Original article

Efficiency of pulsed electromagnetic field and neuromuscular electrical stimulation on painful shoulder following stroke

Eficiência do campo eletromagnético pulsado e da estimulação elétrica neuromuscular em ombro doloroso após acidente vascular cerebral

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ABSTRACT | INTRODUCTION: Shoulder pain after stroke, a complication with a prevalence of up to 16–84% usually occurs after 2–3 months and leads to patients withdrawing from rehabilitation programs, staying in the hospital longer, having less limb function and having a great negative impact on their quality of life. The aim of the present study was to determine the effect of PEMF and NMES in reducing shoulder pain in patients with stroke. **MATERIAL AND METHODS:** A prospective, randomized controlled trial included 51 patients with shoulder pain following stroke. The patients were randomly assigned to three groups (17 people in each group): Pulsed Electromagnetic Field (PEMF), Neuromuscular Electrical Stimulation (NMES) and Control group. The outcome measures were Visual Analogue Scale (VAS), Modified Ashworth Scale (MAS) and Fugl Meyer Assessment–Upper Extremity (FMA-UE), Active and Passive Range of Motion (AROM/PROM) assessed at the baseline, six weeks into the intervention, and one week into the follow-up. **RESULTS:** VAS score for pain showed a mean change of 1.60, 1.60 and 4.94 in PEMF, NMES, and control respectively after 20 sessions. It showed pain was significantly improved in all the groups ($p<0.001$), but the effectiveness of the PEMF and NMES groups was superior to the control group. **CONCLUSION:** The current literature showed that PEMF & NMES are effective in improving post-stroke shoulder pain, spasticity, range of motion and motor function and a novel method for stroke patients undergoing rehabilitation.

KEYWORDS: Clinical Trial. Shoulder Pain. Stroke. Pulsed Electromagnetic Field. Neuromuscular Electrical Stimulation.

RESUMO | INTRODUÇÃO: Dor no ombro após acidente vascular cerebral com prevalência de 16–84% geralmente ocorre após 2–3 meses e pode resultar na suspensão de programas de reabilitação, internações hospitalares mais longas e redução da função dos membros, prejudicando qualidade de vida dos pacientes com AVC. O objetivo do presente estudo foi determinar o efeito da PEMF e da EENM na redução da dor no ombro em pacientes com acidente vascular cerebral. **MATERIAL E MÉTODOS:** Um estudo prospectivo, randomizado e controlado incluiu 51 pacientes com dor no ombro pós-AVC. Os pacientes foram divididos aleatoriamente em três grupos (17 pessoas em cada grupo): grupo Campo Eletromagnético Pulsado (PEMF), grupo Estimulação Elétrica Neuromuscular (EENM) e grupo Controle. As medidas de resultados foram na Escala Visual Analógica (VAS), Escala de Ashworth Modificada (MAS) e Avaliação de Fugl Meyer – Extremidade Superior (FMA-UE), Amplitude de Movimento (AROM/PROM) foram avaliadas no início do estudo, após seis semanas de tratamento, e após um acompanhamento semanal. **RESULTADOS:** A pontuação VAS para dor mostrada uma alteração média de 1,60, 1,60 e 4,94 na PEMF, EENM e Controle, respectivamente, após 20 sessões. Mostrou melhora significativa entre os três grupos ($p<0,001$), mas a eficácia do grupo PEMF e EENM foi superior ao grupo Controle. **CONCLUSÃO:** O presente estudo mostrou que PEMF e EENM são eficazes na melhora da dor no ombro pós-AVC, espasticidade, amplitude de movimento e função motora e um novo método para pacientes com AVC em reabilitação. Nossas descobertas indicam que a eficácia da EENM é claramente superior à do PEMF na manutenção da analgesia a longo prazo.

PALAVRAS-CHAVE: Ensaio Clínico. Dor no Ombro. Acidente Vascular Cerebral. Campo Eletromagnético Pulsado. Estimulação Elétrica Neuromuscular.

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1. Introduction

A stroke is an abrupt loss of neurological function brought on by a disruption in the blood supply to the brain.[1] The occurrence of stroke has the second-highest mortality rate and the third-largest proportion of people with disabilities. Shoulder pain after stroke, a complication with a prevalence of up to 16–84% usually occurs after 2–3 months and leads to patients withdrawing from rehabilitation programs, staying in the hospital longer, having less limb function and having a great negative impact on their quality of life.[2] The post-stroke shoulder pain mechanism is not fully understood. Post-stroke muscle weakness is believed to be the primary cause of shoulder pain.[3] Shoulder pain with a local origin can be caused by a variety of factors and is linked to diminished motor function, limited range of motion, and somatosensory impairments. The most common causes of shoulder pain after a stroke are known to be post-injury consequences, such as hemiparesis (severe muscle weakness and discomfort), unilateral neglect, lesion to the rotator cuff tendons, reflex sympathetic dystrophy, shoulder subluxation and spasticity or hypertonia.[4,5]

The main goal of modern rehabilitation of patients after a stroke was to restore the lost functions by activating the natural mechanisms of functional reorganization. Gentle stretching, botulinum toxin and subacromial corticosteroid injection are all treatments specific to established pain aetiologies.[6,7] Alternative treatments, including acupuncture and mirror therapy, have reportedly been shown to be effective in promoting arm function recovery and preventing the development of secondary problems. New evidence-based techniques for the prevention and management of pain and disability related to post-stroke consequences must be evaluated.[6]

In clinical practice, Neuromuscular Electrical Stimulation (NMES) is the most extensively used pain-relieving therapy.[8] NMES can be used to stimulate neuromuscular activity in paralyzed extremities after stroke. This is because normal electrical excitability is often preserved in lower motor neurons and their innervated muscles.[9,10] NMES enables tightening and gaining strength in order to avoid atrophy, improve blood circulation, give nourishment and re-educate muscles.[11,12] NMES may have an impact on cortical plasticity. NMES may be linked to simultaneous changes in brain physiology, involving activation of major sensory and motor regions as well as additional motor regions, reduced intracranial inhibition, and spike in the amplitude of electrical potentials.[9] To relieve pain, accelerate muscular contraction, stimulate motor relearning, and expand the range of motion, a frequency of 15–50 Hz with a pulse width of 200 ms was used.[10] Furthermore, substantial evidence-based research on the usefulness of NMES in treating shoulder pain are still limited because to a lack of controls and small sample number.

Pulsed Electromagnetic Field (PEMF) therapy has the potential to be used as a non-thermal, non-invasive, long-term supplementary treatment during stroke recovery.[13,14] Furthermore, according to other authors, the benefits of PEMF therapy is associated with enhanced local cellular activity, collagen fiberorientation, elevated oxygen content in the tissue, and dilated blood vessels without causing a rise in local temperature.[12] PEMF benefits as an adjuvant treatment include the protection of brain tissue in the penumbral region, reducing inflammation and promoting neurorestoration post-stroke. PEMF exposure was shown to be both safe and tolerable.[11,15] The effectiveness of PEMF to treat shoulder pain post-stroke has not been shown in previous studies. Therefore, it has been hypothesized that NMES and PEMF could be an effective treatment option that can help stroke patients with shoulder pain.

2. Material and methods

2.1 Study design

The present study was a single-blinded, randomized controlled trial. The research protocol was approved by the Institutional Ethics Committee (IEC) (letter no. PTY/2023/174, dated 11.04.2023) and registered with the Clinical Trial Registry of India (CTRI/2023/06/054354).

2.2 Participants

The sample size was calculated using MCID value 4.42 (FMA-UE) from previous studies with power 80% (p≤0.05) and each group has 17 patients (total of 51 patients) were recruited, considering a 20% dropout rate.[14] In accordance with the Declaration of Helsinki (2013), written consent was taken from each willing participant after giving the full information of the study in their understandable and local language.

Inclusion criteria were patients with unilateral hemiplegia, both male and female, duration of stroke of more than 6 months, a score on Visual Analogue Scale (VAS) of more than 4, and patients with 1–3 degrees of spasticity according to Modified Ashworth Scale (MAS) with age group between 45–70 years. Exclusion criteria were patients who had a history of a traumatic shoulder injury, uncontrolled seizures, severe arrhythmia, and a history of tuberculosis/ infection in the shoulder, patients with severe spasm or contracture of the upper limb, severe cognitive impairment, cardiac pacemaker, and pregnancy.

The main investigators AN collected the data at the department of Physiotherapy, GJUS&T and private clinics and hospitals,but the investigators were blinded to the allocation of groups. A random number sequence generated by a computer was used to assign into groups. All subjects provided written informed consent. They were completely anonymous (blinded) and had the right to withdraw at any time from the study. Participants enrolled in the study were randomly divided into three subgroups: PEMF group, the NMES group and the Control group.

2.3 Procedure

Patients received PEMF and NMES treatment for 30 minutes a day, 3 times a week for 6 weeks. There were no adverse events noted in both groups, such as burns or skin allergic responses, during the study period.

2.4 PEMF group

Each application lasted for 30 minutes, and the equipment used was a previously calibrated OMI PEMF. It was powered by a wall adapter and had a frequency (50 Hz) intensity (20 mT or 200 G)[15] and the mat wasplaced posteriorly on the shoulder joint while the patient wasin a supine position as shown in Figure 1. This group did not receive a conventional protocol.

2.5 NMES group

A portable, dual-channel battery-powered stimulator (Intelect® NMES) with frequency (30-50 Hz) and pulse duration (300 microseconds) was used as these parameters were used previously in hemiplegic shoulder.[16] Surface electrodes were placed close to the medial or posterior bundle of the deltoid and supraspinatus muscles[10] and the patient washeld in the sitting position (Figure 2).

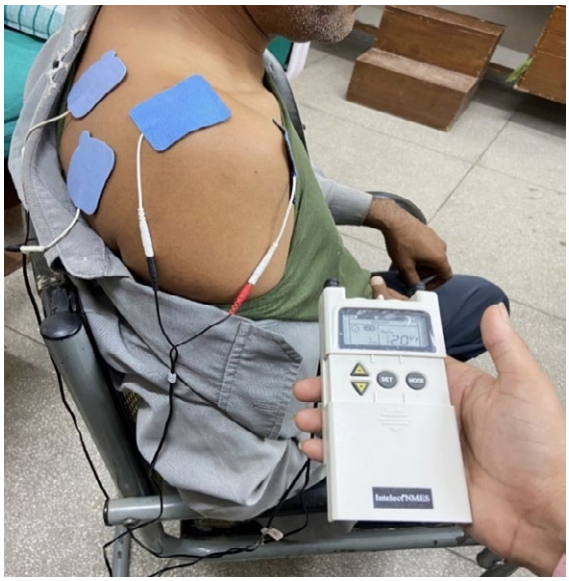
2.6 Control group

The Control group received a conventional protocol i.e., stretching exercises (Pectoralis major, latissimus dorsi); active/assisted range of motion exercises and passive range of motion exercises on the basis of literature review.[16,17]

Figure 1. Positioning of the mat and PEMF equipment

Source: the authors (2023).

Figure 2. Positioning of the electrodes and NMES equipment



Source: the authors (2023).

2.7 Outcomes measures

The primary outcome measure of this study was VAS (Visual Analogue Scale) for pain[18] and secondary outcome measures were FMA-UE (Fugl Meyer Assessment-Upper Extremity) for motor deficits[19]; the tone of the shoulder adductor and internal rotator was assessed using MAS (Modified Ashworth Scale) for spasticity[20] and active and passive range of motion (AROM/PROM) of shoulder flexion, abduction and external rotation was assessed using a universal goniometer. At the baseline, six weeks into the intervention, and one week into the follow-up, outcome measures were evaluated. A blinded assessor recorded all of the outcome measures.

2.8 Statistical analysis

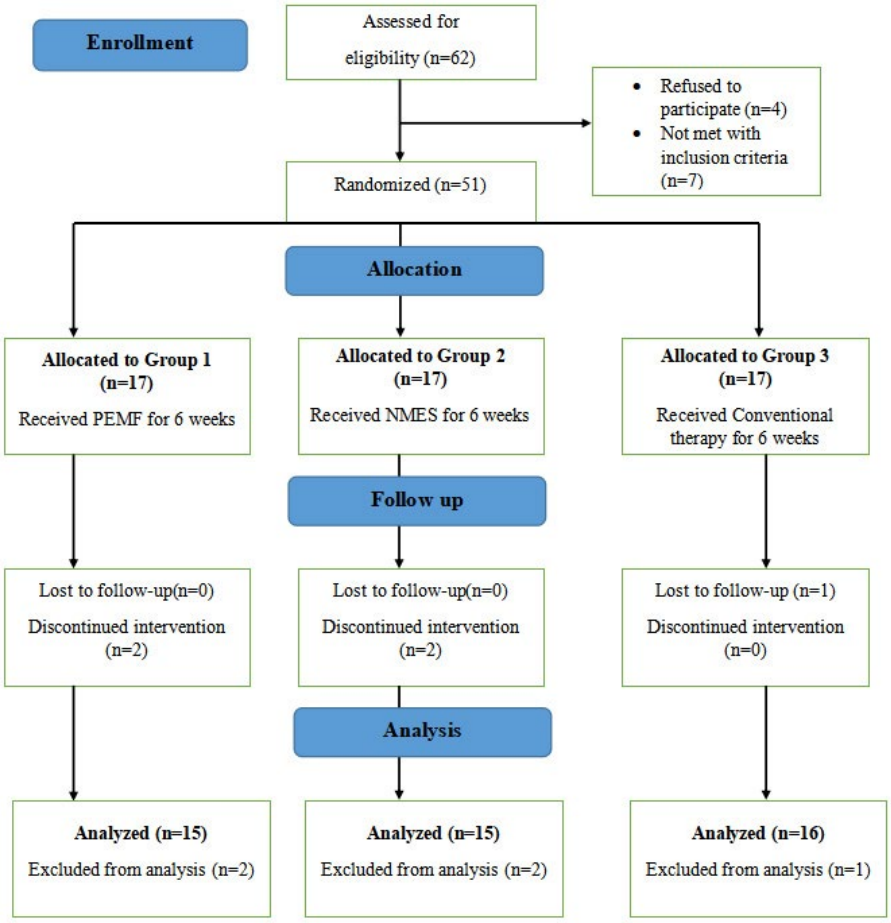
Data were analyzed using the SPSS 21.0 version (SPSSInc, Chicago, Il, USA).The normality of data was checked using the Kolmogorov-Smirnov test. The treatment efficacy was determined using a LSD (Least Significant Difference) post-hoc analysis. To compare the groups, a One-Way ANOVA was used. A paired t-test was used to analyze within-group data. A repeated measure ANOVA was used to calculate the therapeutic efficacy within each group.

3. Results

3.1 Baseline Comparison

51 subjects participated in the study, 17 subjects were allocated to each group. 46 patients (Group 1=17; Group 2=17 and Group=16) have completed all 18 treatment sessions, 5 patients were excluded from the final analysis (Group 1=2; Group 2=2 and Group=1) because they did not complete the treatment sessions (two patients cited a reason for lack of time in group 1 and two patients cited more distance from the residence in group 2 and one due to personal issue in group 3). Screening and selection of participants are shown in the flowchart according to CONSORT guidelines (Figure 3).

Figure 3. Screening and selection of participants are shown in the flowchart according to CONSORT guidelines



Source: the authors (2023).

The data from all the participants was obtained and analyzed. The baseline characteristics of the data (age, time calculated since the stroke occurred, weight, height and BMI) are displayed in Table 1. The pre-intervention scores of the three groups did not significantly differ from one another, indicating that all three groups had similar baseline scores. During the follow-up period, no unfavorable events were noticed in any of the groups.

Table 1. Baseline characteristics before the intervention

Variables		PEMF(N=15)	NMES(N=15)	Control(N=16)	P value
Age		60.90±8.47	60.40±6.70	59.50±6.79	0.860
Time		11.27±4.07	11.13±4.35	9.81±2.58	0.490
Weight (kg)		68.56±7.24	68.06±6.38	64.11±7.27	0.162
Height (cm)		170.40±6.72	168.80±8.82	168.38±10.15	0.796
BMI		23.53±1.24	23.91±1.96	22.60±1.54	0.075
VAS		6.67±0.90	6.93±0.79	6.81±0.91	0.706
FMA		30.93±7.47	33.13±6.50	31.25±5.81	0.617
MAS	Adductors	1.40±0.50	1.67±0.48	1.44±0.51	0.298
	Int Rotators	1.53±0.51	1.47±0.51	1.50±0.51	0.939
AROM	Flexion	44.20±11.44	43.80±10.02	46.63±11.12	0.736
	Abduction	26.53±3.92	25.40±3.62	26.50±4.42	0.679
	Ext Rotation	3.93±0.88	3.80±0.77	3.94±0.68	0.859
PROM	Flexion	97.67±20.15	101.67±16.25	104.19±16.99	0.597
	Abduction	89.40±12.83	93.20±11.35	95.19±10.93	0.388
	Ext Rotation	23.40±7.39	24.80±5.77	25.50±4.21	0.607

Source: the authors (2023).

The highest mean change in VAS scores was shown by PEMF (MD=5.06±0.46; t14=42.87; p≤0.01) and NMES group (MD=5.33±0.48; t14=42.33; p≤0.01*) followed by Control group (MD=1.87±0.95; t15=7.83; p≤0.01*) after 6 weeks of intervention. The highest mean change in FMA was shown by NMES group (MD=19.13±1.55; t14=47.73; p≤0.01*) followed by PEMF group (MD=-12.46±1.06; t14=-45.54; p≤0.01*) after 4 weeks of intervention. The highest mean change in MAS was shown by NMES group, adductors (1.40±0.50; t14=10.69; p≤0.01*) and internal rotators (MD=1.20±0.56; t14=8.29; p≤0.01*) followed by PEMF group, adductors (MD=0.66±0.48; t14=5.29; p≤0.01*) and internal rotators (MD=0.80±0.67; t14=4.58; p≤0.01*). The highest mean change in AROM was shown by NMES group, flexion (MD=-23.20±2.04; t14=-43.99; p≤0.01*), abduction (MD=-22.73±1.75; t14=-50.27; p≤0.01*), external rotation (MD=-3.20±0.77; t14=-16.00; p≤0.01*) followed by PEMF group, flexion (MD=-13.26±1.66; t14=-30.81; p≤0.01*), abduction (MD=-17.93±1.58; t14=-43.96; p≤0.01*) external rotation (MD=-1.46±0.640; t14=-29.66; p≤0.01*). The highest mean change in PROM was shown by NMES group, flexion (MD=-20.00±2.36; t14=-32.81; p≤0.01*), abduction (MD=-13.93±8.53; t14=-6.32; p≤0.01*) external rotation (MD=-12.40±1.68; t14=-28.55; p≤0.01*) followed by PEMF group, flexion (MD=-11.53±1.50; t14=-29.66; p≤0.01*), abduction (MD=-1.66±0.90; t14=-50.22; p ≤0.01*) external rotation (MD=-7.400±2.028; t14=-14.13; p≤0.01*). Comparison of the outcome variables in all three groups as shown in below cited Table 2.

Table 2. Comparison of the outcome variables after intervention and follow up in all three groups

Variables			PEMF	NMES	Control	F value	P value
Post	VAS		1.60±0.74	1.60±0.63	4.94±0.77	112.88	0.000*
	FMA		43.40±7.72	52.27±7.06	36.44±5.87	20.37	0.000*
	MAS	Adductor	0.73±0.70	0.27±0.45	1.06±0.68	6.31	0.004*
		Int Rotator	0.80±0.67	0.47±0.51	1.13±0.80	3.62	0.035*
	AROM	Flexion	57.47±11.83	67.00±9.41	52.19±10.75	7.55	0.002*
		Abduction	44.47±4.43	48.13±4.47	31.69±4.51	58.16	0.000*
		Ext Rotation	5.40±0.98	7.00±1.00	4.56±0.72	28.54	0.000*
	PROM	Flexion	109.20±20.87	121.67±15.91	108.69±16.19	2.59	0.086^{NS}
		Abduction	101.07±13.01	107.13±15.61	99.13±10.85	1.52	0.230^{NS}
		Ext Rotation	30.80±7.35	37.20±6.50	29.56±4.06	6.90	0.003*
Follow Up	VAS		1.53±0.64	0.87±0.64	4.94±0.77	157.10	0.000*
	FMA		44.40±8.06	53.67±6.74	36.63±5.57	24.01	0.000*
	MAS	Adductor	0.73±0.70	0.27±0.45	1.06±0.68	6.31	0.004*
		Int Rotator	0.80±0.67	0.47±0.51	1.13±0.80	3.62	0.035*
	AROM	Flexion	58.13±12.10	68.47±9.84	52.13±10.88	8.72	0.001*
		Abduction	45.93±5.23	49.27±4.81	32.13±4.61	54.02	0.000*
		Ext Rotation	6.00±1.25	7.73±1.28	4.56±0.72	31.69	0.000*
	PROM	Flexion	110.13±20.76	123.93±15.45	108.06±15.69	3.75	0.031*
		Abduction	102.13±13.61	108.60±15.72	99.50±11.02	1.83	0.172^{NS}
		Ext Rotation	31.27±7.26	38.20±7.20	29.25±3.85	8.58	0.001*

*: Significant p≤0.05; NS: Non-significant.
Source: the authors (2023).

All groups experienced statistically greater improvement in post-intervention and follow-up scores relative to pre-intervention scores, according to within-group comparisons. The post-intervention score and the follow-up score did not differ significantly. These findings suggest that after treatment was initiated, improvement has been observed in patients and continued during the follow-up period (Table 3).

Table 3. Repeated measures for VAS, FMA, and MAS scores of all groups at Pre-intervention, Post-intervention and follow-up after intervention

Variables			PEMF	NMES	Control
VAS		Pre	6.66	6.93	6.81
		Post	1.60	1.60	4.93
		Follow-up	1.53	0.86	4.93
		F Test	1437.57; p ≤0.01*	442.79; p ≤0.01*	61.36; p ≤0.01*
FMA		Pre	30.93	33.13	31.25
		Post	43.40	52.26	36.43
		Follow-up	44.40	53.66	36.62
		F Test	939.905; p ≤0.01*	1744.34; p ≤0.01*	275.59; p ≤0.01*
MAS	Adductor	Pre	1.40	1.66	1.43
		Post	0.73	0.26	1.06
		Follow-up	0.73	0.26	1.06
		F Test	28.00; p ≤0.01*	114.33; p ≤0.01*	9.00; p ≤0.01*
	Int Rotator	Pre	1.40	1.66	1.50
		Post	0.73	0.26	1.12
		Follow-up	0.73	0.26	1.12
		F Test	28.00; p ≤0.01*	114.33; p ≤0.01*	9.00; p ≤0.01*

*: Significant p≤0.05; NS: Non-significant.
Source: the authors (2023).

Multiple comparisons of mean change of VAS, FMA, MAS, AROM, and PROM between different groups as shown in below cited Table 4. When VAS was compared between PEMF, NMES and control group, significant differences were there except PEMF and NMES group. FMA showed significant differences between PEMF & NMES, Control and NMES & Control group. In the case of MAS outcome measure, adductor and internal rotators did not show significant differences between PEMF & Control and internal rotator between PEMF & NMES group; only the NMES and control group showed significant differences in both adductors and internal rotators.

Table 4. Multiple comparisons of mean change of VAS, FMA, MAS, AROM, and PROM between different groups

Variables		Group Intervention	Comparison between groups	MD (Mean Difference)	SE	Sig.
VAS		PEMF	NMES	0.00	0.26	1.00^{NS}
			Control	-3.34	0.25	0.00*
		NMES	Control	-3.34	0.25	0.00*
FMA		PEMF	NMES	-8.86	2.52	0.001*
			Control	6.96	2.48	0.008*
		NMES	Control	15.82	2.48	0.00*
MAS	**Adductor**	PEMF	NMES	0.46	0.22	0.04*
			Control	-0.32	0.22	0.15^{NS}
		NMES	Control	-0.79	0.22	0.01*
	Int Rotator	PEMF	NMES	0.33	0.24	0.18^{NS}
			Control	-0.32	0.24	0.19^{NS}
		NMES	Control	-0.65	0.24	0.01*
AROM	**Flexion**	PEMF	NMES	-9.53	3.91	0.01*
			Control	5.27	3.85	0.17^{NS}
		NMES	Control	14.81	3.85	0.00*
	Abduction	PEMF	NMES	-3.66	1.63	0.03*
			Control	12.77	1.60	0.00*
		NMES	Control	16.44	1.60	0.00*
	Ext Rotation	PEMF	NMES	-1.60	0.33	0.00*
			Control	0.83	0.32	0.01*
		NMES	Control	2.43	0.32	0.00*
PROM	**Flexion**	PEMF	NMES	-12.46	6.48	0.06^{NS}
			Control	0.51	6.38	0.93^{NS}
		NMES	Control	12.97	6.38	0.04*
	Abduction	PEMF	NMES	-6.06	4.83	0.21^{NS}
			Control	1.94	4.76	0.68^{NS}
		NMES	Control	8.00	4.76	0.10^{NS}
	Ext Rotation	PEMF	NMES	-6.40	2.22	0.006*
			Control	1.23	2.19	0.57^{NS}
		NMES	Control	7.63	2.19	0.001*

*: Significant p≤0.05; NS: Non-significant.
Source: the authors (2023).

When AROM (Flexion, Abduction, Ext rotation) compared between PEMF, NMES and control group, significant differences was there except PEMF and control group in case of AROM (Flexion). When PROM (Flexion) was compared only significant differences was shown in comparison of NMES and control group and in case of PROM (Ext rotation) significant differences between PEMF and NMES and NMES & Control group.

4. Discussion

This study compares the efficacy of PEMF and NMES on shoulder pain post-stroke for the first time. According to the findings of this randomized controlled trial, patients who had post-stroke shoulder pain effectively reduced pain, improved motor function, and increased range of motion with a PEMF and NMES. After a six-week intervention, all outcomes improved, and treatment effects persisted during a one-week follow-up period.

The mean difference for VAS for PEMF was 5.06, for NMES came out to be 5.33, and the control group was 1.87, which shows that the NMES group showed significant improvement which was clinically and statistically proven. NMES is a neuromodulatory intervention capable of altering central nervous system excitability, the course of shoulder pain after stroke involves local and distal nociceptive and neuropathological mechanisms. NMES may be used in acute and chronic stages after stroke because of its effects on cortical excitability and muscle physiology.[21]

A study by Lin and Yan showed that 3 weeks of long-term NMES supplemented with conventional therapy significantly improved upper limb motor skills during the initial stages of stroke compared with conventional therapy alone, and the effect lasted for at least 6 months.[22] In the present study, NMES affects shoulder abduction by stimulating the deltoid and supraspinatus muscles. The majority of previous studies trials in chronic patients did not examine upper limb function (i.e., activity limitation) or the persistence of the effect but the evidence has shown that NMES can help reduce or prevent shoulder subluxation, relieve pain, and improve muscle strength. The effect is maintained for up to 3 months after the end of treatment.[23]

Sahin et al. evaluate the efficacy of NMES (15 minutes; 5 days/week for 4 weeks)on spasticity and found a significant effect on spasticity by strengthening the antagonist's muscles via spinal cord routes and local neuronal effects.[24] NMES aids in re-educating the muscle as well as preventing atrophy, reducing muscle spasms, increasing blood flow, and nutrition delivery to the muscles.[8]

Recent studies have added additional evidence supporting the effectiveness of PEMF therapy in improving cell communication and promoting healing in the body, this leads to a reduction in toxins in the damaged area and an increase in vital nutrients and endorphins, reducing the sensitivity of nociceptors.[25] Thomas et al. did a study on the analgesic effects of PEMF exposure on chronic musculoskeletal pain in humans and concluded that net pain relief by VAS was comparable to low to moderate doses of opioid analgesics in PEMF-exposed patients.[26] There is no strong evidence that electromagnetic therapy provides additional benefits during the acute period of SIS rehabilitation.[27] For instance, a randomized, placebo-controlled study showed that PEMF therapy improves pain threshold and physical functionality in knee osteoarthritis patients.[28] Moderate evidence supports PEMF's ability to speed up healing and lessen pain.[29] It has been demonstrated that exposure to a pulsed electromagnetic field reduces tissue damage after a stroke. In rabbits, PEMF stimulation reduced infarct size following acute localized ischemia. The study concluded that PEMF offers a mild reduction in inflammation during the early phases of poststroke recovery and a better suppression of the inflammation process during the later stages.[11] In the current study, we showed improved shoulder pain following a stroke in terms of pain, motor function, range of motion, and spasticity. PEMF therapy is a promising approach for treating a variety of illnesses because it uses low-frequency energy fields to promote electrical and chemical processes in the tissues.

It is significant to note that at the 1-week follow-up evaluation, all post-intervention results were unchanged. We compared two therapies in this study to a control group to add to the clinical evidence supporting the efficacy of PEMF and NMES in the treatment of post-stroke shoulder pain, findings suggested that NMES can successfully manage pain relief while maintaining a long-lasting analgesic impact and PEMF not only alleviates

pain but also has a stimulating effect on biological processes. The findings of our study are closely related to other studies that studied the effects of PEMF[15,22,30] and NMES.[8,10,11]

There are numerous major strengths in the study. This is the first randomized controlled trial comparing the efficacy of PEMF and NMES with a control group. To reduce bias, blinding and sample size calculations were used. The findings are not only statistically significant but also clinically relevant.

There are some limitations to the study. First, the sample size is small. Second, only post-stroke participants with moderate to severe deficits were studied. Longer follow-up assessments are necessary. Future research employs large sample sizes and similar stimulation methods to acquire a better understanding of the potential to promote functionally beneficial neuroplasticity in stroke patients.

5. Conclusion

The pulsed electromagnetic field therapy and neuromuscular electrical stimulation are effective in improving post-stroke shoulder pain, spasticity, range of motion and motor function and a novel method for stroke patients undergoing rehabilitation. Our results show that NMES is significantly more effective than PEMF at sustaining long-term analgesia.

Authors' contributions

Punia S and Nimesh A participated in conception, design, and in data collection. Punia S and Singh V worked in data analysis. Punia S, Nimesh A and Boora M contributed in drafting the article. All authors contributed to the critical revision and final approval of the article.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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