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Original Article

UTILIZATION OF PULSED ELECTROMAGNETIC FIELD AND TRADITIONAL PHYSIOTHERAPY IN KNEE OSTEOARTHRITIS MANAGEMENT

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ABSTRACT

Background and Objectives: Pulsed Electromagnetic Field (PEMF) has been suggested as a treatment method for musculoskeletal system disorders. The present study was conducted to determine whether the addition of PEMF to traditional physical program produces better clinical outcomes than traditional physical program alone in the management of moderate knee osteoarthritis (OA).
Design: A single-blinded, randomized controlled study
Methods: Twenty subjects (5 men and 15 women) with unilateral moderate knee OA (Kellgren-Lawrence criteria grade 2). They were randomly allocated in 2 groups to receive: group (A) PEMF plus ultrasound plus exercises; or (B) ultrasound plus exercises. Both groups received the respective treatments 3 times per week for 4 weeks and underwent the same pretreatment and post treatment evaluation that included active knee range of motion (ROM) by universal goniometer, knee pain score by visual analogue scale (VAS) and knee functional performance by Western Ontario and McMaster Universities osteoarthritis index (WOMAC).
Result: There was an improvement in both groups in active knee flexion ROM, reduced VAS score and improved WOMAC index , however, all outcomes were significantly better in group (A) ($p < 0.05$). Moreover, the percentages of outcomes improvement were in favor of group (A).
Conclusion: The addition of PEMF to traditional physical program in managing OA produced a greater improvement in pain relief, range of motion and resulted in better functional performance than did traditional physical program alone. The improvement in current study should be limited to short term outcomes of PEMF.
KEY WORDS: Knee osteoarthritis, Pulsed electromagnetic field, Traditional physiotherapy.

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INTRODUCTION

Degenerative osteoarthritis (OA) is the most common joint disease that is caused by biomechanical stresses affecting the articular cartilage and subchondral bone of the joint [1]. The degenerative OA is the most common form of arthritis and is a major cause of morbidity, limitation of activity and health care utilization, especially in elderly patients [2].

Knee OA occurs in approximately 10% of individuals over 65 years of age and may affect up to 2% of the adult population with greater incidence, prevalence and severity in women than in men [3, 4]. The physical disability arising from knee OA prevents the performance of daily life activities and negatively affects life quality. Several causes lead to the occurrence of physical disability. These include pain, joint movement restriction, muscle weakness and coordination [5].

Pain associated with OA of the knee is the most common complain of patients suffering from OA. The chronicity of the disorder often leads to muscle weakness, joint stiffness or instability and reduced physical function with subsequent losses in functional independence and health related quality of life [6].

Current recommendations for managing OA focus on relieving pain and stiffness and maintaining or improving physical function as important goals of therapy. Both pharmacologic and nonpharmacologic management are focusing on controlling pain and reducing functional limitation [2].

Patients with arthritis are more likely to be identified as 'disabled' compared to those with other chronic conditions. They may experience psychological symptoms, including anxiety, depression and helplessness. It has been reported that 10% of people with OA are depressed, and that psychological symptoms exacerbate pain and disability [7].

Pulsed electromagnetic field (PEMF) is relatively a newly born option for treating selected pathological conditions [8]. PEMF can penetrate through highly resistance structures such as bone, fat, skin or even plaster cast. PEMF provide a practical exogenous method for cell and tissues modification [9]. PEMF control pain in certain neurological conditions, diabetic neuropathy, multiple sclerosis and arthritic conditions [10].

PEMF has been suggested as a treatment method for musculoskeletal system disorders. Electromagnetic field causes biological changes to the cell environment and restores its integrity and function. In addition to that, it increases membrane potentials of erythrocytes, increases oxygen content of tissue, vasodilates blood vessels and relieves pain without increasing local temperature. PEMF was effective in reducing pain and edema after soft tissue injury [11].

Among the treatments available, PEMF is a controversial treatment modality. However, PEMF have been used with increasing frequency over the prior two decades [12]. Furthermore, numerous randomized trials revealed the potential of PEMF to improve OA symptoms were published [13]. The European League against Rheumatism (EULAR) recommendations considered PEMF as a good treatment option for knee OA [14].

The pharmacological modalities are effective in reducing pain and inflammation, but their long-term use is associated with a high incidence of side effects or may not be applicable to some patients [15]. Based on these findings, alternative therapies for this pathological condition might be helpful. PEMF therapy has proved to be safe and has also shown promising therapeutic effectiveness on bone- and cartilage-related pathologies, including knee and cervical spine [16, 17].

This study was conducted to clarify whether The PEMF together with traditional physiotherapy might help patients with knee OA to improve their functional performance, knee flexion range of motion (ROM) and reduce pain encountered with the disease or not.

MATERIAL AND METHODS

Subjects: Twenty subjects (5 men and 15 women, their age ranged 45- 55 years; BMI was < 30 kg/m2 with unilateral moderate knee OA participated in this study. The diagnosis and grading of knee OA was made by an orthopedic surgeon and according to Kellgren and Lawrence system for classification of knee OA [18]. Subjects were included if they had experienced knee pain, stiffness and difficulty in stair climbing, walking and cross legged sitting. Subjects were excluded if they had a history of recent trauma to the knee, acute signs of inflammation over the knee, other knee pathology, were taking analgesic or anti-inflammatory drugs, had metal implants, or had a cardiac pacemaker.

Design of the study: This single-blinded, randomized controlled study was conducted in outpatient clinic of physical therapy faculty, Cairo University and was approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University. All subjects were requested to sign a written informed consent before starting the study. The subjects were randomly allocated into one of the following 2 groups: (A) PEMF plus ultrasound (US) plus exercises. (n = 10); or (B) exercises plus US (n = 10).

Evaluation procedures: Each subject underwent the same evaluation that was performed by the same therapist at the beginning and at the end of the study period (4 weeks). All subjects were asked to maintain their activity levels during the period of the study [19].

1. Measurement of active Knee flexion ROM: While the subject was lying supine on an examination couch, Active knee flexion ROM was measured with a large plastic universal goniometer with 25cm arms (the fulcrum was the lateral epicondyle of the femur, the fixed arm placed over a line extending between greater trochanter and lateral epicondyle of the femur, the movable arm placed over the long axis of the fibula and the goniometer arms were fixed with straps) (Figure 1) [20]. The subject maintained maximum flexion of knee joint with the hip flexion. Concomitant hip flexion prevented premature limitation of knee motion from possible rectus femoris shortening. The degrees of maximum flexion, maximum extension and extension deficits when presented they all were recorded. The angle between maximum flexion and maximum extension was described as the excursion range. The range was measured 3 times and the mean value was [21].

Fig.1: Measurement of knee flexion.

2. Measurement of Pain Severity: The intensity of knee pain was evaluated by the visual analogue scale (VAS) after patients had remained in a weight-bearing state for 5 minutes (walking or standing**)** [21].

3. Measurement of the limitation of functional performance: Each patient's disability was evaluated with the Western Ontario and McMaster Universities osteoarthritis index (WOMAC).

Treatment procedures: Group (A) received PEMF and all treatment groups (A and B) received a standard set of stretching and strengthening exercises and US. A pulsed electromagnetic field device (ASA Easy terza series, Italy) was used to provide an electromagnetic field to the connected applicators /solenoids. The pulse frequencies were 50 HZ for the solenoids and up to 100 HZ for the applicators. The PEMF device was placed on a trolley of a suitable height near to the plinth to be easily accessible to the operator and avoid unduly stretching of the flexes during treatment. The device was routinely inspected to ensure effective treatment. The solenoid encircled the target limb at the level of the affected knee. Each patient was exposed to low intensity 15 GPMF (Gauss per magnetic field) with frequency 50Hz for 30 minutes/ session, 3 times per week for 4 weeks [22].

An ultrasound device (ITO, US-100, Japan) was used to provide a deep heating treatment. The skin was coated with an acoustic neutral gel. US waves were then applied to the knee by the same therapist. The stroking transducer head was applied to the therapy region at a right angle and in a circular manner. Continuous US waves with 1 MHz frequency and 1 watt/cm^2 power were applied with a 4 cm^2 diameter applicator. US therapy lasted 5 minutes /session, 3 times per week for 4 weeks [23].

Immediately after PEMF plus US application in group (A) and US application in group (B), subjects in both groups were asked to perform stretching exercises and strengthening exercises in the following fixed sequence: hamstrings muscle stretching, calf muscle stretching. The physical therapist repeated the stretches 3 times/session .Each stretch was sustained for 30 sec, with 10 sec rest between each stretch [24]. After a rest of 5 min, the subjects in both groups were asked to do (1) isometric quadriceps contraction in full knee extension with holding for 5 sec followed by 5 sec rest (subjects were in long sitting position on floor with back supported and legs extended, with rolled up towel under one knee and subjects were asked to contract quadriceps by pushing into the ûoor against towel), the exercise was performed for 20 repetitions /session [25]. (2) Straight leg raising exercise (The patients were positioned in crock lying position with the unexercised limb was the flexed one then the patient was asked to contract the quadriceps muscle and elevate the limb to 45^0 and hold for 6 sec, slowly lower the limb and then relax for 6 sec), the exercise was performed for 3 sets of 10 repetitions/session [24]. Both stretching and strengthening exercises were performed 3 sessions per week for 4 weeks.

Data analysis: Statistical analyses were performed using the software package SPSS for Windows, version 20. Non parametric tests were applied for not normally distributed data. Pre-treatment and post-treatment knee flexion ROM, pain intensity and patient's disability values were compared within each group with a Wilcoxon signed rank test. Comparisons of knee flexion ROM, pain intensity and patient's disability values were made by Mann Whitney-U test between the two therapy groups. A chi square (X^2) statistic was used to investigate whether sex variable differs in both groups. The level of significance (alpha) was set at 0.05.

RESULTS AND TABLES

None of the subjects in any of the treatment groups dropped out throughout the study period. There was no significant difference ($p > 0.05$) between the 2 groups as regards demographic data as well as ratio of sex (Table 1).

No significant difference ($p > 0.05$) was found among all of the outcome measures (knee flexion ROM, pain intensity (VAS) and functional performance (WOMAC) at the pre-treatment condition, while there was an improvement in active knee flexion ROM, functional performance (WOMAC) values and reduced pain scores (VAS) in both groups at the post-treatment condition ($p < 0.05$) (Tables 2, 3 and 4). The percentage of improvement of active knee flexion ROM in group (A) was 10.8%, and in group (B) was 2.5%.

Table 1: Demographic data for the subjects in the 2 groups (mean ±SD).

	Group (A) (n=10)	Group (B) (n=10)
Age (years)	47.1(±2.51)	48.9 (±1.91)
Weight (Kg)	81.7(±6.25)	83.05 (±7.72)
Height (cm)	165.8 (±6.69)	167.3 (±7.51)
Sex F/M	7/3	8/2

There is no significant difference shown in between-group (p>0.05)
SD: standard deviation; F: female; M: male.

Table 2: Average group mean (±SD) of the active knee flexion ROM.

	Groups: (A) (n = 10)	Groups: (B) (n = 10)	p-value (between group)
Pre-treatment	118.5(±3.97)	118.1(±5.34)	0.88
Post-treatment	131.3(±2.9)	121.1(±5.23)	0.0001
p-value (within-group)	0.0001	0.0001	

There is no significant difference shown in between-group in pre-treatment. There is significant difference shown in between-group in post-treatment Overall within-group difference is there. SD: standard deviation.

Table 3: Average group mean (±SD) of pain intensity (VAS).

	Groups: (A) (n = 10)	Groups: (B) (n = 10)	p-value (between group)
Pre-treatment	6.0 (±1.24)	5.7(±1.49)	0.71
Post-treatment	1.1 (±0.87)	4.0(±1.49)	0.0001
p-value (within-group)	0.0001	0.0001	

There is no significant difference shown in between-group in pre-treatment. There is significant difference shown in between-group in post-treatment. Overall within-group difference is there.
SD: standard deviation.

Table 4: Average group mean (±SD) of functional performance (WOMAC).

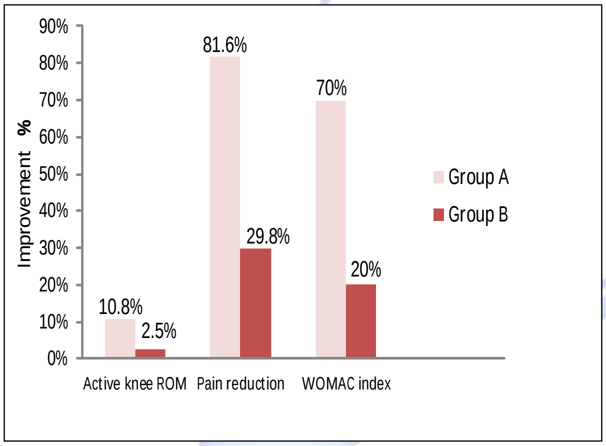
	Groups: (A) (n = 10)	Groups: (B) (n = 10)	p-value (between group)
Pre-treatment	41.2 (±3.25)	41.9(±6.83)	0.89
Post-treatment	12.2 (±3.42)	33,2(±6.52)	0.0001
p-value (within-group)	0.0001	0.0001	

There is no significant difference shown in between-group in pre-treatment. There is significant difference shown in between-group in post-treatment. Overall within-group difference is there.
SD: standard deviation.

The percentage of reduction of pain scores (VAS) in group (A) was 81.6%, and in group (B) was 29.8%. The percentage of improvement of functional performance (WOMAC) in group (A) was 70%, and in group (B) was 20 % (Fig. 2).

Improved active knee flexion ROM, reduced pain scores (VAS) and improved functional performance (WOMAC) were, however, significantly better in the group (A) ($p < 0.05$).

Fig.2: The percentage of outcomes improvement I both groups.



DISCUSSION

OA is one of the most prevalent articular disorders affecting humankind and a major cause of disability and socioeconomic burden [26]. However**,** the treatment of knee OA is currently limited to the management of symptoms rather than reducing disease progression [27]. Analgesic and anti-inflammatory drugs are widely used in management, despite known serious adverse effects associated with long term use and doubts about their efficacy [28]. Based on these foundations, PEMF therapy has proved to be safe and has effectiveness on bone- and cartilage-related pathologies.

This study aimed to investigate the effect of PEMF with intensity of 15 Gauss and frequency of 50Hz for 30 minutes/ sessions 3 times per week for 4 weeks on pain intensity, ROM and functional performance in patients with knee OA.

The present study showed that there was a significant improvement in the both group A (PEMF plus traditional treatment) and group B (traditional treatment) pre and post treatment for knee flexion ROM, limitation of functional performance and pain intensity. Significant difference was observed when comparing the post treatment results of the two groups in the favor of the group A. These findings were in line with the findings of the research work that was done by Pawluk [22] who investigated the effect of PEMF at 5 to 15 G, from 70 Hz to 40 kHz and was used at the site of pain and related trigger points for 20 to 45 minutes, he found that some patients remain pain free 6 months after treatment. He explained that short term effects were due to decrease in cortisol and noradrenalin and an increase serotonin, endorphins and enkephalins. While, longer term effects in the present study was not recorded.

Improvement fulfilled in the study group A might be attributed to the effect of the piezoelectric signal of PEMF that normally stimulates chondrocyte activity by creating a streaming potential in the extracellular matrix when bone is subjected to pressure. Although the transmission of this signal is impaired in OA, Pfeiffer [29] suggested that PEMF can reproduce this streaming potential in affected joints under no load. Non-invasive treatments are devoid of any adverse side effects. Long term follow up confirms sustained pain relief, improved mobility, and a high safety profile. This explanation could be also supported by various studies (animal models of arthritis, cell culture systems and clinical trials) reporting the use of PEMF for arthritis cure, they have shown that PEMF not only alleviates the pain in the arthritis condition but it also affords chondro-protection, exerts anti-inflammatory action and helps in bone remodeling and this could be developed as a viable alternative for arthritis therapy [30].

The reduction of pain intensity was better in group A that was treated by PEMF plus traditional treatment than group B that was treated by traditional treatment at the end of treatment. This result come in agreement with others who postulated that magnetic therapy has become one of the most rapidly emerging alternative therapies where magnets have been promoted for their analgesic and energizing effects with no side effects unlike drugs [31]. The analgesic effect of pulsed electromagnetic field therapy could be attributed to the physiologic mechanisms of pain relief, which may be due to presynaptic inhibition, or decreased excitability of pain fibers [32].

Moreover, PEMF can modulate the actions of hormones, antibodies and neurotransmitters surface receptor sites of a variety of cell types. This may cause changes in the transfer rate of electrons during the electron exchange between single molecules that may either slow down or accelerate chemical reaction [12].

Similarly, pain reduction by PEMF results from the membrane to be lowered to a hyper-polarization level of about (-90 mV) and so it blocks the pain signal transmission. Magnetic field also influence ATP production; increases the supply of oxygen and nutrients via the vascular system; improves the removal of waste metabolites via the lymphatic system and help to rebalance the distribution of ions across the cell membrane thus reducing pain; reducing muscle spasm [33].

The results of our study come in agreement with Ryang and his colleagues [34] who investigated the effect of (PEMF) on the management of knee OA as compared with a placebo. Fourteen trials were analyzed, comprising 482 patients in the treatment group and 448 patients in the placebo group. Highly significant effects were observed on pain level when trials employing high-quality methodology were analyzed, PEMF was significantly more effective at 4 and 8 weeks than the placebo. A significant improvement in function was observed 8 weeks after the treatment initiation while in the present study it was observed after 4 weeks. The results of this study provided suggestive evidence supporting PEMF efficacy in the management of knee OA.

The results of knee flexion ROM obtained in the current study showed that there was a significant increase of knee flexion ROM after treatment for both groups in favor of group (A). These results come in consistent with Diniz and his collogues who explained that this occurred because the knee mobility was affected in Knee OA 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. Improvement in stiffness level of PEMF group might be due to enhanced blood circulation in the periarticular compartment, to activate synthesis of nitric oxide which mayenhance blood flow

These results were supported by Jari and his colleagues [32] who reported that the application of magnetic field to the musculoskeletal problems can reduce pain, inflammation and enhance movement.

Other study assessed the efficacy of PEMF therapy on patients with knee OA in a randomized, placebo-controlled, double-blind study of six weeks duration. 75 patients were randomized to receive active PEMF treatment by unipolar magnetic devices versus placebo. The primary outcome measure was reduction in overall pain assessed on a four-point Likert scale. Secondary outcome measures showed significant improvements in the actively treated group in the WOMAC score and EuroQol score at study end compared to baseline. In contrast, there were no improvements in any variable in the placebo-treated group. These results suggested that the magnetic field was beneficial in reducing pain and disability in patients with knee OA resistant to conventional treatment in the absence of any side-effects[36].

The present study could explain that, based on both the significant pain reduction and the increased knee flexion ROM that were observed in group A the functional performance was consequently improved significantly in group A compared with group B.

The improvement in all outcome measures in this study comes in consistent with findings from Fischer [37] who showed improvement in knee OA patients that treated with low-frequency PEMF therapy for 6 weeks. Patients had an increase in mobility and distance of walking. Moreover, long-term analgesic and functional effects were observed at 4 weeks after the end of treatment.

CONCLUSION

From this study, it could be concluded that both traditional physiotherapy and PEMF with traditional physiotherapy are effective in improving knee OA symptoms with a favor for using PEMF in addition to traditional physio-therapy. Also the results should be limited to short term outcomes of PEMF.

Abbreviations

ROM - Range Of Motion.
PEMF - Pulsed Electomagnetic Field.
VAS - Visual Analogue Scale.
OA - Osteoarthritis.
WOMAC - Western Ontario and McMaster Universities.
EULAR - European League against Rheumatism.
US - Ultrasound.
X^2 - Chi square.

Conflicts of interest: None

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