynamometry, the active PEMF group had increased strength for lateral rotation at 9 weeks ($P<.05$), and increased strength for medial rotation at 9 weeks and 3 months (both $P<.05$) when compared with baseline. There was no significant difference for shoulder strength in the placebo PEMF group ($P>.05$), as well as no significant differences ($P>.05$) for all outcome measures.

Conclusions: The combination of PEMF and shoulder exercises is effective in improving function and muscle strength and decreasing pain in patients with SIS. However, these results should be carefully interpreted because of the lack of differences between groups.

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Shoulder impingement syndrome (SIS) is considered one of the main causes of pain in the upper extremity and can lead to a decrease in the function of this joint and a reduction in quality of life. It affects about 20% of the population, and its prevalence increases over the course of aging.[1-4] Since the main complaints of patients with SIS are joint pain, stiffness, and functional deficit, nonsurgical treatments have focused on symptom relief and improved function.[5] The first-line management of SIS is represented by conservative treatment, based on medication, therapeutic exercises, and the application of physical agents.[6-8] The use of physical agents with analgesic and anti-inflammatory outcomes is very

Clinical Trial Registration No.: NCT01452204.

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common in physical therapy practice because they may provide benefits similar to medications but without the same adverse effects.

Among these physical agents, the pulsed electromagnetic field (PEMF), also commonly referred to as "magnet therapy," is based on the principle of the interaction between nonionizing electromagnetic fields and biological systems—that is, "bioelectromagnetics."[9,10] In the extremely low frequency spectrum of electromagnetic fields (below 300Hz), experimental studies have suggested therapeutic effects in various pathologic conditions, such as pseudoarthrosis,[11] osteoarthritis,[12] and acute and chronic pain from different musculoskeletal conditions,[13] as well as in accelerating the healing of tendon injuries.[14,15] Additionally, other authors hypothesize that PEMF treatment effects may be related to increased local cellular activity, orientation of collagen fibers, increased oxygen content to tissue, and vasodilation of blood vessels, without increasing local temperature.[10,13,16,17]

However, the effectiveness of PEMF to treat shoulder problems still remains controversial. Some clinical trials[8,16,17] have shown positive results, while other clinical trials[18,19] did not show the same effects. Therefore, the purpose of this study was to evaluate the effectiveness of PEMF and exercises in reducing pain, improving functionality, and enhancing muscle strength in patients with SIS. We hypothesized that the patients who received active PEMF and exercises would demonstrate significantly better results when compared with those who received placebo PEMF and exercises.

Methods

Participants

Fifty-six patients aged 40 to 60 years (N=56; mean age ± SD, 50.5±8.9y), with a diagnosis of SIS, were randomly assigned to receive active PEMF (n=26; mean age ± SD, 50.1±8.2y) or placebo PEMF (n=30; mean age ± SD, 50.8±9.6y). After 3 weeks of active or placebo PEMF, both groups performed the same program of exercises focusing on shoulder strengthening. Four patients who were in the active PEMF group and 6 patients who were in the placebo PEMF group did not complete the study. All study procedures were explained to the volunteers, and they signed informed consent forms in accordance with the National Health Council Resolution No. 196/96. The study was approved by the Research Ethics Committee of Irmandade da Santa Casa de Misericórdia de São Paulo, Brazil.

Calculations for estimating sample size were based on detecting a 30% improvement in pain scores (visual analog scale [VAS]), which was based on a previously conducted study by Bang and Deyle,[20] assuming an alpha level of .05, and 80% power. A sample size of 24 subjects per group was determined. With allowance for dropouts, 56 subjects were recruited for this study.

The study sample included both men and women, with an SIS medical diagnosis of grade I or II based on a history of shoulder pain for at least 3 months. Furthermore, these patients had previously received a clinical examination and ultrasonography or magnetic resonance imaging, according to Neer's criteria.[21] The patients should be able to actively elevate their shoulders in overhead activities. This active overhead elevation of the arm was a concern since older patients with SIS and possible moderate rotator cuff degeneration were being evaluated; therefore, we attempted to ensure that these patients still had adequate function of this musculature. The participants were recruited from the Rehabilitation Service - 254/09 by a single physical therapist (T.Y.F.) with more than 10 years of clinical experience in shoulder rehabilitation. Participants were excluded if they met 1 of the following criteria: (1) had a neurologic disorder; (2) had an injury to the cervical region, elbow, or hand; (3) had rheumatoid arthritis; (4) had a heart condition; (5) had previous surgery involving the upper extremities; (6) were pregnant; (7) had received intra-articular anti-inflammatory infiltrations in the past 60 days; or (8) had other pathologic disorders of the shoulder such as hooked acromion, osteoarthritis, adhesive capsulitis, or traumatic labrum tears. During the screening, all subjects who used anti-inflammatory medications were asked to interrupt their medication before starting the treatment. However, only 5 patients (2 in the active PEMF group, 3 in the placebo PEMF) reported using oral anti-inflammatory medications before the study. All of these patients stopped using these medications 15 days before the beginning of the study and were randomly assigned to 1 of the 2 groups.

The assignment of subjects to the 2 groups was performed randomly using opaque, sealed envelopes, each containing the name of 1 of the groups (active PEMF or placebo PEMF). The envelopes were selected by an individual not involved in the study. Group assignment was performed after the initial evaluation but before the initial treatment session. A single therapist (T.Y.F.) was responsible for setting up the equipment (active or placebo) before treatment in order to maintain the randomized, double-blind design. This therapist did not remain beside the patient during the session to avoid influencing the results. Two therapists (F.B.M., S.G.R.) were trained in delivering the exercise protocols used for the study and provided all treatment. These 2 therapists and all patients were blinded in relation to active PEMF or placebo PEMF treatment. Finally, the examiner (D.G.F.) was blind to the group assignment of the patients and did not participate in the interventions.

Interventions

The active PEMF and placebo PEMF groups completed 9 sessions that were provided 3 times per week for 3 weeks. The duration of each application was 30 minutes, and the electrodes were positioned on the anterior and posterior part of the shoulder joint with the subject positioned in lateral decubitus (fig 1).

The equipment used was a previously calibrated Magnetherp 330,[a] pulsed with a frequency of 50Hz and an intensity of 20mT or 200G. Since the optimal dosimetry for therapy with electromagnetic fields has not yet been established,[16] these parameters were predetermined according to the manufacturer. For the placebo application, the subjects remained in the same position as the active group; the device was turned on but kept in standby mode during 30 minutes without any electromagnetic field being applied.

After 3 weeks of active or placebo PEMF, all subjects initiated a therapeutic exercise program. The exercise protocol duration was 6 weeks and was provided twice a week. All subjects were asked to perform the same protocol 2 more times at home during

List of abbreviations:

ICC	**intraclass correlation coefficient**
MCID	**minimal clinically important difference**
PEMF	**pulsed electromagnetic field**
SIS	**shoulder impingement syndrome**
VAS	**visual analog scale**
UCLA	**University of California/Los Angeles**

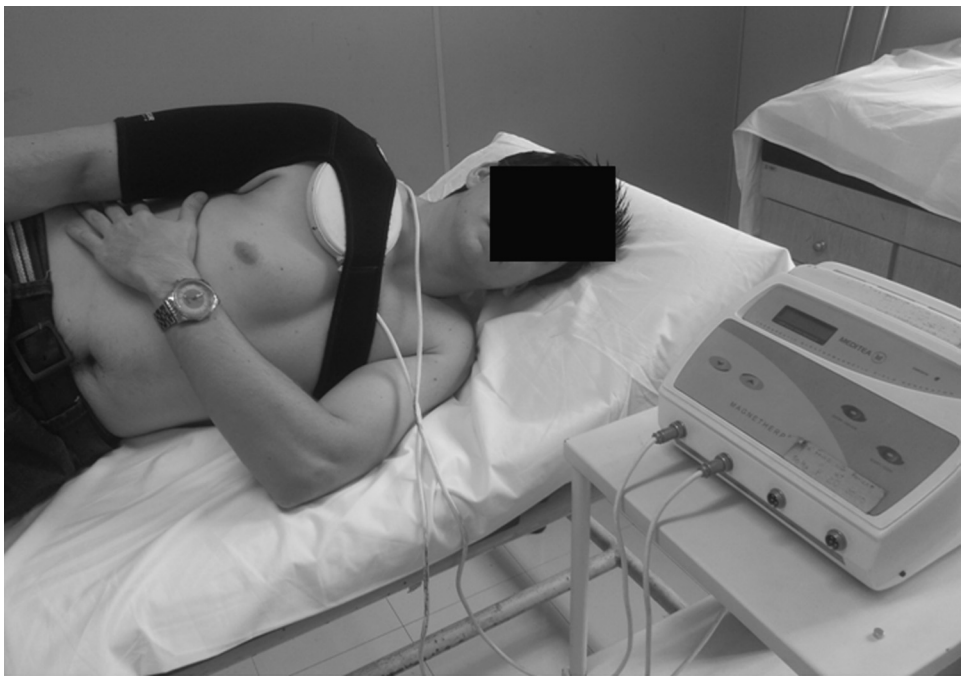

Fig 1 Electrodes positioned and PEMF equipment used in the study.

the week. At the end of treatment, they were instructed to continue the exercises at home. This protocol contained simple exercises for improving shoulder mobility and for increasing shoulder girdle muscle strength (appendix 1).[22]

Evaluation

A VAS, where 0 corresponded to no pain and 10 to the worst imaginable pain, was used to measure pain during the last week. The VAS has been shown to be reliable and valid for shoulder injuries, with a minimal clinically important difference (MCID) of 1.4 points.[23]

The Constant-Murley[24] and University of California/Los Angeles (UCLA)[25] scales have been used to measure function in clinical outcome studies and are recommended for use in individuals with shoulder disorders. The Constant-Murley scale is a 100-point functional shoulder-assessment tool in which higher scores reflect increased function.[24] The UCLA scale is a 3-item assessment tool with items differentially weighted for a maximum score of 30, with higher scores also indicating better function.[26] The MCID of the Constant-Murley and UCLA scales has not yet been well defined; however, other upper extremity scales have shown changes between 6% and 13%.[27]

Handheld dynamometry[b] was used for measuring the strength of the rotator cuff muscles (medial and lateral rotation) and arm elevation. To measure the strength of the medial and lateral rotators, the subject was positioned in supine with the shoulder abducted at 45° and flexed at 30° (scapular plane), and the elbow flexed at 90°, with the dynamometer placed on the wrist.[28-30] To assess the shoulder elevation strength, the subject remained seated, with the shoulder abducted at 45° and flexed at 30°, in neutral rotation, and the elbow fully extended. The dynamometer was placed on the dorsal aspect of the wrist.[30] During strength testing, we used 2 submaximum trials to familiarize the subjects with each test position. This was followed by 3 trials with maximum isometric effort for each muscle group. For data analysis, the average values of the 3 trials with maximum effort were used. When the examiner observed any trunk compensation during a test, values were disregarded and the test was repeated after 20 seconds of rest. Strength values were measured in kilograms and were normalized by body mass (kg) using the following formula: (Strength/Body mass) × 100. Results of a pilot study indicated excellent reliability for the lateral rotators (intraclass correlation coefficient [ICC]=.93), high reliability for shoulder elevation (ICC=.88), and satisfactory reliability for medial rotation (ICC=.50). All outcome measures were administered before treatment (baseline), at 3 and 9 weeks of treatment, and 3 months posttreatment (fig 2).

Data analysis

Data were analyzed using SPSS, version 13.0.[c] The Kolmogorov-Smirnov test (with Lilliefors correction factor) was used to test the normality of the data. Descriptive statistics for demographic data and all outcome measures were expressed as averages and SDs with a normal curve. The homogeneity within-group for sex at baseline was confirmed by the chi-square test. Comparison between the groups was performed using independent *t* tests for age, body mass, height, pain score, and functional scales to determine homogeneity of the groups at baseline (pretreatment). The data for the 2 functional scales (Constant-Murley and UCLA), muscle strength, and the VAS were analyzed using separate 2-by-4 (group-by-time) mixed-model analysis of variance. The factor of group had 2 levels (active PEMF and placebo PEMF), and the repeated factor of time had 4 levels (pretreatment, 3 and 9wk of treatment, and 3mo posttreatment). If significant main effects or interactions were detected, then a simple main effects analysis continued using Bonferroni adjustments. Statistical significance

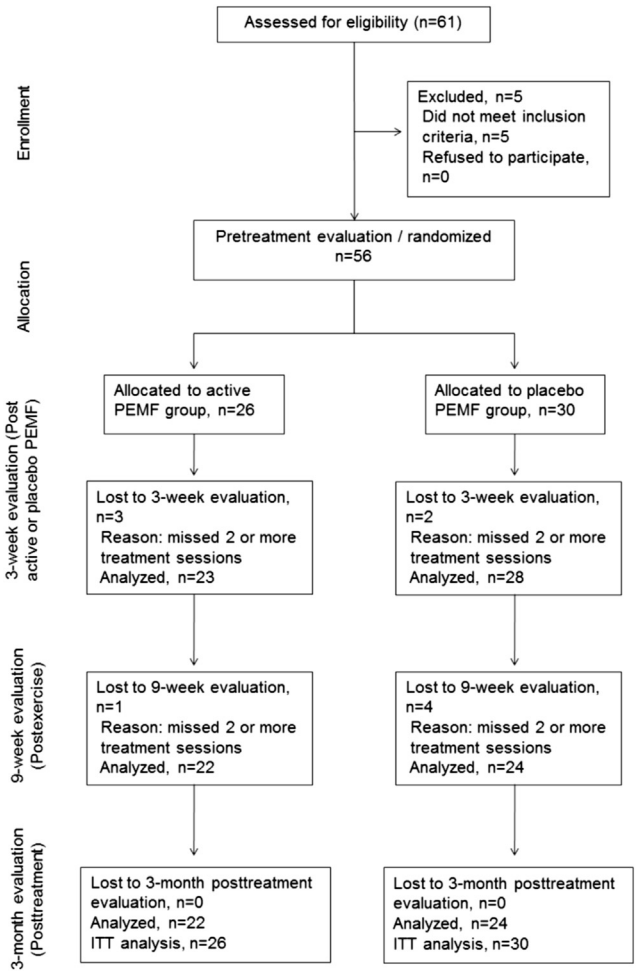

Fig 2 CONSORT flow chart, including ITT analysis. Abbreviation: ITT, intention-to-treat.

was defined as $P<.05$. After the per-protocol data analysis, an intention-to-treat analysis was performed using the mean value obtained from the remaining subjects of each group.

Results

At 3 months, 4 subjects in the active PEMF group and 6 subjects in the placebo PEMF group were lost during follow-up. Therefore, all per-protocol data analyses were performed with 22 subjects in the active PEMF group and 24 subjects in the placebo PEMF group.

Baseline and demographic data

There was no statistically significant difference ($P>.05$) for demographics between the participants in the active and placebo PEMF groups (table 1). There was also no statistically significant difference ($P>.05$) between groups for any of the outcome variables at baseline (pretreatment) (table 2).

Pain, function, and muscle strength

There was a statistically significant group-by-time interaction for the 2-by-4 mixed-model analysis of variance for pain, muscle strength, and all functional assessment measures ($P<.05$, $F=14$). Planned pairwise comparisons for the Constant-Murley and UCLA scales and the VAS indicated that the patients in the active PEMF group had better function and decreased pain at the 3- and 9-week assessments and at 3 months posttreatment compared with baseline (Constant-Murley: range, $P<.05$ to $P<.001$; UCLA: range, $P<.01$ to $P<.001$; VAS: range, $P<.01$ to $P<.001$). The same analysis indicated that the only significant differences for function and pain in the placebo PEMF group were found at the 9-week assessment and 3 months posttreatment (Constant-Murley: $P<.01$ and $P<.001$, respectively; UCLA: both $P<.01$; VAS: $P<.01$ and $P<.001$, respectively). For muscle strength, the active PEMF group had increased strength for lateral rotation at 9 weeks ($P=.02$), and for medial rotation at the 9-week and the 3-month assessment posttreatment (both $P=.03$) when compared with baseline. There was no difference for muscle strength in the placebo PEMF group ($P>.05$) during the course of the treatment and follow-up when compared with baseline. However, the between-group analysis at the 3- and 9-week assessments as well as at 3 months posttreatment indicated no significant difference for all pain scores, functional scales, and muscle strength (all $P>.05$) (see table 2). The results of the intention-to-treat analysis were consistent with the per-protocol analysis, providing evidence that the missing data had no substantial influence on the overall results. Of note, patients reported performing the exercises at home during the course of treatment.

Table 1 Demographic data of active PEMF and placebo PEMF groups

Characteristics	Active (n=26)	Placebo (n=30)	P
Age (y)	50.1±8.2	50.8±9.6	>.05
Body mass (kg)	76.3±13.7	70.2±12.6	>.05
Height (m)	1.7±10.1	1.6±8.4	>.05
Body mass index (kg/m^2)	26.7±3.9	27.4±4.4	>.05
Duration of symptoms (mo)	22.0±17.7	21.2±19.0	>.05
Sex			
Men	10	10	>.05*
Women	16	20	

NOTE. Values are mean ± SD, n, or as otherwise indicated. There were no differences between groups ($P>.05$).
* Chi-square test.

MCID analysis

Based on the MCID for the VAS (1.4 points), the proportion of patients who met or exceeded the MCID in the 3-week evaluation (ie, after active or placebo PEMF) compared with baseline was 61% in the active group and 43% in the placebo group. Unfortunately, we did not find an MCID standard value for the Constant-Murley and UCLA scales, but there is speculation that improvement can be significant in general shoulder scales when the proportion of patients who meet or exceed the MCID is above 13%.[27] Thus, when we examined the 3-week evaluation, the proportion of patients who met or exceeded 13% of improvement was 65% in the active group and 24% in the placebo group for the Constant-Murley scale, and 91% in the active group and 54% in the placebo group for the UCLA scale.

In the 9-week and 3-month evaluation, the proportion exceeding MCID for VAS in the active group was 82% and 77%,

Table 2 Outcome measures pretreatment (baseline) and 3 weeks (after active or placebo PEMF), 9 weeks (postexercise), and 3 months posttreatment for subjects in active PEMF (n=22) and placebo PEMF (n=24) groups who completed the study

		Posttreatment		
Analysis/Measures	Pretreatment	3wk	9wk	3mo
Outcomes				
Constant-Murley (0–100)*				
Active PEMF	31.3±10.6	40.7±12.6†	50.8±11.8†	52.7±11.7†
Placebo PEMF	35.8±11.7	35.6±11.7	48.0±11.0†	50.4±12.0†
UCLA (0–30)*				
Active PEMF	14.7±5.7	22.0±5.7†	26.2±5.5†	27.4±7.2†
Placebo PEMF	15.0±4.8	16.7±7.0	23.5±7.5†	24.3±7.8†
VAS (0–10cm)‡				
Active PEMF	6.8±2.0	4.8±2.4†	2.9±2.7†	2.7±3.0†
Placebo PEMF	7.7±1.9	6.0±2.1	4.4±2.8†	3.4±3.1†
Shoulder lateral rotation (normalized to body weight)				
Active PEMF	22.9±8.5	26.8±12.9	32.2±14.1†	32.7±14.5
Placebo PEMF	19.5±7.0	21.6±10.3	24.8±10.6	24.9±10.2
Shoulder medial rotation (normalized to body weight)				
Active PEMF	32.6±15.8	38.1±17.0	42.0±17.1†	43.8±4.0†
Placebo PEMF	30.7±11.1	33.7±12.0	36.0±12.0	36.6±13.2
Shoulder elevation (normalized to body weight)				
Active PEMF	23.8±10.8	24.0±9.6	27.2±10.4	28.5±11.4
Placebo PEMF	18.9±7.3	19.7±7.9	21.8±8.8	22.2±8.8
Within-group change score from baseline§				
Constant-Murley (0–100)*				
Active PEMF		9.4 (2.5 to 16.3)	19.5 (12.8 to 26.2)	21.4 (14.8 to 28.0)
Placebo PEMF		−0.2 (−7.2 to 6.8)	12.2 (5.4 to 20.0)	14.6 (7.6 to 21.6)
UCLA (0–30)*				
Active PEMF		7.3 (3.9 to 10.7)	11.5 (8.2 to 14.8)	12.7 (8.9 to 16.5)
Placebo PEMF		1.7 (−1.8 to 5.2)	8.5 (4.8 to 12.2)	9.3 (5.5 to 13.1)
VAS (0–10cm)‡				
Active PEMF		−2.0 (−3.3 to −0.7)	−3.9 (−5.3 to −2.5)	−4.1 (−5.6 to −2.6)
Placebo PEMF		−1.7 (−2.9 to −0.5)	−3.3 (−4.7 to −1.9)	−4.3 (−5.8 to −2.8)
Shoulder lateral rotation (normalized to body weight)				
Active PEMF		3.9 (−2.5 to 10.3)	9.3 (2.5 to 16.1)	9.8 (2.8 to 16.8)
Placebo PEMF		2.1 (−3.1 to 7.3)	5.3 (0.0 to 10.6)	5.4 (0.2 to 10.6)
Shoulder medial rotation (normalized to body weight)				
Active PEMF		5.5 (−4.2 to 15.2)	9.4 (−0.4 to 19.2)	11.2 (4.2 to 18.2)
Placebo PEMF		3.0 (−3.9 to 9.9)	5.3 (−1.6 to 12.2)	5.9 (−1.3 to 13.1)
Shoulder elevation (normalized to body weight)				
Active PEMF		0.2 (−5.9 to 6.3)	3.4 (−2.9 to 9.7)	4.7 (−1.9 to 11.3)
Placebo PEMF		0.8 (−3.7 to 5.3)	2.9 (−1.9 to 7.7)	3.3 (−1.5 to 8.1)

NOTE. Values are mean ± SD or mean (95% confidence interval).
* Higher scores on the Constant-Murley and UCLA scales represent better function.
† Significant difference when compared with pretreatment.
‡ Scored from 0 to 10, where 0 is no pain and 10 is the worst imaginable pain.
§ Compared with pretreatment.

respectively, and the proportion exceeding MCID for VAS in the placebo group was 71% and 67%, respectively. The proportion of patients who surpassed the MCID for the Constant-Murley scale in the active group was 91% and 86%, respectively, and the proportion of patients who surpassed the MCID for the Constant-Murley scale in the placebo group was 67% and 58%, respectively. Finally, the proportion of patients exceeding MCID for the UCLA scale in the active group was 82% and 86%, respectively, and the proportion of patients exceeding MCID for the UCLA scale in the placebo group was 63% for both evaluations.

Discussion

The results of this randomized controlled trial demonstrated that a 3-week intervention with PEMF is effective for improving function and reducing pain in patients with SIS. A combination of shoulder exercises is essential for increasing muscle strength and increasing the overall effectiveness of these improvements. Both active and placebo PEMF groups showed improvements for all functional and pain outcome measures when combined with shoulder exercises. The group that received active PEMF and performed exercises

showed improvements for medial and lateral rotators muscle strength, in contrast to the group that received placebo PEMF and exercises, which showed no changes in muscle strength.

Previous clinical studies have shown that electromagnetic therapy can be a useful tool when used to facilitate the healing of skin ulcers,[31] manage diabetic neuropathic pain,[30] and facilitate functional improvement in patients with fibromyalgia[15,32] or knee osteoarthritis.[12,33,34] However, the effects of PEMF in patients with shoulder pain are still controversial.[18,35,36] In the present study, we used a full treatment program based on analyzing the isolated effects of PEMF and when combined with exercises. Our protocol contained exercises for range of motion and muscle relaxation such as pendulum exercises and stretching, as well as exercises to strengthen the rotator cuff muscles and scapular stabilizers. Our assessments, which are based on previously validated assessment scales in the literature, were applied immediately after PEMF application, after exercises, and after 3 months.

Some divergent aspects became very clear when we analyzed the literature regarding patients who received electromagnetic therapy. Aktas et al[18] showed no convincing evidence that electromagnetic therapy is of additional benefit in the acute phase of SIS rehabilitation. The authors applied PEMF during 25 minutes per session, 5 days per week for 3 weeks with an equipment frequency of 50Hz and a field intensity of 30G. In the present study, we demonstrated improved function and muscle strength, as well as pain relief, with an equipment frequency of 50Hz and an intensity of 20mT or 200G. This electromagnetic treatment lasted 30 minutes per session, 3 days per week, for a total of 9 sessions. However, we assessed patients with chronic pain and also added strengthening exercises. Corroborating these data, Sutbeyaz et al[32] concluded that low-frequency PEMF might improve function, pain, fatigue, and global status in patients with fibromyalgia using 30-minute sessions, twice a day for 3 weeks. Of note, PEMF was administered to the whole body using a magnetic mat, which produced a mean intensity of 40mT and a frequency ranging from 0.1 to 64Hz.[32] Despite using a transcranial-type application, Shupak et al[17] also provided some initial support for the use of PEMF in reducing pain in chronic pain populations with fibromyalgia and rheumatoid arthritis.

In relation to shoulder strengthening programs, some authors have demonstrated that exercise has clinically significant effects on pain reduction and improving function, but not strength improvement.[7,22] We partially agree with this information because the exercise protocol used in our study led to pain relief and functional improvement, as well as increased muscle strength.

Study strengths and limitations

The present study has several strengths, including the randomized, double-blind, placebo-controlled design, effect-size calculation, intention-to-treat analysis, and confirmation of diagnosis by experienced radiologists who performed the ultrasonography or magnetic resonance imaging. Additional strengths are the treatments provided by experienced personnel, and the multidimensional evaluation of patients' function, symptoms, and muscle strength. On the other hand, a limitation of the study may have been the inclusion and assessment of older patients with SIS, who had moderate rotator cuff degeneration. Nevertheless, we believe this bias was minimized because we selected patients who had an active overhead elevation of the arm. This tendon degeneration may have been the reason for the lack of improvement in arm elevation in both groups. Of note, this population is the most frequent age group found in our shoulder policlinics hospital. Another limitation is the high dropout rate in both groups (approximately 15% each). We did not control whether the patients performed their rehabilitation exercises during the 3-month follow-up. However, immediately after treatment, all patients were instructed to maintain their normal activities in the same manner that they were performed during treatment. Another limitation of the study was the absence of a group performing PEMF and exercises at the same time. However, we intended to observe the isolated effect of PEMF on pain and function, and subsequently the effect of the association with exercises.

We showed an alternative PEMF combined with shoulder exercises for treating patients with musculoskeletal injuries, specifically the SIS, aimed at pain relief and functional improvement. However, this potential analgesic and functional effect of the isolated PEMF application does not seem to be as significant as if associated with exercises, especially taking into account the improvement in muscle strength. Future studies should include a longer follow-up and a group that receives PEMF and exercises simultaneously from the very beginning, as well as other groups with different PEMF parameters, such as intensity, frequency, or application time. Furthermore, we did not evaluate the likely biomechanical changes after the exercises were completed.

Conclusions

Our findings suggest that the combination of PEMF and shoulder exercises is effective in improving function and muscle strength and decreasing pain in patients with SIS. However, these results should be carefully interpreted because of the lack of between-group differences.

Suppliers

a. Meditea, Viamonte 2255 / 2265, Buenos Aires, Argentina.
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Keywords

Diathermy; Magnetic field therapy; Rehabilitation; Rotator cuff; Shoulder impingement syndrome

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Appendix 1 Shoulder Exercise Protocol Performed by the Active PEMF and Placebo PEMF Groups

Range of motion

- *Pendular exercise:* Bend forward 90° at waist using table for support. Body in a circular pattern to move arm clockwise and counterclockwise. 3 sets of 1 minute

- *Doorway pectoral stretch:* Bring arm out to the side with elbow bent, forearm contacting wall. Turn your body away from the wall until you feel a stretch. 3 sets of 30 seconds
- *Cross-body posterior shoulder stretching:* Bring arm across your body and use other hand to apply overpressure, pulling the elbow. 3 sets of 30 seconds
- *Shoulder external rotation cane stretch:* Grasp cane with affected elbow bent. Use unaffected arm to push hand back toward plinth. 3 sets of 10 repetitions

Strengthening exercises

- *Resisted shoulder medial rotation (neutral):* Begin with forearm out to the side and elbow against body. Pull toward your abdomen, then slowly release. Can use towel in armpit if more comfortable. 10 sets of 10 seconds
- *Resisted shoulder lateral rotation:* Begin with hand in front of the stomach. Pull away from abdomen, then slowly release. Can use towel in armpit if more comfortable. 10 sets of 10 seconds
- *Resisted scapular protraction:* Grasp tube while lying on your back with arm flexed to 90°. Punch arm up toward the ceiling while keeping arm straight. Your shoulder blade should lift off table. 3 sets of 10 repetitions
- *Sidelying lateral rotation:* Lie on uninvolved side, with involved arm at side of body and elbow bent to 90°. Keeping the elbow of involved arm fixed to side, raise arm. 3 sets of 10 repetitions
- *Push Up:* Push-up plus—do a push-up (on either your hands or forearms) and then really push to bring your spine to the ceiling. 3 sets of 10 repetitions

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