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Efficacy of pulsed electromagnetic field on hemarthrotic knee in haemophilic adolescence

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ABSTRACT

Background: Haemophilia is a hereditary coagulopathy disease affecting males. It is characterized by musculoskeletal bleeding, leading to chronic synovitis and severe joint hemarthrosis. Objective: To determine the impact of pulsed electro- magnetic field on swelling, range of motion and muscle strength of hemarthrotic knee joints of haemophilic adolescents. Participants and Methodology: Thirty haemophilic adolescent males ranging in age between thirteen and sixteen years who fulfilled the inclusion criteria participated in this study. They were assigned randomly into two groups of equal numbers A (control) and B (study). Groups A and B received a specific program of physical therapy for sixty minutes, in addition, group A received a placebo pulsed electromagnetic field for twenty minutes, while group B received pulsed electromagnetic field for twenty minutes. The treatment program was applied three days/week for three successive months. Evaluation of knee swelling using tape measurement, range of motion using electronic goniometer and muscle strength using isokinetic dynamometer was conducted for each patient of groups A and B before and after treatment. Results: Significant improvement was observed in the post-treatment mean values of the measuring variables of groups A and B when compared with their pre-treatment results ($p < .05$). High significant improvement was observed in group B when comparing the post-treatment results of groups, A and B ($p < .05$). Conclusions: Pulsed electromagnetic field is an effective modality which can be used with the traditional methods for treatment of knee hemarthrosis in haemophilic adolescents.
Keywords: Haemophilia; Hemarthrosis; Pulsed electromagnetic field.

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INTRODUCTION

Haemophilia is considered a hereditary sex recessive genetic disorder which guard against the body's ability to clot blood (Srivastava et al., 2013). It includes two types; haemophilia A which occurs due to deficit of factor FVIII (clotting protein) and haemophilia B which is called IX haemophilia or Christmas disease. Haemophilia is classified into; severe which accounts more than 1%, moderate from 1 to 5%, and mild less than 5% (Santos, 2011). The most common type is haemophilia A (Lissauer and Clayden, 2007).

This disease is characterized by hemarthrosis which is a haemorrhage in the muscles and joints of the musculo-skeletal system including knees, ankles and elbows (Gringeri et al., 2014 and Gomis et al., 2009). Haemorrhage in the muscle or joints accounts for 80% to 90% of all bleeding episodes in people with haemophilia (Balkan et al., 2005). Knees are the most commonly affected joints in non-prophylaxis patients accounting for (45%) which is thought to be due to the large size of the synovial membrane and large rotational forces present. It is followed by the elbows (30%), ankles (15%), shoulders (3%), and wrists (2%). Before the clinical signs appear, Bleeding is best detected by the patients themselves as bruising and swelling or described as a feeling of warmth or tingling within the joint (Knobe and Berntorp, 2011).

In individuals with severe haemophilia, the first occurrence of hemarthrosis ordinarily occurs by around the age of 2 years (Knobe and Berntorp, 2011). If not treated adequately, these individuals will develop haemophilic arthropathy by the age of 20 years (Blanchette et al., 2004).

Physiotherapy should be initiated as soon as the patient can tolerate it. For subacute hemarthroses, 6–8 weeks of physiotherapy is recommended (Rodriguez-Merchan et al., 2008). Physiotherapy and rehabilitation in haemophilic patients with knee hemarthrosis should be done daily to improve muscle strength as well as joint mobility, obtain the optimal functional levels and improve the patients' quality of life (Carcao et al., 2015). The rehabilitation program should be patient-specific and include electrotherapy (Gomis et al., 2009), stretching, strengthening, balance, proprioception and aerobic exercises to increase physical fitness (Alhaosawi, 2014).

Pulsed electromagnetic field (PEMF) is an effective therapeutic modality which can be used in pain management, ulcers and bone healing, treatment of osteoarthritis and inflammatory diseases of the musculoskeletal system (Quittan et al., 2004), as it increases the anti-inflammatory effect (Vincenzi et al., 2013).

So, the current study was conducted to determine the impact of PEMF on swelling, range of motion and muscle strength of the affected knee joints in subjects with haemophilia accompanied by hemarthrosis.

METHOD

Participants

Thirty haemophilic type A adolescent boys, ranging in age from 13-16 years, they were assigned in two equal groups; control A and study B groups, each contained 15 patients. group A (control) received a specific program of physical therapy for 60 minutes and a placebo treatment using PEMF for 20 minutes, whereas group B (study) received the physical therapy program given to the control group for 60 minutes and PEMF therapy for 20 minutes, Patients were selected from the Out-Patient Clinic of the Faculty of Physical Therapy at Delta University for Science and Technology and Haematology Clinics in Mansoura, Damietta, and Port-Said by an announcements to participate in this study. Patients of group A and B received the same pharmacological treatment and met the following criteria: diagnosed as type A haemophilia (moderate) with one time per week bleeding and were free from any skeletal deformities or bone fractures, and patients who had surgical procedures conducted 6 weeks before the study were excluded.

Randomization

Thirty-three haemophilic patients were assessed for eligibility. one of them did not meet the inclusion criteria, and two refused to participate in the study. The final remaining participants were then randomized into two groups of equal number (A and B) using closed envelopes by an independent investigator, Figure 1.

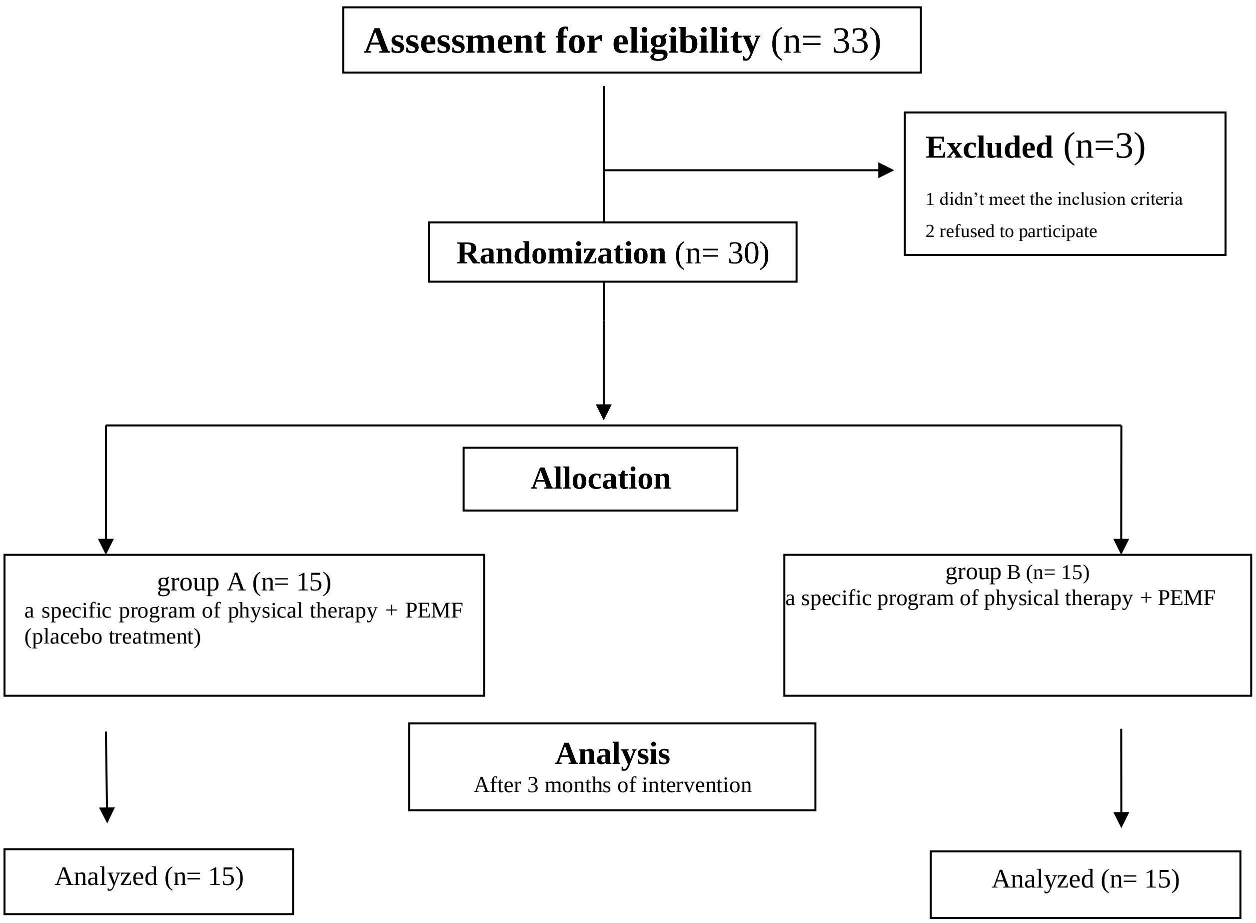

Figure 1. Flow chart demonstrating the sample participated in the study.

Outcome measures

Knee swelling, knee flexion and extension range of motion and Isokinetic measurements of knee. All outcome measures were recorded before and after treatment (after 3 months).

Procedures and instrumentation

- A height and weight scale (SH-8024) was used to measure the patient's height and weight.
- Tape was used to measure the knee circumference in centimetre to determine the degree of knee swelling.
- Electronic goniometer was used to assess knee flexion and extension range of motion.

- Iso Med 2000 isokinetic dynamometer: was used to assess muscular strength of the quadriceps and hamstring muscles which was calibrated before every test session. Previous studies have demonstrated the reliability and validity of isokinetic devices for measuring muscle strength in adults as well as in children (Dirnberger et al., 2012). Concentric peak torque and power of flexors and extensors muscles of the affected knee joint were measured during concentric mode at angular velocity 60 deg/sec.
- Pulsed electromagnetic field device with a frequency from 0, 5 to 100 Hz
- (Automatic PMT Quattro pro).

All procedures for evaluation and treatment were explained to all patients and their parents, who signed a consent form.

For evaluation

- The degree of swelling was determined using tape at midpoint of the patella and above its upper border (Mcrae, 1989).
- Active range of the knee flexion and extension were measured using electronic goniometer.
- Muscle strength: using an isokinetic dynamometer, knee strength testing started after system calibration and stabilization, participants were positioned with hip angle of 95◦ (Baltzopoulos, 2007). Each participant was asked to do a testing set with practice repetitions to warm-up and habituate the procedures. Then, a rest period for 30 sec was given. The first testing set measured peak concentric knee extensor (KE) torque followed by two-minute rest period then the second testing set started to assess the peak concentric knee flexor (KF) torques. All tests were performed at angular velocity speed of 60◦/s for 5 repetitions (Wilk, 1990).

For treatment

Physical therapy program

The patients in both groups received a specific program of physical therapy; those in group A (control) received the program for 60 min. in addition to placebo treatment with PEMF for 20 min. whereas patients in group B (study) received the same program for 60 min in addition to 20 min of PEMF. The specific program of physical therapy was conducted for 3 days/week on non-consecutive days and included the following items with clear instructions to the patients: cold packs, isometric, passive ROM and isotonic exercises were given in addition to proprioception, and stretching exercises were applied (Eid and Aly, 2015).

Pulsed electromagnetic field

Any metal objects were removed before starting treatment. From a comfortable supine position, the solenoid of the magnetic field apparatus was adjusted over both knee joints. The parameters of the apparatus were adjusted for a frequency of 15 Hz, intensity of 20 gauss. The treatment was applied for 20 minutes, 3 times/week for three successive months (Trock, 1993).

Sample size

To avoid a type II error, a preliminary power analysis [power (1 − error p) = 0.8, = 0.05, effect size = 0.984] determined a sample size of 14 for each group in the study. The effect size was calculated in accordance with a pilot study involving 10 participants (4 in the study group and 6 in the control group), with the consideration of knee effusion as a primary outcome.

RESULTS, ANALYSIS AND DISCUSSIONS

A total of 30 patients participated in this study, they were randomly distributed into 2 groups of equal number (15 patients/group). The pre-treatment mean values revealed no significant differences in age, weight, height, and BMI between control group and study group (Table 1).

Table 1. Comparison mean values of demographic data between two groups.

Variables	Groups (Mean ± SD)		t-value	*p-value*
	Group A (n = 15)	Group B (n = 15)		
Age (Year)	14.44 ± 0.76	14.46 ± 1.01	0.065	*.949*
Weight (kg)	52.24 ± 1.93	52.47 ± 4.50	0.180	*.858*
Height (cm)	163.71 ± 2.91	162.63 ± 4.46	0.782	*.441*
BMI (kg/m²)	*19.49 ± 0.80*	*19.84 ± 1.33*	*0.806*	*.427*

Note. Data are expressed as mean ± standard deviation (SD) and compared by using independent-t test (t-test). p-value: probability value. p-value > .05: non-significant.

Multivariate tests by MANOVA for outcome measures (Table 2) presented a statistically significant ($p < .05$) effects due to main effects of tested groups (F = 3.356; $p = .002$; Partial $\eta^2 = 0.472$), measuring time (F = 16.116; $p = .0001$; Partial $\eta^2 = 0.811$), and group x time interaction (F = 3.195; $p = .002$; Partial $\eta^2 = 0.460$).

Table 2. Main effects of independent variables by MANOVA test for all dependent measuring variables.

Source of variation	Wilk's Lambada value	Partial Eta² (η²)	F-value	*p-value*
Tested groups effect	0.528	0.472	3.356	*.002**
Measuring period effect	0.189	0.811	16.116	*.0001**
Interaction effect	*0.540*	*0.460*	*3.195*	*.002**

*Note. p-value: probability value. * Significant (p-value < .05).*

Comparing the pre-treatment mean values of circumference measurements of groups A and B showed no significant difference ($p > .05$). Significant difference was observed when comparing the pre and post treatment mean values of each group. However high significant difference was observed in group B when comparing the post treatment mean values of groups A and B ($p < .05$). Table 3.

Comparing the pre-treatment mean values of range of knee motion of groups A and B showed no significant difference ($p > .05$). Significant difference was observed when comparing the pre and post treatment mean values of each group. However high significant difference was observed in group B when comparing the post treatment mean values of groups A and B ($p < .05$). Table 4.

Comparing the pre-treatment mean values of knee isokinetic measurements of groups A and B showed no significant difference ($p > .05$). Significant difference was observed when comparing the pre and post treatment mean values of each group. However high significant difference was observed in group B when comparing the post treatment mean values of groups A and B ($p < .05$). Table 5.

Table 3. The 2 x 2 mixed design MANOVA for circumference measuring variables within and between two groups.

Variables			**Circumference measurements (Mean ± SD)**		**F-value**	***p*-value**
			Group A (n = 15)	Group B (n = 15)		
Right knee	Mid patella	Pre-treatment	31.00 ± 3.89	30.98 ± 3.88	0.000	.990
		Post-treatment	28.20 ± 3.81	25.03 ± 3.39	5.789	.023*
		Change	2.80	5.95		
		Improvement %	9.03%	19.21%		
		F-value	3.957	19.988		
		p-value	.043*	.0001*		
	Above patella	Pre-treatment	31.83 ± 4.03	31.48 ± 3.99	0.056	.814
		Post-treatment	28.95 ± 3.95	26.85 ± 3.67	5.823	.018*
		Change	2.88	4.63		
		Improvement %	9.04%	14.71%		
		F-value	3.888	10.922		
		p-value	.045*	.003*		
Left knee	Mid patella	Pre-treatment	30.67 ± 3.50	30.56 ± 3.49	0.008	.930
		Post-treatment	28.70 ± 4.02	25.40 ± 3.55	5.664	.024*
		Change	1.97	5.16		
		Improvement %	6.42%	16.88%		
		F-value	5.489	16.048		
		p-value	.030*	.0001*		
	Above patella	Pre-treatment	31.47 ± 4.04	31.38 ± 4.03	0.004	.952
		Post-treatment	28.10 ± 3.79	26.48 ± 3.57	6.713	.015*
		Change	3.37	4.90		
		Improvement %	10.71%	15.62%		
		F-value	5.539	12.403		
		p-value	.026*	.001*		

*Note. Data are expressed as mean ± standard deviation (SD) and compared by using MANOVA test (F-test). p-value: probability value. * Significant (p-value < .05). p-value > .05: non-significant.*

Table 4. The 2 x 2 mixed design MANOVA for range of motion measuring variables within and between two groups.

Variables			**Range of motion measurements (Mean ± SD)**		**F-value**	***p*-value**
			Group A (n = 15)	Group B (n = 15)		
Right knee	Extension	Pre-treatment	2.32 ± 0.51	2.25 ± 0.48	0.163	.690
		Post-treatment	1.79 ± 0.49	1.11 ± 0.53	12.670	.001*
		Change	0.53	1.14		
		Improvement %	22.85%	50.67%		
		F-value	8.433	36.576		
		p-value	.007*	.0001*		
	Flexion	Pre-treatment	126.00 ± 5.03	127.20 ± 4.44	0.479	.494
		Post-treatment	130.87 ± 5.21	132.53 ± 1.80	11.224	.002*
		Change	4.87	5.33		

		Improvement %	3.86%	4.19%		
		F-value	6.792	18.543		
		p-value	0.015*	0.0001*		
Left knee	Extension	Pre-treatment	2.27 ± 0.51	2.25 ± 0.40	0.010	.923
		Post-treatment	1.45 ± 0.40	1.03 ± 0.67	4.214	.050*
		Change	0.82	1.22		
		Improvement %	36.12%	54.22%		
		F-value	23.554	35.719		
		p-value	.0001*	.0001*		
	Flexion	Pre-treatment	125.89 ± 4.91	127.26 ± 4.58	0.628	.435
		Post-treatment	128.04 ± 7.02	132.87 ± 1.59	13.589	.001*
		Change	2.15	5.61		
		Improvement %	1.71%	4.41%		
		F-value	6.683	19.916		
		p-value	.021*	.0001*		

*Note. Data are expressed as mean ± standard deviation (SD) and compared by using MANOVA test (F-test). p-value: probability value. * Significant (p-value < .05). p-value > .05: non-significant.*

Table 5. The 2 x 2 mixed design MANOVA for isokinetic right knee measuring variables within and between two groups.

Variables		**Isokinetic right knee measurements (Mean ± SD)**		**F-value**	***p*-value**
		Group A (n = 15)	Group B (n = 15)		
Peak torque values of knee flexors (60 degree/sec.)	Pre-treatment	25.33 ± 8.37	25.80 ± 8.39	0.025	.877
	Post-treatment	30.34 ± 10.05	37.16 ± 7.87	11.032	.004*
	Change	5.01	11.36		
	Improvement %	19.62%	44.03%		
	F-value	5.462	14.597		
	p-value	.025*	.001*		
Peak torque values of knee extensors (60 degree/sec.)	Pre-treatment	35.11 ± 9.00	35.19 ± 8.02	0.001	.978
	Post-treatment	39.67 ± 8.54	43.02 ± 8.84	10.996	.002*
	Change	4.56	7.83		
	Improvement %	12.99%	22.25%		
	F-value	6.201	6.443		
	p-value	.019*	.017*		

*Note. Data are expressed as mean ± standard deviation (SD) and compared by using MANOVA test (F-test) p-value: probability value. * Significant (p-value < .05). p-value > .05: non-significant.*

The present study investigated the effects of PEMF on swelling, ROM and muscle strength of the knee joints in haemophilic adolescents. Statistical analysis revealed significant improvement in all measured variables of group B in which PEMF was conducted.

These findings supported with other reports revealed that PEMF has positive effects and so it is highly recommended for treatment of knee hemarthrosis in haemophilic adolescents. Accordingly, PEMF may be considered an effective modality in improving physical fitness via increasing range of knee joint movement, minimizing pain and swelling (Parhampour et al., 2014) and (Tiktinsky et al. 2010).

Table 6. The 2 x 2 mixed design MANOVA for isokinetic left knee measuring variables within and between two groups.

Variables		**Isokinetic left knee measurements (Mean ± SD)**		**F-value**	***p*-value**
		Group A (n = 15)	Group B (n = 15)		
Peak torque values of knee flexors (60 degree/sec.)	Pre-treatment	25.41 ± 8.79	25.54 ± 8.33	0.002	.965
	Post-treatment	44.06 ± 5.34	47.93 ± 5.95	3.505	.048*
	Change	18.65	22.39		
	Improvement %	73.40%	87.67%		
	F-value	49.260	71.618		
	p-value	.0001*	.0001*		
Peak torque values of knee extensors (60 degree/sec.)	Pre-treatment	34.99 ± 8.49	35.65 ± 7.93	0.048	.828
	Post-treatment	38.98 ± 10.17	42.47 ± 9.26	7.223	.012*
	Change	3.99	6.82		
	Improvement %	11.40%	19.13%		
	F-value	3.853	4.697		
	p-value	.042*	.039*		

*Note. Data are expressed as mean ± standard deviation (SD) and compared by using MANOVA test (F-test). p-value: probability value. * Significant (p-value < .05). p-value > .05: non-significant.*

Significant improvement observed in group B could be due to the effect of PEMF, which enhanced microcirculation, facilitated water reabsorption, accelerated hematoma resolution and decreased the number of circulating neutrophils leading to reduction of edema (Bassett, 2002) and inflammation (Ramasamy et al., 2008).

Markov and Colbert, 2000, confirm the findings of our study. They reported that electromagnetic field is a safe non-invasive method for treating pain, reducing inflammation and dysfunction. Hinman et al., 2002, also concluded that, the application of magnetic field over painful knee joints reduced pain and enhanced functional movements.

Improvement of the range of knee joints could be due to the anti-inflammatory, analgesic effects of PEMF which lead to decrease pain and swelling in the knee joints (Segal et al., 1999). Ryczko and Persinger, 2002 measured pain threshold of rates hot skin surface; before, 30 and 60 minutes after exposure to PEMF and reported an increase in pain threshold due to the analgesic effect.

Improvement of knee muscles strength may be attributed to the effect of PEMF which extended to the connective tissues and muscles decreasing inflammation, improving circulation, diminishing pain and so, improving performance (Jacobson et al., 2001). In addition, PEMF could improve joint function and integrity by the maintenance of its bony surface and cartilage repair (Trock et al., 2000).

Limitations

This limitations for this study such as the small sample which might limit the generalization of the results, the age of the patients who participated in this study was limited to adolescent so, further studies are needed for different ages groups, follow up was needed to determine the long-term effect of PEMF.

Ethical approval

This study was performed in accordance with the code of ethics of the world medical association (Declaration of Helsinki) for experiments involving humans. In addition, acceptance of the ethical committee of the Cairo University was taken.

Informed consent

A consent form was obtained from patients and their parents prior to participation.

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