Combined Effect of Electromagnetic Field and Therapeutic Exercises on Muscle Mass in Juvenile Rheumatoid Arthritis

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Abstract: Background/Purpose: The aim of the study was to investigate the combined effect of electromagnetic field and therapeutic exercises on lean muscle mass in children with juvenile rheumatoid arthritis (JRA). **Methods:** Thirty children with polyarticular JRA were included in this study. Fifteen children represent study group and treated with electromagnetic field and therapeutic exercises and fifteen children represent control group and treated with therapeutic exercises only. Lean muscle mass was determined before and after six months of treatment. **Results:** Pre-treatment results of both groups indicate that mean lean muscle mass was 23975.2± 8152.21 gm. (mean ± SD) in control group and 24016.26 ± 7864.39 gm.in study group. There was no significant difference between both groups which indicate they were homogenous ($p = 0.98$). But post-treatment results showed that mean lean muscle mass was 24143.26 ± 8416.94 gm. in control group while that of study group was 27488.8 ± 7543.39 gm. which was significantly higher than the control group ($p = 0.26$). **Conclusion:** We conclude that treatment with electromagnetic field together with therapeutic exercises are effective in increasing lean muscle 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 morbidity, and growth impairment is one of the complications, especially in polyarticular and systemic JRA.[3] 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.[4] 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.[5] 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.[6] Dual energy x-ray absorptiometry (DEXA) is the most common method for assessing bone mineral density(BMD) and muscle mass in children and must take into consideration age, height, weight and sexual maturity rating.[7] 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.[8] 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.[9]

2. Materials and Methods

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 King Khalid Hospital and Pediatric Hospital in Najran, KSA. The diagnosis and classification of JRA were based on the 1977 American College of Rheumatology (ACR) criteria.[10] 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 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.[11]

Data collection

The main outcome measure of this study was lean muscle mass that was 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.

Statistical analysis

The collected raw data of the current study was statistically treated to analyze the results of lean muscle mass for all children of both groups to study the combined effect of low frequency and low intensity pulsed magnetic field and therapeutic exercises on lean muscle mass in juvenile rheumatoid arthritis. Analysis was carried out using paired t-test. The age, gender, weight, and height are expressed as mean ± standard deviation.

3. Results

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

	Stud y group	Cont rol group
No. of patients	15 (50%)	15 (50%)
Gender, male/female	7/8	7/8
Age (yr)	13.0 7±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

I. Within group comparison:

The mean values ± SD of lean muscle mass of control group before treatment was 23975.2 ± 8152.21 gm while after treatment was 24143.26 ± 8416.94 gm. The mean difference was -168.06 gm. There was no significant difference between pre and post treatment in lean muscle mass in the control group (p = 0.50). The mean values ± SD of lean muscle mass of study group before treatment was 24016.26 ± 7864.39 gm while after treatment was 27488.8 ± 7543.39 gm. The mean difference was 3472.54 gm. There was a significant difference between pre and post treatment in lean muscle mass in the study group (p = 0.0001). (Table 2, figure 1).

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 Pre	Post	MD	t- value	p-value	sig
Control	23975.2 ± 8152.21	24143.26 ± 8416.94	-168.06	-0.68	0.50	NS
Study	24016.26 ± 7864.39	27488.8 ± 7543.39	3472.54	-5	0.0001	S

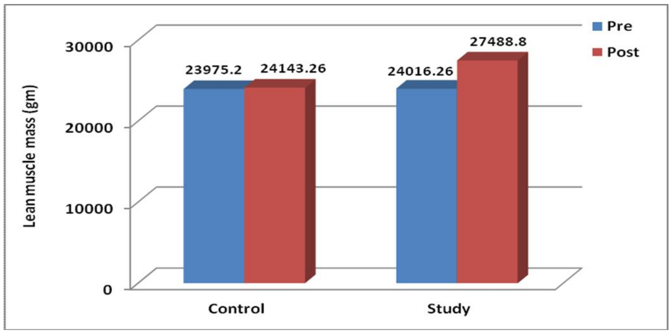

Figure (1): Pre and post treatment mean values of lean muscle mass in control and study groups.

II- Between group comparison:

The mean values ± SD of lean muscle mass before treatment of control group was 23975.2 ± 8152.21 gm while that of study group was 24016.26 ± 7864.39 gm. There was no significant difference between control and study groups in lean muscle mass pretreatment (p = 0.98). The mean values ± SD of lean muscle mass after treatment of control group was 24143.26 ± 8416.94 gm, while that of study group was 27488.8 ± 7543.39 gm. There was no significant difference between control and study groups in lean muscle mass post treatment (p = 0.26). (Table 3, figure 1)

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	24143.26 ± 8416.94	27488.8 ± 7543.39	-3345.54	-1.14	0.26	NS

4.Discussion

In our 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.[13] 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.[14] 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.[7] Generalized osteoporosis and fractures are major problems in children with JRA in which many factors such as, inflammation, long use of corticosteroid therapy, decreased calcium intake, hormonal disturbance and lack of physical activity can induce osteopenia and muscle weakness that increased the risk of fractures.[12] Regular physical activity decreases the possibility of fall and incidence of osteoporotic fracture as a result of improved muscle strength and flexibility. Also, it was reported that physical activity has a positive effect on increasing bone mineral density and the intensity of exercise measured by the level of acceleration of physical activity was significantly related to changes in bone mineral density which may help to keep safe life style.[15]

In our study, the improvement that occurred in control group can be attributed to exercise therapy in the form of passive stretching, strengthening exercises and dynamic exercises. 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. In rheumatoid arthritis, a hand exercise program may help maintain grip and pincer strength.[28] 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.[29] Dynamic exercise is added when joint inflammation subsides. Both concentric and eccentric exercises are included. Functional movement patterns can be incorporated into the training. External resistance, in the form of light hand or cuff weights or elastic bands, can be safely added once the child is able to correctly perform 8 to 10 repetitions of motions against gravity without pain.[30] Passive stretching is usually needed to regain lost ROM. Active exercises is required to rebuild muscle strength. Atrophy of the extensor muscles begins early, and active exercises must be instituted during the initial phases of the disease to maintain the strength of these muscle groups.[31] Aerobic exercise is also important to improve the child's endurance for routine physical activities and play. Recent studies for the benefits of aerobic exercise indicates that children with JRA who performed moderately vigorous (60% - 85% HR max) aerobic activity for at least 30 minutes twice a week for at least 6 weeks can improve their aerobic fitness.[32] A daily regimen of ROM exercises is necessary to preserve joint motion and soft tissue extensibility. All joints with arthritis and adjacent joints should be moved through the available range three to five repetitions preferably twice a day. Active ROM exercise is optimal, since it preserves muscle function as well as joint mobility. If the child is unable to perform active ROM, use active-assisted ROM to encourage the child to move through the full range. Passive ROM should be avoided if there is acute joint inflammation to prevent overstretching and trauma to vulnerable tissues.[4]

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.[16] So, the improvement in lean muscle mass in study group could be attributed to the combined effect of therapeutic exercises that result in increase in physical activity and PEMF exposure which plays an important role in subsiding signs and symptoms of JRA. It was also reported that magnetic field influences the small C fibers. Also, it was found that exposure to magnetic field produces a reversible blockade of sodium-dependent action potential firing and calcium-dependent responses to the irritant.[16,17] Another point of view explained that the physiological mechanism for pain relief due to application of magnetic field may be due to presynaptic inhibition or decreased excitability of pain fibers.[18] The effect of magnetic field extends to structures such as connective tissue, muscles and organs, thus producing decreased inflammation, improved circulation, diminution of pain and hence improved mobility of joints.[18,19] Application of magnetic field promote cellular and sub-cellular molecular effects within damaged cartilaginous and bony tissues. Pulsed magnetic field can stimulate both bone and cartilage cells, thus improving joint function and joint integrity due to improved bone and cartilage maintenance and repair.[20] Increased lean muscle mass in study group rather than in control group as a result of application of electromagnetic field may be due to its influence on pain.[11,18,19,22] there is significant pain relief due to application of magnetic field for patients with JRA. the analgesic effect of low frequency and low intensity pulsed magnetic field therapy that could be attributed to one of the following mechanisms: First, the physiologic mechanism for pain relief due to application of magnetic field may be due to presynaptic inhibition or decreased excitability of pain fibers.[18] Second, the molecular mechanism of the effect of magnetic field may involve conformational changes in the ion channels or neuronal membrane. Considering the time required for the effect on action potentials, multiple mechanisms must be acting simultaneously, possible including indirect effects, such as reduction in activity of channel phosphorylating enzymes.[22] Third, Evidence exists that pulsed magnetic fields can modulate the actions of hormones, anti-bodies and neurotransmitters at surface receptor sites of a variety of cell types.[23] Also increased lean muscle mass in study group rather than in control group as a result of application of electromagnetic field may be due to its influence on inflammation that synovitis and the inflammatory process are significantly suppressed by application of magnetic field.[24] 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.[19,25] 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.[26] 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.[27]

In conclusion, the group that are treated with therapeutic exercises and pulsed magnetic field has higher improvement than the group that are treated with therapeutic exercises only. This indicate that the combined effect of pulsed magnetic field and therapeutic exercises has much higher improvement on lean muscle mass in children with JRA than therapeutic exercises alone.

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