Effect of Pulsed Magnetic Field on Lean Muscle Mass and Fat Mass In Juvenile Rheumatoid Arthritis

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Abstract: Background: The severity of joint pain and joint stiffness and their effects on walking variables especially in children who have juvenile rheumatoid arthritis (JRA) are serious and represent functional problems. So, the aim of this study was to investigate the effect of pulsed magnetic field (PMF) on lean muscle mass and fat mass in children with juvenile rheumatoid arthritis. **Methods:** Thirty children with polyarticular JRA were included in this study. Fifteen children represent control group who treated with therapeutic exercises only and fifteen children represent study group who treated with pulsed magnetic field and therapeutic exercises. Lean muscle mass and fat mass were determined before and after six months of treatment. **Results:** The current Study showed significant changes in both lean muscle mass and fat mass in study group compared with control group. Pre-treatment results of mean lean muscle mass was 23975.2± 8152.21 g. in control group and 24016.26 ± 7864.39 g. in study group. There was no significant difference between both groups which indicate that they were homogenous (p = 0.98). But post-treatment results showed that mean lean muscle mass was 27143.26 ± 8223.52 g. in control group while that of study group was 35755.46 ± 7106.45 g. which was significantly higher than the control group (p = 0.05). Also, pre-treatment results of mean fat mass were 10742.13 ± 5466 g. in control group and 12358.53 ± 6210.27 g. in study group. There was no significant difference between both groups which indicate that they were homogenous (p = 0.45). But post-treatment results showed that mean fat mass was 10008.26 ± 5110.66 g. in control group while that of study group was 6265 ± 3957.92 g. which was statistically significant than the control group (p = 0.03). **Conclusion:** Pulsed magnetic field together with therapeutic exercises are effective in increasing lean muscle mass and decreasing fat mass in children with polyarticular JRA than therapeutic exercises alone.

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1. Introduction:

Juvenile rheumatoid arthritis (JRA) is one of the most common pediatric rheumatic diseases, with peak age at 4 and 10 years.[1] It is a heterogeneous group of unknown etiology, each of which has specific clinical features and prognostic implications.[2] It is one of the major causes of short and long-term disability among the pediatric age group with chronic pediatric diseases, and growth impairment is one of the complications, especially in polyarticular and systemic JRA.[3,4] Clinically pain, inflammation, morning stiffness and functional inactivity are seen to be the major moderating factors in the ability to cope with the disease. Growth retardation and decreased final height can be the product of the disease itself or a side effect of treatment, most commonly corticosteroids.[5] Children with JRA usually suffer from pain, tiredness, and stiffness. So they are less active than their peers. Reduced mobility may lead to systemic muscle weakness, decreased flexibility, cardiovascular reserves and exercise capacity.[6] Muscle weakness and atrophy are most severe near inflamed joints, but may also occur in distant areas and persist long after remission of the arthritis. Contributing factors include alterations in anabolic hormones, production of inflammatory cytokines and high resting energy metabolism, abnormal protein metabolism, motor unit inhibition from pain and swelling and disuse. Common patterns include weakness in hip extension and abduction, knee extension, planter flexion, shoulder abduction and flexion, elbow flexion and extension, wrist extension, and hand grip. Muscle weakness may contribute to activity restrictions that may result in decreased endurance.[7] Some evidence reports that prepubertal children with JRA are physically less active when compared with healthy children. There was less daily physical activity in children with JRA than for healthy age– and sex-matched control subjects, and they participate in strenuous activities less significantly than their healthy peers.[8] Low physical activity levels may be as important as excess energy intake that may result in increased body fat mass.[9] There is also evidence of increased inflammatory cytokine production and increased inflammation in skeletal muscles in obesity.[10] Dual energy x-ray absorptiometry (DEXA) is the most common method for assessing bone mineral density(BMD), lean muscle mass and fat mass in children and must take into consideration age, height, weight and sexual maturity rating.[11] Pulsed electromagnetic field is a physical therapy modality which has been used widely in the management of

nerve paralysis, migraine, carpal tunnel syndrome, low back pain, ulcers, bed sores, itching skin disease, chronic osteomyelitis, retarded healing, osteoporosis, frozen shoulder, aseptic necrosis, tennis elbow, calcaneal spur, arthritis, tinnitus, sinusitis, trigeminal pain and other conditions.[12,13] 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 correcting selected pathological states.[14] Magnetic fields were applied to promote bone healing, treat osteoarthritis and inflammatory diseases of the musculoskeletal system, alleviate pain and enhance healing of ulcers. This demonstrates how much magnetic field is beneficial for the field of physical therapy.[15]

2. Material and Methods

2.1. Patients

Thirty children with polyarticular JRA ranged in age from 12 to 16 years were enrolled in this study. They were selected from Rheumatology Clinic of Cairo University Specialized Pediatric Hospital" in Cairo, Egypt. The diagnosis and classification of JRA were based on the 1977 American College of Rheumatology (ACR) criteria.[16] Inclusion criteria for the study were presence of arthritis in five or more joints during first 6 months of disease, symmetry of arthritis however, degree of involvement was varied, cardinal hallmark signs and symptoms of joints involvement in JRA that generally were marked by pain, swelling and morning stiffness and children who are free from severe tightness or any skeletal abnormality. Exclusion criteria were patients with systemic or oligoarthritis onset, patients who have congenital or acquired skeletal deformities, patients who have any cardiopulmonary dysfunctions, patients with advanced radiographic changes including: bone destruction, bony ankylosis, knee joint subluxation, epiphyseal fractures and growth abnormalities related to marked skeletal changes of JRA. Children were assigned randomly into two groups of equal number, (control group and study group). Both groups were assessed for detecting amount of muscle mass and fat mass by using dual energy x-ray absorptiomertry (DEXA). The assessment was done before and after six successive months of application a designed treatment program. A selected physical therapy protocol was established for both groups that included (stretching exercises, strengthening exercises, bicycle ergometer and treadmill training). Control group consisted of 15 children that were treated by the selected physical therapy program only (stretching exercises, strengthening exercises, bicycle ergometer and treadmill training). While study group consisted of 15 children that were treated by the same exercise program that was given to the control group in addition to low frequency and low intensity pulsed magnetic therapy. The options of the appliance was adjusted with very low frequency (15 HZ), very low intensity (20 G) and for (20) minutes per session for six successive months.[17]

2.2. Data collection

The main outcome measures of this study were lean muscle mass and fat mass that were collected before and after six successive months of application a designed treatment program. Patient characteristics considered as explanatory measures were age, gender, weight, and height. The data were collected to compare between pre-treatment differences of the two groups, pre and post treatment differences of the same group and post treatment differences of the two groups.

2.3. Statistical analysis

The collected raw data of the current study was statistically treated to analyze the results of lean muscle mass and fat mass for all children of both groups to study the effect of low frequency and low intensity pulsed magnetic field and therapeutic exercises on lean muscle mass and fat mass in juvenile rheumatoid arthritis. The age, gender, weight, and height are expressed as mean ± standard deviation. Statistical analysis was conducted through SPSS (version 19). T test was conducted for comparison between pre and post treatment mean values of fat mass and lean muscle mass between control and study groups. Paired T test was conducted for comparison between pre and post treatment mean values of fat mass and lean muscle mass in each group.

3. Results

3.1. Demographic and patient characteristics

The demographic and patient characteristics are described in table 1. There were 15 (50%) patients in study group and also 15 (50%) patients in control group.

Table 1. Demographic and patient characteristics

	Study group	Control group
No. of patients	15 (50%)	15 (50%)
Gender, male/female	7/8	7/8
Age (yr.)	13.07±1.85	12.93±1.33
Weight (kg.)	34.2±11.3	38.7±11.8
Height (cm.)	139.5±11.0	143.7±14.5

3. 2. Lean muscle mass

I- Within group comparison:

The mean values ± SD of lean muscle mass of control group before treatment was 23975.2 ± 8152.21 g. while after treatment was 27143.26 ± 8223.52 g. The mean difference was -3168.06 g. There was a significant difference between pre and post treatment in lean muscle mass in the control group (p = 0.01). The mean values of lean muscle mass of study group before treatment was 24016.26 ± 7864.39 g. while after treatment was 35755.46 ± 7106.45 g. The mean difference was -11739.2 g. There was a significant difference between pre and post treatment in lean muscle mass in the study group (p = 0.0001). (Table 2).

Table (2): **Paired t test for comparison between pre and post treatment mean values of lean muscle mass for control and study groups:**

Item	Lean muscle mass (gm.) $\overline{X}$ ±SD		MD	t- value	*p*-value	sig
	Pre	Post				
Control	23975.2 ± 8152.21	27143.26 ± 8223.52	-3168.06	-2.69	0.01	**S**
Study	24016.26 ± 7864.39	35755.46 ± 7106.45	-11739.2	-9.81	0.0001	**S**

II: Between group comparison:

The mean values of lean muscle mass before treatment of control group was 23975.2 ± 8152.21 g. while that of study group was 24016.26 ± 7864.39 g. There was no significant difference between control and study groups in lean muscle mass pre-treatment which indicate that they were homogenous (p = 0.98). The mean values of lean muscle mass after treatment of control group was 27143.26 ± 8223.52 g. while that of study group was 35755.46 ± 7106.45 g. There was a significant improvement in lean muscle mass of the study group compared to control group (p = 0.005). (Table 3).

Table (3): **T test for comparison between pre and post treatment mean values of lean muscle mass for control and study groups:**

Item	Lean muscle mass (gm.) $\overline{X}$ ±SD		MD	t- value	*p*-value	sig
	Control	Study				
Pre	23975.2 ± 8152.21	24016.26 ± 7864.39	-41.06	-0.01	0.98	**NS**
Post	27143.26 ± 8223.52	35755.46 ± 7106.45	-8612.2	-3.06	0.005	**S**

3.3. Fat mass

I- Within group comparison:

The mean values ± SD of fat mass of control group before treatment was 10742.13 ± 5466 g. while after treatment was 10008.26 ± 5110.66 gm. The mean difference was 733.86 gm. There was a significant difference between pre and post treatment in fat mass in the control group (p = 0.02). The mean values of fat mass of study group before treatment was 12358.53 ± 6210.27 gm. while after treatment was 6265 ± 3957.92 gm. The mean difference was 6093.53 gm. There was a significant difference between pre and post treatment in fat mass in the study group (p = 0.0001). (Table 4).

Table (4) Paired t test for comparison between pre and post treatment mean values of fat mass for control and study groups:

Item	Fat mass (gm.) $\overline{X}$ ±SD		MD	t- value	*p*-value	sig
	Pre	Post				
Control	10742.13 ± 5466	10008.26 ± 5110.66	733.86	2.57	0.02	**S**
Study	12358.53 ± 6210.27	6265 ± 3957.92	6093.53	7.9	0.0001	**S**

II: Between group comparison:

The mean values of fat mass before treatment of control group was 10742.13 ± 5466 gm. while that of study group was 12358.53 ± 6210.27 gm. There was no significant difference between control and study groups in fat mass pre-treatment (p = 0.45). The mean values of fat mass after treatment of control group was 10008.26 ± 5110.66 gm. while that of study group was 6265 ± 3957.92 gm. There was a significant reduction in fat mass of the study group compared to control group (p = 0.03). (Table 5).

Table (5): **T test for comparison between pre and post treatment mean values of fat mass for control and study groups:**

Item	Fat mass (gm) $\overline{X}$ ±SD		MD	t- value	*p*-value	sig
	Control	Study				
Pre	10742.13 ± 5466	12358.53 ± 6210.27	1616.4	-0.75	0.45	**NS**
Post	10008.26 ± 5110.66	6265 ± 3957.92	3743.26	2.24	0.03	**S**

4. Discussion

In this study, all patients in both groups had hallmark signs and symptoms of joints involved in JRA that generally is marked by swelling, stiffness, excruciating pain that result in decreased physical activity which in turn leads to muscle weakness.[22]

Regarding to sex distribution, females were represented more than males in both groups and this going in agreement with studies which reported that the polyarticular JRA occurs more frequently in females.[23] The weights of children who participated in this study were under the normal average weight of healthy children at the same age period, this may be due to loss of appetite and anemia which are common in children with polyarticular JRA and this comes in accordance with studies which reported that children with polyarticular JRA have low weight gain as a result of fever, anorexia, loss of appetite and anemia. Also, he added that growth failure is related to a number of factors including inadequate caloric intake, increased catabolic demands from active disease and systemic corticosteroid therapy.[11]

Children with JRA commonly experience acute and chronic pain, decreased mobility and joint stiffness leading to restrictions on activities and isolation from their peers.[18] This restriction in physical activity may leads to systemic muscle weakness and wasting, decreased cardiovascular reserves and exercise capacity.[6] Physical activity is essential for the social, emotional, and cognitive development of children and adolescents with JRA.[19] It is demonstrated that physical activity is a main determinant of health in children, and this is of particular importance in young patients with chronic diseases to prevent the development of comorbidities such as cardiovascular diseases.[20,21]

From this point of view, this push us to study this aspect in JRA by studying the effect of pulsed magnetic field on increasing physical activity in those children and hence increasing lean muscle mass and decreasing fat mass as a result of increasing activity. The results of the present study showed statistically significant improvement in lean muscle mass within both groups post-treatment compared with pre-treatment results, but there is statistically significant improvement in study group compared with control group post-treatment.

The improvement in lean muscle mass in control group may be attributed to exercise therapy in the form of passive stretching, strengthening exercises and dynamic exercises and this comes in accordance with studies that revealed that exercise therapy can increase joint range of motion, endurance, muscle strength, and coordination and can improve joint stability. Exercises may be prescribed for specific joints or muscles or for part of a program to maintain or improve overall cardiovascular fitness and endurance. [24] Also, Strengthening exercises play an important role in increasing muscle mass in children with JRA and this result is supported by Minor and Westby, 2005 who reported that Strengthening exercises are very beneficial for the muscles surrounding and supporting the joints with arthritis and adjacent areas. During acute joint inflammation, isometric exercise is recommended to maintain muscle bulk and strength. Resistance can be provided manually or by a stable external object or heavy elastic bands placed around the limb close to and proximal to the joint. Prolonged maximal isometric contractions should be avoided because they may increase intra-articular pressure and constrict blood flow through the muscles. The child is taught to perform and hold a submaximal contraction for approximately 6 seconds, exhaling during the contraction and inhaling during the relaxation phase. Five to ten repetitions are sufficient.[25]

Decreased physical activity was considered one of the main causes that can develop decreased lean muscle mass in children with JRA. Physical activity was decreased in those children as a result of pain, inflammation and morning stiffness.[26] As the improvement in lean muscle mass in study group was statistically higher than that in control group, this can be attributed to the analgesic effect of pulsed magnetic field (PMF) through its influence on cell behaviour and this comes in accordance with recent studies that approved that extremely low frequency magnetic field (ELF-MF) can change cell behaviours and activations by affecting the biochemical and/or biophysical processes. Chemical and physical processes at the atomic levels are the bases of reactions between biomolecules in an electromagnetic field, since the field can magnetically affect chemical bonds between adjacent atoms with consequent production of free radicals.[27,28,29] Also, this improvement can be attributed to the influence of PMF on skeletal muscles. Recently,

Lambert *et al.* [30] reported that skeletal muscles represent the most important metabolically active mass of the body and play a major role in the regulation of lipid and glucose metabolism. Therefore, skeletal muscles may be sensitive to magnetic field exposure. Metabolic response is highly dependent on oxidative and glycolytic muscle fiber type with sensitivity to external stimuli related to muscle typology. Magnetic field enhance skeletal muscle differentiation.[31] and accelerates Ca^{2+} / calmodulin-dependent myosin light-chain phosphorylation.[32] Moreover, magnetic fields alter ion transporters[33] and seem to affect muscle microcirculation.[34] Finally, magnetic field is widely used in therapeutics for musculoskeletal pain relief.[35]

The present study showed that PMF increase physical activity and thus increasing lean muscle mass in study group compared with control group and this can be attributed to its analgesic effect. This results 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.[36] 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.[37] Other postulation is magnetic field influences the small C-fibers and produces a reversible blockade of sodium-dependent action potential firing and calcium dependent response to the irritant.[26,38] Shupak *et al.,* [13] found that the analgesic effect of PEMF could be attributed to the neuropathic pain arising from firing of unmyelinated C fibers with accumulation of sodium and calcium channels because PEMF safely induce extremely low frequency current that can depolarize, repolarize neurons. It was hypothesized that this energy could potentially modulate neuropathic pain. Pulsed electromagnetic field 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.[39] Other explanation for pain improvement is that PEMF causes the membrane to be lowered to a hyper-polarization level of about (-90 mV) 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 and reducing muscle spasm.[40] In addition to analgesic effect, the PEMF has positive anti-inflammatory which leads to decrease pain and improve function.[41]

Also, increased lean muscle mass in study group rather than in control group as a result of application of PMF may be due to its influence on inflammation as an anti-inflammatory effect that synovitis and the inflammatory process are significantly suppressed by application of magnetic field.[42] Also the experimentally induced inflammation and edema were significantly inhibited by exposure to magnetic field. pulsed magnetic field was used to treat soft tissue inflammation. The anti-inflammatory effect of pulsed magnetic field was due to their magnetic field action, independent of any heat produced by the fields themselves, probably by altering the cell membrane potential and influencing ionic fluxes. Inflammatory edema and hematoma formation were decreased by PMF treatment and microcirculation was significantly enhanced.[43,44] PMF was used to reduce edema and improve microcirculation, possibly by facilitating water reabsorption. Magnetic field exposure inhibits inflammatory edema, accelerates hematoma resolution, enhances microcirculation and decreases the number of circulating neutrophils.[45] Also, the physiological mechanism by which magnetic field affect joint swelling that, the magnetic waves pass through the tissues and induce secondary currents, which produce impacting heats thus reducing pain and swelling.[46]

The results of the present study showed that there was a significant reduction in fat mass in both groups. But the reduction in the study group was higher than the reduction in the control group and this can be attributed to increased physical activity and lean muscle mass in study group compared with control group. This result comes in agreement with studies that approved the analgesic and anti-inflammatory effect of PMF which result in increased physical and functional activities which in turn leads to decreased fat mass. Regular exercise and physical activity is the main cause to improve body composition and cardiovascular fitness. Body fat percent, body mass index, water cells, muscle mass are factors which are influenced by exercise. Recent investigations have been shown that there are close relationship between the body composition factors and cardiovascular and aerobic fitness.[47]

In summary, it can be concluded from this research that the group that are treated with pulsed magnetic field and therapeutic exercises has much higher improvement in lean muscle mass than the group that are treated with therapeutic exercises only. Also, the group that are treated with pulsed magnetic field together with therapeutic exercises has much higher reduction in fat mass than the group that are treated with therapeutic exercises only. This indicates that pulsed magnetic field is effective in increasing physical activity and improve functions which in turn result in increasing lean muscle mass and decreasing fat mass in children with JRA than therapeutic exercises alone.

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