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RESEARCH ARTICLE

PULSED ELECTROMAGNETIC FIELD VERSUS PULSED ULTRASOUND IN TREATMENT OF MECHANICAL NECK PAIN: RCT

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ABSTRACT

Mechanical neck pain (MNP)affects approximately two thirds of the population in the middle age due to poor postural habits. Purpose: to compare the effect of pulsed electromagnetic field versus pulsed ultrasound on pain intensity, cervical range of motion and functional restriction in treating patients with MNP. Design: randomized controlled trial. Methods: 45 patients with MNP participated in this study. They were assigned randomly into three groups: Group (A) received pulsed ultrasound and conventional physical therapy program, group (B) received pulsed electromagnetic field and conventional physical therapy program, group (C) "control group" received conventional physical therapy program. Subjects received three sessions a week for four weeks. The authors measured pain intensity, cervical range of motion and neck disability by the visual analogue scale, Acu Angle Inclinometer and neck disability index, respectively before and after four weeks of treatment. Results: There were statistical significant improvements in all groups after intervention in favor of group (B). Conclusion: It was concluded that the group that received pulsed electromagnetic field had the greatest improvement in pain intensity, cervical range of motion and neck disability in patients with MNP.

INTRODUCTION

The neck—or cervical spine—is a coordinated network of nerves, bones, joints, and muscles. It has the important job of providing support and mobility for the head, but sometimes it can become painful.(1) Neck pain is common among adults, but it can occur at any age, pain can develop suddenlyfrom an injury such as trauma, or it may develop slowly over time, such as from years of poor posture or wear and tear (2). Mechanical neck pain (MNP) is a mechanical disorder affecting the neck region commonly arises insidiously and is generally multifactorial in origin, which is manifested by neurological impairments caused by tightness of neck muscles due to one or more of the following bad habits, such as poor posture, poorly-designed seating, and incorrect bending and lifting motions or another causes as anxiety, depression, neck strain, and sporting or occupational activities. (3) As a significant disabling health problem that might cause work absence, (4) MNP showed a higher incidence in females (18%) than males (13.2%). (5). Several modalities have been used in treating MNP such as electromagnetic field, ultrasound, acupuncture, massage, laser, exercise, biofeedback,TENS and shock waves. (6). Magnetic therapy is considered as a safe, easy and non-invasive physical therapy modality used to treat pain, inflammation and other types of pathologies and diseases (7).

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Pulsed electromagnetic field (PEMF) refers to a basic law of electromagnetism that describes how a magnetic field interacts with an electric circuit to produce an electromotive force known as electromagnetic induction. Exposure to PEMF has been reported to modulate neuronal excitation and neurogenesis related to Na+ channel activity, where neurons excited by the exogenous electromagnetic force can also affect neighboring cells by ephaptic interaction also modulatelevels of various growth factors that prevent autoimmune disease and inhibit tissue degeneration (8). Therapeutic ultrasound can help relax tight muscles that are sore. It also warms muscles and soft tissues, which increases circulation that helps healing. The heat and increased blood flow produced by ultrasound treatments can relieve inflammation and pain, accelerate tissue healing and reduce muscle spasms. It can also help promote a greater range of motion. In addition to thermal ultrasound effects on soft tissues pulsed ultrasound waveshave mechanical effects on the soft tissues which make it indicated in many cases for these additional effects (9). The purpose of this study was to compare between the effectiveness of PEMF and PUSwaves on pain intensity, cervical range of motion (ROM) and neck function disability in patients with MNP.

METHODS

This study was a randomized controlled trial with patients randomly assigned to one of three intervention groups: Group (A) received pulsed ultrasound and conventional physical

therapy program, group (B) received pulsed electromagnetic field and conventional physical therapy program, group (C) "control group" received conventional physical therapy program. Patients received three sessions a week for four weeks. Measurements were taken at baseline and after four weeks. The tester who took the measurements and the treating therapist were blinded to group allocation. Among 52 examined patients 7 patients were excluded with different causes 5 refused to continue due to chest infection and post Covid-19 and 2 patients moved out and only 45 patients continued with the study. Forty five patients diagnosed with MNP were recruited from outpatient clinic in the faculty of Physical therapy in Cairo University and from private clinic participated in the current study. All patients were referred from an orthopedic and neurologic consultant. Inclusion criteria were middle aged between 18-40 years of both genders and body mass index from 18.5 to 24.9 Kg/m².Inclusion criteria also included subjects with neck pain unilateral or bilateral of unknown specific causefor at least 12 weeks. Reasons for exclusion criteria included cervical disc problems, history of neck trauma, head injuries, pregnancy, cancer or been on chemotherapy or radiotherapy, osteoporosis of the cervical spine, cervical rib, post-surgical neck conditions, open wound over the cervical region, internal fixation of the cervical vertebrae, stenosis or cerebrovascular abnormalities. All patients read and signed a consent form permitting the use of their data for research purposes, and confidentiality was assured by the use of an anonymous coding system. Patients were asked to refrain from other forms of physical therapy or other medical procedures for pain during the study. The procedures were followed according to the agreement of the institutional Ethical Committee (No. P.T.REC/012/002403).

Instrumentation: Visual analogue scale (VAS) was used to measure pain intensity. Its validity and test-retest reliability was between 0.95 and 0.97 (10). AcuAngle® Inclinometer was used to measure cervical spine ROM. It is valid and reliable tool. (11) The authors also used the Neck disability index (NDI). It is a self-rated disability questionnaire with high test-retest reliability and good concurrent validity. (12)Walton DM *et al*reported that the NDI is strongly correlated (>0.70) to a number of similar functional disability measures and moderately related to both physical and mental aspects of the general health (13). JAMAVA® S Magneto therapeutic apparatus (Electrotechnical testing institute, Prague, Czech Republic) was used to deliver electromagnetic field with maximum induction 70 mT. (14)Ultrasound device (Chattanooga, Intelect Advanced, USA) was utilized to produce ultrasound waves. The device was produced by Chattanooga group and clinically used after government approval by the Food and Drug Administration in the USA (FDA). (15) Hydrocollator heating unit (Chattanooga, USA) where hot packs are kept in which is a container of water usually kept at a temperature between 70°C and 75°C. When a hot pack is placed in contact with the skin, thermal energy transfers from hot pack to the tissues (16).

Procedures

Group (A): The therapist applied PUS waves of 1.1 MHz frequency and 1-1.5 watt/cm² power were applied for 8 minutes with 5 cm² diameter transducer using gel as a coupling medium and conventional physical therapy as in group (C) 3 times per week for 4 weeks. (17)

Group (B): The therapist applied PEMFwith burst low frequency of 12.5 Hz, and intensity of 0.8 milliTesla (mT) were applied for 20 minutes with 5 cm² diameter applicator and conventional physical therapy as in group (C) 3 times per week for 4 weeks. (18)

Group (C) (Control group): Conventional physical therapy in the form of hot packson cervical spine for duration from 15-20 min while the patient sitting or supine (19)and therapeutic exercises as stretching exercises program for the upper fibers of trapezius, scaleni and suboccipital muscles. (20) Active neck ROM exercise of flexion and extension was applied in pain free range as 3 set of 10 repetitions with a 60 seconds rest period between After 5 minutes rest 3 times per week for 4 weeks. (21)

Data analysis: A statistical power analysis suggested that sample sizes are 15 participants per group were required to achieve more than 80% power. Statistical analysis was conducted using SPSS for Windows, version 20 (SPSS, Inc., Chicago, IL). Descriptive statistically include mean and standard deviation for all variables (pain, ROM and functional level). Analysis of variance ($p<0.05$) was used to compare between groups and within each group with post hoc test if there was significant difference between groups.The authors used the ANOVA test to assess pain intensity, cervical ROM and neck disability among the three groups.

RESULTS

45 patients with MNP were randomly assigned into three groups with 15 patients in each group. There was no significant difference between the three groups in their ages where their P-values were (p = 0.999)at baseline as shown in Table 1.

Table 1. Means and standard deviations of age of groups (A), (B) and (C)

	Group (A)		Group (B)		Group (C)			Comparison
	Mean	± SD	Mean	± SD	Mean	± SD	F-value	P-value
Age	32.6	± 5.4	32	± 5	32.5	± 5.6	0.001	0.999

While there was no significant difference between the three groups in their ages and gender where their P-values were (p = 0.999) and (p = 0.649) respectively at baseline as shown in Table 2.

Pain level: There was no significant difference in the mean values of pain for pre treatment value between the three groups (F = 0.112 and P = 0.895), while there was a statistical significant difference for post treatment value between the three groups (F = 14.5 and P = 0.001) as shown in Figure 1.

Neck flexion ROM: There was no significant difference in the mean values of neck flexion pre-treatment value between the three groups (F = 0.628 and P = 0.536), while there was a statistical significant difference for post treatment value between the three groups (F = 15.1 and P = 0.001) as shown in table 3.

Neck extension ROM: There was no significant difference in the mean values of neck extension pre-treatment value between the three groups (F = 0.107 and P = 0.899), while there was a statistical significant difference for post treatment value between the three groups (F = 16.9and P = 0.001) as shown in table 4.

Table 2. The frequency distribution and chi squared test for comparison of sex distribution of groups (A), (B) and (C)

	Group (A)		Group (B)		Group (C)		Comparison	
Sex	Male	Female	Male	Female	Male	Female	χ^2 value	P-value
No.	5	10	5	10	3	12	0.865	0.649
%	33.3%	66.7%	33.3%	66.7%	20%	80%		

Table 3. Results of ANOVA among the three groups for neck flexion ROM

	Neck Flexion ROM	SS	MS	F	P value	S
Pre treatment	Between Groups	18.32	9.16			
	Within Groups	533.6	12.7	0.628	0.536	NS
	Total	551.92				
Post treatment	Between Groups	373.3	186.65	15.1	0.001	S
	Within Groups	624.7	14.87			
	Total	998				
S: significant		NS: non significant				

Table 4: Results of ANOVA among the three groups for neck extension ROM

	Neck Extension ROM	SS	MS	F	P value	S
Pre treatment	Between Groups	0.853	0.426			
	Within Groups	777.05	18.5	0.107	0.899	NS
	Total	777.91				
Post treatment	Between Groups	640.85	320.42	16.9	0.001	S
	Within Groups	926.39	22.05			
	Total	1567.24				

S: significantNS: non significant

Table 5. Results of ANOVA among the three groups for neck side bending ROM to the right

	Neck Side bending ROM	SS	MS	F	P value	S
Pre treatment	Between Groups	37.92	18.96			
	Within Groups	847.99	20.19	0.217	0.805	NS
	Total	885.91				
Post treatment	Between Groups	226.18	113.09	7.67	0.001	S
	Within Groups	1017.73	24.23			
	Total	1243.91				

S: significantNS: non significant

Table 6. Results of ANOVA among the three groups for neck rotation ROM to the right

	Neck RotationROM	SS	MS	F	P value	S
Pre treatment	Between Groups	210	105			
	Within Groups	1410	33.57	0.987	0.377	NS
	Total	1620				
Post treatment	Between Groups	323.33	161.6	5.08	0.008	S
	Within Groups	1846.6	43.96			
	Total	2170				

S: significantNS: non significant

Table 7. Results of ANOVA among the three groups for functional disability

	Functional disability	SS	MS	F	P value	S
Pre treatment	Between Groups	4.93	2.465			
	Within Groups	596.27	14.19	0.094	0.911	NS
	Total	601.2				
Post treatment	Between Groups	503.51	251.75	13.9	0.001	S
	Within Groups	1039.39	24.74			
	Total	1542.97				

S: significantNS: non significant

Neck side bending ROM to the right: There was no significant difference in the mean values of neck neck side bending to the right pre-treatment value between the three groups (F = 0.217 and P = 0.805), while there was a statistical significant difference for post treatment value between the three groups (F = 7.67and P = 0.001) as shown in Table 5.

Neck rotation ROM to the right: There was no significant difference in the mean values of neck rotation to the right pre-treatment value between the three groups (F = 0.987and P = 0.377), while there was a statistical significant difference for post treatment value between the three groups (F = 5.08and P = 0.008) as shown in Table 6.

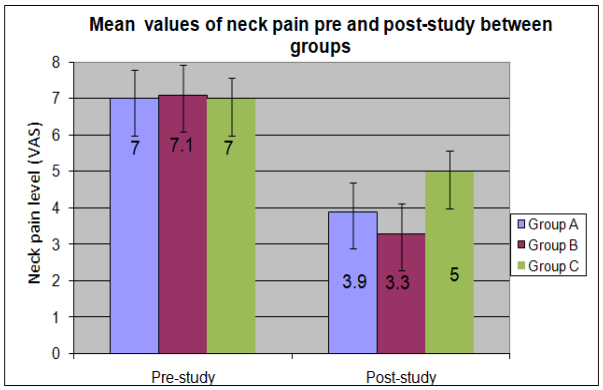

Figure 1. Mean and SD values of pain pre and post-study between groups

Functional disability: There was no significant difference among the three groups for the pre-treatment value (F=0.094, P=0.911). On the other hand, there were statistical significant differences for the post-treatment value (F=13.9, P=0.001) as shown in table 7 and Figure 2.

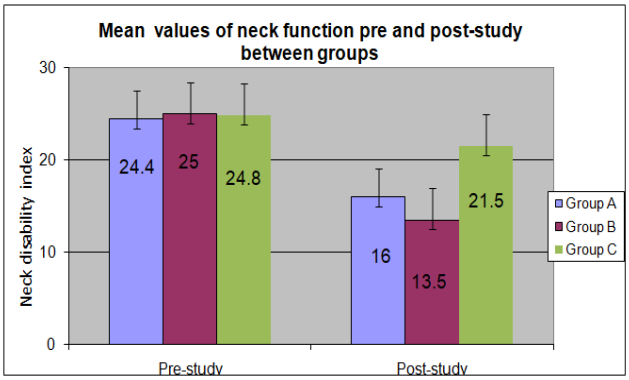

Figure 2. Mean and SD values of neck disability pre and post-study between groups

DISCUSSION

The purpose of this study was to compare between the PEMF and PUS in patients with MNP. The results of this randomized trial showed that there were statistical significant differences between the 3 groups after the end of the intervention, in favor of the group that received the PEMF and conventional physical therapy. The Least significant difference test showed a statistical significant difference in the mean value of all parameters of the group(B) (PEMF & Conventional physical therapy) when compared to groups (A) (Pulsed US & Conventional physical therapy, P=0.208) and group (C) (Conventional physical therapy, P=0.001).

The observed improvements in each group were most likely the result of the intervention. It is unlikely that the results are due to the passage of time or tester bias due to utilization of an appropriate study design. The design included random assignment of subjects into the groups and blinded tester to the group allocation. There have been a few studies comparing between the PEMF and PUS in patients with MNP. This study showed that group B who received PEMF &conventional treatment assembled in hot packs and exercises (stretching and strengthening)had the best outcomes in patients with MNP.

Our results revealed that there was a statistical significant improvement of pain and function values post treatment in comparison to pre- treatment, this improvement in pain could be due to the mechanism of action as PEMF causes flow of electrical charges which in turn causing a flow of ionic current necessary for restoration of basic cellular activities and the stimulation of growth factor. (22) Magnetotherapy increased the local blood flow which may speed tissue recovery and cause pain relief. It may also alter the body fluids pH, increase the enzyme activity and pain thresholds in free nerve endings. Moreover, researches suggested that PEMF decrease pain and restricted spinal mobility relieve the myofascial pain and effectively reduce cervical spondylotic pain. (23) The results of this study agreed with MS Alayat *et al*., 2017 who investigated the effect of PEMF in combination with exercises on pain and neck functions in patients with chronic MNP. The finding in the current study was that PEMF combined with exercise was effective more than exercises alone in decreasing the scores of VAS and NDI after 6 weeks of treatment. (24) The results of this study agreed with Paolucci T. *et al*., 2020 who investigated the use of PEMF in rehabilitation about its efficacy of acute and chronic mechanical neck pain. They revealed that PEMF therapy is an effective treatment in the management of mechanical neck pain that can reduce pain intensity and improves function. (25) Further our results come in the same line with Abd El-Hakem A. *et al*., 2013 who compared the effect of pulsed magnetic field with ultrasound in treating patients with carpal tunnel syndrome (CTS), Result as pulsed magnetic field was more effective than ultrasound in decreasing pain level and increasing hand grip strength in treating patients with carpal tunnel syndrome (26). Also our results revealed that there was a statistical significant improvement of range of motion values post treatment in comparison to pre- treatment. This improvement in CROM could be because PEMF had a stimulatory effect on the osteoblasts in the early stages of culture, which increased bone tissue-like formation. This stimulatory effect was most likely associated with enhancement of the cellular differentiation, might enhance the repair of cartilage: an alteration of chondrocyte receptor activation and transformation of growth factor β by PEMF has been demonstrated. (27). PEMF cause the movement of calcium and other ions across cell membranes, and stimulate transcription with increased protein synthesis. In addition to these effects on chondrocytes, an increase in glycosaminoglycan has been observed. This mechanism possibly enhances the ability of cartilage to absorb more compressive stresses, thereby reducing the transmission of such stresses to the underlying bone thus increasing ROM (28).

SerapTomruk *et al*., 2005 evaluated the effect of pulsed electromagnetic field therapy (PEMF) on pain, range of motion (ROM) and functional status in patients with cervical osteoarthritis (COA). The results of this study are promising, in that PEMF treatment may offer a potential therapeutic adjunct to current COA therapies in the future. (29)The results of this study agreed with Mazen M. *et al*., 2013 who investigated pulsed magnetic field in shoulder impingement syndrome. The study concluded that pulsed magnetic field had a significant effect on decreasing shoulder pain severity, shoulder functional disability and increasing shoulder abduction range of motion. (30) The results of this study also agreed with Alkady S. *et al*., 2013 who compared between electroacupuncture and pulsed electromagnetic field efficacy in the management of knee osteoarthritis and showed that pulsed

electromagnetic field may be beneficial and had the upper hand over electroacupuncture in improving range of motion, functional performance and perceived knee pain in patients with knee osteoarthritis. (31) O.Celik *et al*., 2014 investigated the effectiveness of therapeutic ultrasound (US) in non-specific mechanical neck pain, and to compare the effects of intermittent and continuous US applications on pain severity and functional disability. The study showed Therapeutic US applications are effective in reducing the severity of pain and sensitivity level of painful point on cervical region by increasing pain pressure threshold, furthermore it affects the functional status positively by increasing cervical range of motion (32). However this study disagreed with Khaled M. *et al*., 2011 who compared the effect of pulsed ultrasound and progressive pressure release on pain in myofascial pain syndrome of upper trapezious muscle. Study indicated that Progressive pressure release on MTrPs was very effective on pain in myofascial pain syndrome of upper trapezius muscle more than pulsed ultrasound. (33) This study also disagreed with Asmaa W. *et al*., 2014 who compared the efficacy of Myofascial trigger points pressure release and Ultrasound therapy on trigger points associated with knee osteoarthritis. Myofascial trigger points pressure release treatment proved to be beneficial and had the upper hand over Ultrasound in improving range of motion, perceived knee pain and decreasing the limitation of functional performance in patients with knee osteoarthritis (34). This study also disagreed with M.N. Kocic *et al*., 2014 who examined the effect of low-frequency pulsed electromagnetic field (PEMF) in patients with subacute non-specific neck pain. The study showed that in patients with subacute non-specific neck pain, exercises led to a statistically significant reduction in pain. Adding PEMF had no effect on pain reduction (35). There are some limitations in this study. First, the treatment period needed to be extended more than 4 weeks. Second, the sample size was small. Third, the limited age groupson only middle aged participants. Last but not the least the daily living activities of the patients could not be completely controlled. In this study, the researchers concluded that PEMF and conventional physical therapy is more effective than PUS and conventional physical therapy in reducing pain, functional disability and increasing neck ROM in patients with MNP.

Conclusion

It was concluded that group (B) that had received PEMF and conventional physical therapy had the greatest improvement in pain intensity, cervical range of motion and neck disability in patients with MNP than other groups.

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