Pulsed Magnetic Field Versus Low Frequency Transcutaneous Electrical Nerve Stimulation in Management of Chronic Mechanical Low Back Pain

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ABSTRACT

Background: *Chronic mechanical low back pain is reported to be a major health problem worldwide.* ***Purposes:*** *To investigate and compare the efficacy of pulsed magnetic field and low frequency transcutaneous electrical nerve stimulation in management of chronic mechanical low back pain.* ***Study Design:*** *A pre test post test control group design.* ***Materials and methods:*** *Thirty patients with chronic mechanical low back pain from both sexes were involved, aged between 35– 50 years old. They were divided into three equal groups, ten patients each. Patients in the first group (control group) received a therapeutic ultrasound in addition to traditional exercise program in the form of stretching and strengthening exercises for the back and abdominal muscles. Patients in the second group received pulsed magnetic field in addition to the program of the control group. Patients in the third group received low frequency transcuteanous electrical nerve stimulation in addition to the program of the control group. Treatment was done 3 times a week for 4 weeks. Range of motion, pain level and functional performance were measured before and after treatment.* ***Results:*** *There were significant differences within the three groups before and after treatment ($P<0.05$) and between the three groups after treatment in range of motion, pain level and functional performance ($P<0.05$).* ***Conclusion:*** *Pulsed magnetic field proved to be more beneficial than low frequency transcuteanous electrical nerve stimulation in improving range of motion, functional performance and perceived back pain in patients with chronic mechanical low back pain.*

Key words: *Chronic mechanical low back pain, pulsed magnetic field, transcutaneous electrical nerve stimulation.*

INTRODUCTION

Back problems are common and costly. Chronic mechanical low back pain (CMLBP) continue to represent the most common form of the work related musculoskeletal disorder resulting in substantial costs to society. In addition, some observed that there has been no progress in the control of low back pain (LBP). A barrier to their progress has been the inability to facilitate proper treatment strategies and to quantify the changes in the extent of related severity of pain and limitation of functional activities associated LBP[25].

International studies have estimated that back pain afflicts 65 to 80 percent of the population at least briefly at some time during their lives[14]. Due to favorable prognosis in the acute stage, 75 to 80 percent of the patients will improve considerably within 6 to 8 weeks. The prognosis of chronic low back pain (CLBP) is considerably less favorable causing potentially long lasting suffering to the patient and significant socioeconomic costs[7,10]. Despite this high incidence, LBP is poorly understood clinical problem because unclear diagnosis labels of patient and incomplete information of pathogenesis[18,35].

Chronic low back pain is the most common complaint of the working age

population .In addition to human suffering, it causes a substantial economic burden due to the wide use of medical services and absence from work. Although in most patients a cute LBP resolves with conservative treatment or without any treatment, the back pain appears to recur and become chronic more often than expected[26].

On the other hand there are different causes for LBP to become chronic, one of that is pain avoidance behavior which leads to increase dysfunction when muscles and ligaments are not used to their ultimate limits. If the functional range of motion (ROM) is limited because of pain for long period of time, the actual ROM will decrease as the soft tissues shorten and strength decreases. The impairment then may be a result of these consequences of disuse, rather than a result of the initial injury[24].

Magnetic field (MF) is the space permeated by the magnetic lines forces surrounding a permanent magnet or coil of carrying electric current. A magnetic field always exists when there is an electric current flowing. There are three types of magnetic field: a static magnetic field which is fanned in the case of direct current, a time varying magnetic field and pulsed magnetic field. The human body is transparent to the magnetic field, so during application, it acts on all molecules, has no selective action[29,38].

Since the magnetic field generated can penetrate through high resistance structures such as bone, fat, skin, clothes, or even plaster cast, it has been shown that electromagnetic fields provide a practical exogenous method for inducing cell and tissue modification and correct selected pathological states[5].

Magnetic field (MF), were applied to promote bone healing, treat osteoarthritis and inflammatory diseases of musculoskeletal system, alleviate pain and enhance healing of ulcers. This demonstrates how much magnetic field is beneficial for the field of physical therapy[31]. Pulsed electromagnetic field is useful in reducing pain and relieving of muscle spasm, so improves patient functions and trunk ROM in chronic low back pain patients[16].

Transcutaneous electrical nerve stimulation (TENS) is one of the most commonly used forms of electro analgesia. Hundreds of clinical reports exist concerning the use of TENS for various types of conditions such as LBP, myofascial and arthritic pain, sympathetically mediated pain, bladder incontinence, neurogenic pain, visceral pain and post surgical pain[21]. TENS is one of the most important electrical modalities in management of LBD as it reported to decrease pain, reestablish normal ROM and improve functional performance[8].

Transcutaneous electrical nerve stimulation a non-invasive electrotherapeutic modality is widely applied to treat chronic and acute pain. It is normally delivered to the tissues in one to three modes; conventional TENS, acupuncture-like TENS and burst mode TENS. These three modes have different electrical parameters that are, frequency and intensity of the current, and are thought to have different biological mechanisms for their analgesic effects[27,3].

Previous studies recommended the use of PMF and TENS in management of CMLBP but not determining which is more effective.

In this prospective randomised controlled trial, our aim was to evaluate and compare the efficacy of PMF and TENS in management CMLBP.

SUBJECTS AND METHODS

1) Design of the study

A pre test post test control group design was used to investigate and compare the

efficacy of pulsed magnetic field and low frequency transcutaneous electrical nerve stimulation in management of chronic mechanical low back pain.

2) Characteristics of subjects

Thirty patients with CMLBP of both sexes with age of 35-50 years randomly assigned into three groups, each group consisted of ten patients. The first group (control group) received a therapeutic ultrasound in addition to traditional exercise program in the form of stretching and strengthening exercises for the back and abdominal muscles. Patients in the second group received pulsed magnetic field in addition to the program of the control group. Patients in the third group received low frequency transcuteanous electrical nerve stimulation in addition to the program of the control group.

3) Instrumentation

- (BROM) back range of motion devise is modified protractor goniometer for measuring trunk motion.
- ASA Magnetic field (Automatic PMT Quattro pro) was used to apply PMF to the low back area of the patients with CMLBP.
- TENS apparatus: Phyaction 787 was used to apply low frequency transcutaneous electrical nerve stimulation to the low back area of the patients with CMLBP.
- Ultrasonic apparatus: Phyaction 190 was used to apply ultrasound to the low back area of the patients with CMLBP.

4) Procedure

A- Evaluative procedures

All subjects agreed to participate in the study by completing an informed consent form. The active lumbar flexion and extension (ROM) was measured by using (BROM) back range of motion devise. They were asked to report their pain level by using a Visual Analogue Scale (VAS). The oswestrey disability questionnaire was administered for the subjects for assessment of the functional level and the induced disability in the daily functions. The ages of subjects were recorded and their heights and weights were measured. Subjects were given verbal instructions concerning the purpose and procedure of the study.

B- Treatment procedures

The patients divided into three groups of equal number (10 patients for each) randomly. The first group (control group) received ultrasonic of 1 MHz frequency, 1.5 watt/cm^2 power and continuous mode for 5 minutes to the target low back area. Acoustic gel was used as a coupling medium[4], in addition to traditional exercise program in the form of stretching and strengthening exercises for the back and abdominal muscles. The second group received the same program of the control group in addition to PMF with a frequency of 10 Hz, intensity of 20 gauss and duration of 15 min[36].

The third group received the same program of the control group in addition to low frequency TENS with a frequency of 1-20 Hz , pulse duration of 300-400 µsec and the intensity according to the patient's tolerance for a period of 20 minutes[20].

The three groups were trained 3 times/week for a period of four weeks.

5) Data collection and statistical analysis

- Descriptive statistics using mean and standard deviation.
- Inferential statistics using paired t-test, one way ANOVA test and post hoc test.

RESULTS

Subjects characteristics

Control group (A)

Ten subjects were included in this group 4 male and 6 female. Their ages ranged from (35-50) years with mean age was (41.6±4.92) years, their weights ranged from (67-88) with mean weight (77.00±7.37) kg and their heights ranged from (159-181) with mean height (169.8±7.53) cm, as shown in table (1) and figure (1).

PMF group (B)

Ten subjects were included in this group 5 male and 5 female. Their ages ranged from (35-50) years with mean age was (43.8±5.9) years, their weights ranged from (69-97) with mean weight (77.9±9.27) kg and their heights ranged from (162-187) with mean height (170.9±7.18) cm, as shown in table (1) and figure (1).

TENS group(C)

Ten subjects were included in this group 5 male and 5 female. Their ages ranged from (35-50) years with mean age was (45.2±4.96) years, their weights ranged from (68-97) with mean weight (79.9±10.09) kg and their heights ranged from (162-171) with mean height (167.7±2.86) cm, as shown in table (1) and figure (1).

Table (1): Physical characteristics of patients in each group.

Items	A		B		C		Comparison		S
	Mean	±SD	Mean	±SD	Mean	±SD	t-value	P-value	
Age (yrs)	41.6	±4.9	43.8	±5.9	45.2	±4.96	1.18	0.32	NS
Weight (Kg)	77.0	±7.3	77.9	±9.2	79.9	±10.09	0.27	0.76	NS
Height (cm)	169.8	±7.5	170.9	±7.1	167.7	±2.86	0.67	0.51	NS

*SD: standard deviation P: probability S: significance NS: non-significant.

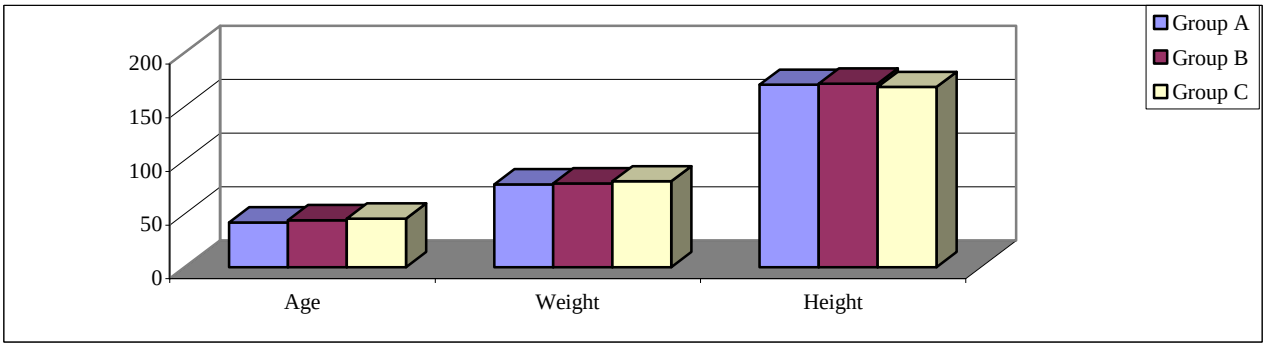

Fig. (1): Age, weight and height characteristics in the three groups.

Differences in pain level, function level and ROM before treatment between the three groups:

The results of the ANOVA test between the three groups revealed that there were no significant differences in range of motion, pain level, and functional level before treatment as shown in table (2) and figure (2).

Table (2): Results of ANOVA test for pain, function level and ROM (flexion-extension) between the three groups before treatment.

		A	B	C	F	P	Sig
Pain		8.1±1.37	8.12±1.1	8±1.63	0.017	0.98	NS
Function		49.3±15.21	51.4±15.37	50±11.23	0.058	0.94	NS
ROM	flex	20.9±4.77	23.8±4.93	24.4±4.55	1.54	0.23	NS
	Ext	10.1±2.33	10.9±1.96	10.4±2.45	0.31	0.73	NS

NS: Non significant

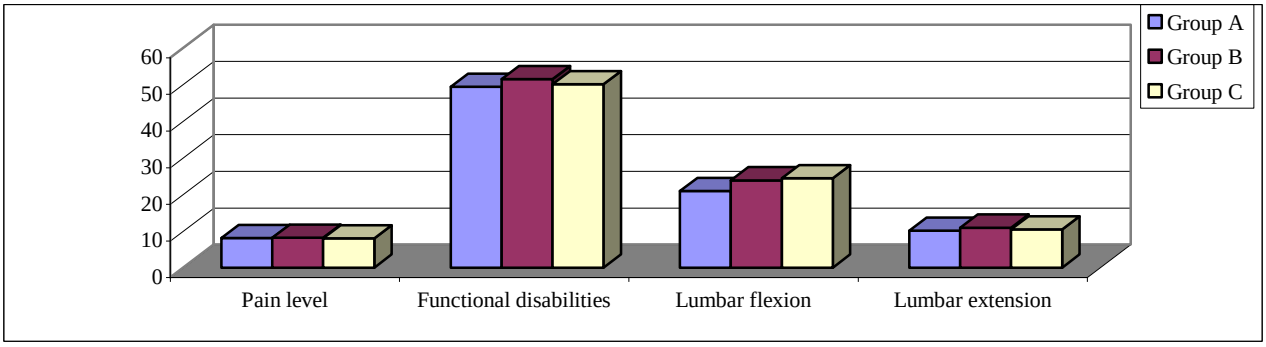

Fig. (2): Results of ANOVA test for pain level, function level and ROM between the three groups before treatment.

Differences in pain level, function level and ROM after treatment between the three groups:

The results of the ANOVA test between the four groups revealed that there were significant differences in range of motion, pain level, and functional level after treatment as shown in table (3) and figure (3).

Table (3): Results of ANOVA test for pain, function level and ROM (flexion-extension) between the three groups after treatment.

		A	B	C	F	P	Sig
Pain		7.1±1.52	1.8±0.78	3.3±1.05	55.05	0.00	HS
Function		41.9±12.06	12.5±2.46	20.9±6.36	34.49	0.00	HS
ROM	Flex	22.8±4.96	35.7±2.45	31.3±3.91	28.05	0.00	HS
	Ext	12±2.21	17±1.33	14.4±1.71	19.54	0.00	HS

HS: High significant

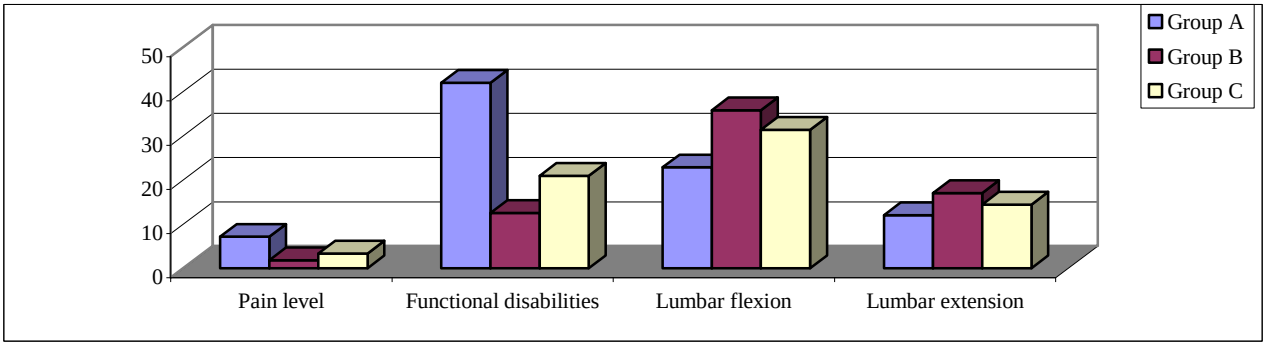

Fig. (3): Results of ANOVA test for pain level, function level and ROM between the three groups after treatment.

Post hoc tests were applied and the results were as follow:

1- Pain level

Pulsed magnetic field group was the best results and there was significant difference between the PMF group and TENS group and control group.

There was significant difference between TENS group and the control group.

2- Functional level

Pulsed magnetic field group was the best results and there was significant difference between the PMF group and TENS group and control group.

There was significant difference between TENS group and the control group.

3- Range of motion

Pulsed magnetic field group was the best results and there was significant difference between the PMF group and TENS group and control group.

There was significant difference between TENS group and the control group.

DISCUSSION

Within the limitations of this randomized controlled study, statistically significant difference were detected in the PMF group, TENS group and the control group in pain level (P was 0.000), functional disability (P was 0.000) and lumbar ROM of flexion (P was 0.00) and extension (P was 0.00). The results indicated that both PMF group and TENS show more improvement than the control group, and the PMF group show better improvement than the TENS group.

As LBD seems to be due to several structures within the lumbar spine that have been incriminated as possible source of it including the nerve roots, dura, the ligaments, external annular fibers of the disc, facet joints, joint capsules, muscles and fascia with the associated connective tissue and blood vessels. But no single structure was reported as the most common source of pain. Those tissues contain nociceptors that are the main potential source of pain. The activation of nociceptors occurs by mechanical and chemical stimuli that postulate the pain to the CNS. Muscular pain can occur with acute muscle strain or secondary to underlying entity such as disc lesion or injury to apophysial joint[30,32]. Many life style activities and specific work related tasks could predispose to structural component changes of the joints and soft tissues, that is accompanied with the occurrence of back pain and affect the performance of human being[23]. In the presence of pressure on nerve fibers, inflammation and/or pain, the afferent input

changes. This will result in muscle weakness, spasms, loss of co-ordination and reduced proprioception. Additionally, efferent firing from the peripheral sympathetic nervous system can change muscle tone as well as blood flow. Finally, cognitive factors such as emotion and fear-avoidance behavior will influence peripheral muscle tension. Taken together, the functional stability of the system may be compromised leading to excessive stiffness. Therefore, pain and inflammation creates suboptimal biomechanics which lead to further dysfunction[12].

So the analgesic effect of PMF therapy could be attributed to one of the following mechanisms:

First, the physiologic mechanisms of pain relief due to application of magnetic field may be due to the presynaptic inhibition or decreased the excitability of pain fibers[15].

Second, the molecular mechanism of the effect of magnetic field may involve conformational changes in the ion channels or neuronal membrane[33].

Third, evidence exists that pulsed magnetic field can modulate the actions of hormones, antibodies and neurotransmitters surface receptor sites of a variety of cell types[1].

The results come in agreement with Trock et al., (1993)[36], Jacobson et al., (2001)[17] and Hinman, (2002)[15] who revealed significant pain relief after application of PMF to the patients of CLBP.

Regarding to the TENS group there was significant reduction of pain level after treatment more than the control group but less than the PMF group.

The strong low rate TENS that provide a low frequency (less than 10 Hz), wide pulse width (300-400 μsec) and high intensity produce strong visible muscle contractions in the segmentally related myotomes[9]. This mode of stimulation provides a definite prolonged after-effect of pain relief, which seems to relate to the long onset. One distinct problem with this mode is that in some cases it is not well tolerated by the patient in the area of pain. Its analgesic effect may be blocked with the intravenous naloxone hydrochloride. This analgesic effect was attributed to the beta-endorphin release[22].

So, the significant reduction of pain level might be due to the effect of TENS on paravertebral muscles and nerves of the back which reduced muscle tension and relieved the compression on muscles nociceptors and on nerve roots and broke the vicious circle.

These results about the effect of TENS were in agreement with previous reported studies by Gadsby et al., (2000)[13] who proved that there was an evidence that TENS reduces pain and improves range of motion in chronic back pain patients, at least in the short term.

Regarding the lumbar ROM, the results obtained in the current study showed that there was significant increase of lumbar flexion and extension after treatment for the three groups. The results indicated that the PMF group and TENS group show more improvement than the control group and the PMF group show better improvement than the TENS group.

For the group (B) the improvement in the lumbar ROM by the application of PMF could be attributed to the positive analgesic effect, anti inflammatory effect and reduction of muscle spasm so improve lumbar mobility and range of motion[36].

In the current study, PMF appeared to be effective in improvement of lumbar ROM. This occurred because the spine mobility was affected in LBD patients as a result of pain avoidance behavior which caused the muscles and ligaments not to be used to their ultimate limits or full ROM. If the limited lumbar ROM was maintained for a long period of time, the

ROM would actually decrease as the soft tissues shorten and strength decrease especially lumber flexion as result of shortening of the back and hamstring muscles[2,24,34].

These results can be explained by the work of (Van Nguen et al., 2002)[37] who found that PMF decreases joint and muscle pain, decreases joint swelling and stiffness and improve soft tissue repair so increase mobility and quality of life.

These results come in agreement with (Hinman, 2002)[15], who reported that the application of magnetic field to the musculoskeletal problems can reduce pain, inflammation and enhance the movement.

Regarding the patients in group (C) who received TENS, there was improvement in the lumbar ROM but less than that of the group (B) who received PMF therapy, this may be due to that TENS can mainly decrease the pain level which will improve the mobility which may be in a short term.

This was supported by Gadsby, et al., (2000)[13], who concluded that there was an evidence that TENS reduces pain and improves range of motion in chronic back pain patients, at least in the short term.

Regarding the functional activities, the results obtained in the current study showed that there was significant decrease of functional disabilities after treatment for the three groups. The results indicated that the PMF group and TENS group show more improvement than the control group and the PMF group show better improvement than the TENS group.

For the PMF group, the improvement in functional ability could be attributed to the positive anti inflammatory and analgesic effects of the PMF which lead to decrease pain and inflammation and hence improve functions.

These results can be explained by the work of (Jacobson, et al., 2001)[17], who stated that the effects of magnetic field extend to the structures in the deep levels such as connective tissue, muscles and organs, so producing less inflammation, improve circulation, diminution of pain and hence improve function.

Regarding the patients in group (C) who received TENS, there was improvement in the functional ability but less than that of the group (B) who received PMF therapy.

This might occurred because the functional activities in LBD patients are greatly influenced due to painful limited mobility of the spine and lack of strength and motor control which guarding the patients during performance of the functional activities as sitting, standing and walking which are markedly influenced. The patient's functional activities improved as the pain decreased and the lumbar ROM increased[19,11].

These results are in agreement with (Peter and Jarzem, 2005)[28], who stated that TENS therapy significantly reduces pain and improves performance on the majority of standardized tests of physical capacity.

These results are contradicted with the results of a meta analysis done by (Brossaeu et al., 2002)[6] who find no statistically significant difference between the active TENS group compared with the placebo TENS group for any outcome measure in patients with CLBP, but this can be explained by the small sample size and the difference of TENS parameters between this study and the meta analysis.

For the control group the significant difference before and after treatment might be due to the influence of stretching exercise which leads to increase muscle flexibility so minimize shortening, decrease pain and increase range of motion which maintained by strengthening exercise leading to more practice and activities that patient can do

through daily living activities so improve functional performance.

The significant difference between the PMF group and TENS group may be related to the different mechanisms of action and the different effects of the PMF on the living cells and tissues which include vasodilatation, analgesic action, anti-inflammatory action, spasmolytical activity, healing acceleration and antioedematous activity. This also may be due to that the biological effects of the magnetic field on biological systems include several structural levels; subatomic, atomic, molecular, sub cellular, cellular, tissue, organs and whole system[17].

The potential limitation to this study is the small number of subjects in each group in the study. For confirming the results, large randomized controlled trials are needed.

Conclusions

Pulsed magnetic field proved to be more beneficial and had the upper hand on low frequency transcutaneous electrical nerve stimulation in improving range of motion, functional performance and perceived back pain in patients with chronic mechanical low back pain.

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الملخص العربي

المجال المغناطيسي المتقطع مقابل التيار المنبه للعصب عبر الجلد منخفض التردد في علاج الم أسفل الظهر الميكانيكي المزمن

يهدف هذا البحث إلى دراسة ومقارنة تأثير المجال المغناطيسي المتقطع و التيار المنبه للعصب عبر الجلد منخفض التردد في حالات الم أسفل الظهر الميكانيكي المزمن وتم استخدام جهاز البروم لقياس المدى الحركي للفقرات القطنية، بالإضافة إلى ميزان لقياس الوزن والطول. و تم استخدام المقياس البصري لقياس شدة الألم و مؤشر العجز الأوسويسترى لقياس الأداء الوظيفي . وقد أجريت هذه الدراسة بكلية العلاج الطبيعي خلال المدة من مارس إلى يوليو 2007 م . شارك في هذه الدراسة ثلاثون مريضا من مرضى الم أسفل الظهر الميكانيكي المزمن من كلا الجنسين تراوحت أعمارهم من 53 إلى 50 سنة ، تم تقسيمهم إلى 3 مجموعات ، 10 مرضى في كل مجموعة . أعطيت المجموعة الأولى (المجموعة الضابطة) الموجات فوق الصوتية بجانب برنامج تمارين تقليدي في شكل تمارين إطالة وتمارين تقوية لعضلات الظهر والبطن ، وأعطيت المجموعة الثانية المجال المغناطيسي المتقطع بجانب برنامج المجموعة الضابطة و أعطيت المجموعة الثالثة التيار المنبه للعصب عبر الجلد منخفض التردد بجانب برنامج المجموعة الضابطة ، وتم العلاج ثلاث مرات أسبوعيا لمدة أربعة أسابيع وتم قياس المدى الحركي ، مستوى الألم والأداء الوظيفي قبل وبعد العلاج . كانت أهم النتائج التي تم استخلاصها وجود اختلافات ذات دلالة إحصائية في المدى الحركي ، مستوى الألم والأداء الوظيفي قبل وبعد العلاج بين الأشخاص في المجموعات الثلاث قبل وبعد العلاج ووجود اختلافات ذات دلالة إحصائية في المدى الحركي ، مستوى الألم والأداء الوظيفي بين المجموعات الثلاث بعد العلاج لصالح المجموعة المستخدم فيها المجال المغناطيسي المتقطع عن بقية المجموعات مع وجود اختلافات ذات دلالة إحصائية بين مجموعة التيار المنبه للعصب عبر الجلد منخفض التردد والمجموعة الضابطة .