Middle-East Journal of Scientific Research 21 (10): 1848-1854, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.21.10.84168

Effect of Pulsed Low Frequency Magnetic Field on Balance and Ankle Function in Patients with Juvenile Rheumatoid Arthritis

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Abstract: *Background,* juvenile rheumatoid arthritis is a significant public health problem that frequently restricts patients' activity with a major impact on the ankle joint stability and function. Magnetic field is recently used treatment options for joint arthritis. The purpose of this study is to investigate the efficacy of pulsed magnetic field on stability of the ankle joint in children with juvenile rheumatoid arthritis. *Subjects*, 30 patients with juvenile rheumatoid arthritis (13boys, 17girls), aged from (8-12) years were randomly assigned into two groups: group A(control group) received conservative physical therapy program & group B (magnetic field group) received the same program in addition to pulsed magnetic field. The program was applied 3 times/week for eight weeks. The main outcomes were ankle joint stability [in the form of: overall stability index (OSI), medial/lateral stability index (MLSI), anterior/posterior stability index (APSI)], ankle joint Range of motion and foot functional disability. *Results*, Patients in magnetic field group showed a significant improvement in the ankle stability, range of motion and reduction in foot functional disability than patients in the control group. *Conclusion*, Pulsed magnetic field may be an effective in increasing ankle joint stability, range of motion and reducing foot disability in patients with juvenile rheumatoid arthritis.

Key words: Pulsed Magnetic Field · Balance · Ankle Function · Juvenile Rheumatoid Arthritis

INTRODUCTION

Juvenile idiopathic arthritis is a broad term that describes a clinically heterogeneous group of arthritides of unknown cause, which begin before 16 years of age. This term encompasses several disease categories, each of which has distinct methods of presentation, clinical signs and symptoms and, in some cases, genetic background. The cause of disease is still poorly understood but seems to be related to both genetic and environmental factors, which result in the heterogeneity of the illness [1].

Juvenile Idiopathic Arthritis (JIA) is the commonest rheumatic disease in childhood with a variable world wide prevalence ranging from 0.07 to 4.01 per 1000 children [2], while in the UK the prevalence is estimated at between 0.65 and 2.0 per 1000 children [3, 4] and a varying worldwide incidence between 0.07 and 4.01 per 1000 children [3, 4] Foot problems in JIA were previously thought to be common. It found that around 90% of the children with JIA presented with at least one foot problem from a range of structural and functional problems, such as synovitis, limited range of motion, malalignment and deformity [9].

Musculoskeletal arthritis is the second most commonpresenting symptom in JRA [5] and arthralgias can precede the arthritis [6, 7]. According to Behrens *et al*., 88% of children presented with arthritis [5]. In those cases where arthritis was not found initially, it typically appeared within a few months; infrequently the arthritis will not present until several years later [8]. In Behrens *et al.* [5]'s study, equal distribution between polyarticular and oligoarticular patterns was noted at presentation (41% polyarticular, 40% oligoarticular and

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7% monoarticular presentation). The wrists, knees and ankles are primarily the most commonly involved joints on initial presentation [5-8].

Foot problems have been reported as being common in JIA with 90% of children in a cross-sectional survey presenting with at least one foot problem associated with the disease process [9]. Foot and related problems attributable to JIA include synovitis, deformity, pain, stiffness, limited joint range of motion, enthesitis and bony erosions [9-10]. As such, many sufferers have a reduced capacity to function.These are considered relatively common in children with JRA and impact adversely on balance and gait [11].

Postural control is based on three distinct processes which develop through childhood: (1) a sensory organizational process, in which one or more of the orientation senses (visual, somatosensory and vestibular) are involved and integrated within the Central Nervous System (CNS) [12]; (2) a motor adjustment process, involved in executing coordinated and properly scaled sensorimotor responses [13]; and (3) an internal representation of body scheme that slowly matures during childhood [14], Both children and adults make use of visual, vestibular and proprioceptive information to control their body posture, but the respective contribution of these sensory inputs varies during ontogenesis [16].

Of the three sensory systems governing postural control, proprioceptive inputs are thought to have the greatest influence in the detection of body sway [8]. Indeed, many developmental studies reported the importance of the proprioceptive system for postural control in children [9].

Using immovable platform and visual surround, [15] reported that children younger than 7 years and 6 months could not avoid the influence of sensory inputs providing inappropriate orientation information [13]. showed with development a shift from a visual dependence to a more adult-like dependence with a combination of ankle joint and visual inputs for controlling posture when children were placed on a movable platform capable of antero-posterior displacements or dorsi-plantar flexing rotations of the ankle joint. This shift occurred around 4 to 6 years of age and reached theadult form in 7- to 10-years-old children. Specifically, these children seemed capable to resolve inter-sensory conflicts as adults do.

Treatment for foot and ankle disease in JIA has focused on the use of intra-articular cortico-steroid injections (ICIs), physiotherapy, orthoses and orthopaedic surgery as an adjunct to medical care to both resolve synovitis and tocorrect or maintain foot posture and function [17].

Pulsed electromagnetic fields (PEMFs) have been proved to be clinically used treatment modality for treating JRA. They are designed as a portable PEMF generator, which consists of electromagnetic fields with an on-off effect of pulsing. This produces athermal effect that suppresses inflammation, promotes tissue healing and relieves pain [18]. In vitro and in vivo studies have shown that pulsed electromagnetic fields (PEMFs) act as adenosine A2a agonists, leading to anincrease of Transforming Growth Factor β-1, thereby improving bone development, reducing cartilage damage and increasing chondrocyte proliferation [19-20]. These results clearly indicate improved regeneration of bone and possibly cartilage in a scientific setting.

Aim of the Study: To identify the effects of pulsed low frequency magnetic field on balance, ankle range of motion and foot functional disabilities inchildrenwith Juvenile Rheumatoid Arthritis.

Significance of the Study: Juvenile Rheumatoid Arthritis involves periodic inflammation of the synovium in joints of the hand, wrist, foot, knee orshoulder. This causes swelling of the joint capsule and irritation of nerve endings, producing pain and resulting indamage to both bone and cartilage. In turn this may lead to joint limitations and functional impairments that cause both disability and mortality. Few studies were done aiming to assess the impact of various manual and/or electrotherapeutic modalities effect on joint range, pain, balance and functional outcome in this population.

MATERIALS AND METHODS

Subjects: Thirty Juvenile Rheumatoid Arthritis children of both sexes from the Out patient Clinic of the Faculty of Physical Therapy, Cairo University and the National Institute of Neuromotor disorders were recruited to participate in this study their age ranged from 8-12 years. They were randomly assigned into two groups of equal numbers. Patients in group A (control group) received traditional physical therapy program for JRA, while patients in group B (study group) received the same program in addition to pulsed low frequency magnetic field on the ankle joint. This study was approved by the ethical committee of the Faculty of Physical Therapy, Cairo University.

Patients included in this study were diagnosed by a rheumatologist as having a polyarticuler RA. All patients should have fulfilled the American College of Rheumatology (ACR) criteria for polyarticular JRA.

Exclusion criteria included ankle surgery, intra-articular steroid injection, any neurological condition affecting lower limbs, use of assistive devices for walking, the presence of visual or hearing defects, lower extremity surgical interventions, or advanced radio graphical bony changes. All patients were required to refrain from seeking other forms of treatment during the study.

Instrumentation:

For Evaluation:

Universal Geniometer: It was used to measure ankle dorsiflexion (DF) and plantar flexion (PF).

The Biodex Balance System: (Biodex Medical System, ShirkyNy 11967) consists of a movable balance platform and is interfaced with a microprocessor based actuator connected to computer system was used to measure the static and dynamic balance parameters.

The Foot Function Index (FFI): It assesses multiple dimensions of foot function. The FFI consists of 23 items divided into 3 subscales that quantify the impact of foot pathology on pain, disability and activity limitation in patients with RA. The FFI has been widely used by clinicians and investigators to measure pain and disability in various foot and ankle disorders and its use has expanded to involve children, adults and older individuals. Furthermore, the FFI has been widely used in the study of various pathologies and treatments pertaining to foot and ankle problems such as congenital, acute and chronic diseases, injuries and surgical corrections [21].

Assessments were conducted at baseline and after 8. Assessment included balance measurement in the form of overall stability index (OSI), medial/lateral stability index (MLSI) and anterior/posterior stability index (APSI). Ankle range of motion in the form of non-weight bearing dorsiflexion and planter flexion and foot functional disability were also measured.

For Treatment:

Physical Therapy Tools of Different Shapes in the Form Of: Mat, wedges, rolls, medical balls and tilting board were used in conducting the exercise program.

Pulsed Magnetic Field Device: (ASA magneto therapy, automatic PMT Quattro PRO, 00001543) consists of an appliance, motorized bed and applicable solenoids which can be move in four different positions according to the treatment area.

Procedure:

For Evaluation:

Range of Motion Assessment: Ankle planter flexion and dorsiflexion measurements were measured in a bent knee position to account for the potential interaction of the gastrocnemius muscle on ankle dorsiflexion. Goniometry techniques followed standard clinical guidelines [22] and were measured by the same experienced clinician for every subject.

Balance Assessment: Biodex Balance System testing: The tests were done at the balance Lab at the Faculty of Physical Therapy.

The static test requires the subjects to look straight while standing as still as possible with his eyes open, focusing on the display monitor to maintain the curser within a centrally positioned in the bull's eye through the time of the test (20 seconds for each trail). A high overall balance stability index (SI) is indicative of a lot of movement during a test and less stability, on the contrary, a lower SI reflects less time spent away from the level position, interpreted as a better balance score.

A limit of stability (LOS) is recorded for all subjects. LOS test is designed to assess an individual ability to volitional move the center of gravity COG to predetermined positions in space. The subject was instructed to begin the test while the platform advanced to unstable surface (50%). One trail was performed without recording then the test begins. The countdown clock at the lower right part of the screen provided a three seconds. When the countdown time was completed, the LOS test screen displays eight boxes arranged around the central box. The boxes on the top position of the screen represent the anterior-medial stability. The boxes at the bottom of the screen represent the posterior stability. Once the test began, the subject tried to move the cursor to the box which appeared on the screen and then back to the center box with a little deviation as possible. The mean value of three trails was calculated and recorded. High scores are good while lower scores are worse.

The Foot Function Index (FFI): The questionnaire was designed to give information as to how foot pain has affected the ability to manage in everyday life. 23 questions had to be answered. For every question, a score was given on a scale from 0 (no pain or difficulty) to 10 (worst pain imaginable or so difficult it required help) that best describes your foot over the past week. Questions were read carefully and explained then a number was placed from 0-10 in the corresponding box [21].

For Treatment:

The Two Groups Received the Following Physical Therapy Program for Thirty Minutes: A selected physical therapy protocol was established for both groups that included:

- Stretching exercises for the tightened muscles to the limit of pain without vigorous pressure.
- Active, active-assistive and passive ROM exercises; isometric exercises; and contract relax techniques [23].
- Gait training: in the form of open environment to minimize or eliminate observed deviations. This may be done through postural training; weight-bearing activities; and attention to symmetry, form and cadence in front of mirror [23].

Magnetic Therapy: Patients in group B (study group) received pulsed magnetic field from supine lying position. The patient was exposed to low intensity 20 G PMF with low frequency 20Hz for 20 minutes /session.

RESULTS

Thirty children with Juvenile Rheumatoid Arthritis, aged from (8 to 12) years who fulfilled the inclusion criteria agreed to participate in this study and were randomly allocated to either the traditional physical therapy program (control group) or pulsed low frequency magnetic field (study group) treatment groups. Demographic characteristics and clinical features of both groups before the treatment are shown in (Table 1). There was no significant difference between the two groups regarding age, weight and height (P>0.05).

Comparing the pre and post-treatment outcome measurements related to ankle ROM between the two groups revealed that there was a statistically significant improvement in ankle dorsiflexion and planer flexionin group B compared with group A (p<0.05). (Fig.1).

The results of the static and dynamic balance parameters (Overall Stability Balance index SI and Dynamic limit of stability LOS) revealed that there were a statistical significant difference of medial/lateral, anterior/posterior and overall stability between group A and group B in favor of group B as presented in Table 2.

Table 2. Comparisons between mean values of dynamic balance parameters between both groups (A and B) post treatment.

Figure (2). Showsfoot functional disability values between group A and B before and after treatment. The results revealed that functional disability of the ankle joint decreased following treatment and there was a significant difference between both groups in favor of group B.

DISCUSSION

This study was conducted to investigate the effect of pulsed magnetic field on balance parameters, ankle range of motion and foot functional disability in children with juvenile rheumatoid arthritis. The results of this study showed a significant increasing of all balance parameters, ankle range of motion with reduction of foot functional disability in the magnetic field group compared with control group.

Table 1: Demographic Data of children in both groups:

Characteristics	Group A (n=15) mean±SD	Group B (n=15) mean±SD	P-value	Sig
Age (years)	10±1.4	10.2±1.5	0.712	NS
Weight (kg)	32.46±6.2	30.66±5.8	0.981	NS
Height (cm)	137.6±4.5	141.2±6.1	0.12	NS

Table 2: Comparisons between mean values of dynamic balance parameters between both groups (A and B) post treatment

Variables	group A Mean ± SD	group B Mean ± SD	Pvalue	Sig
medial/lateral stability index (MLSI)	4.48±0.65	2.68±0.54	0.001	sig
anterior/posterior stability index (APSI)	4.52±1.21	2.5±0.69	0.001	sig
Overall stability index (OASI)	3.88±0.56	2.2±0.69	0.001	Sig

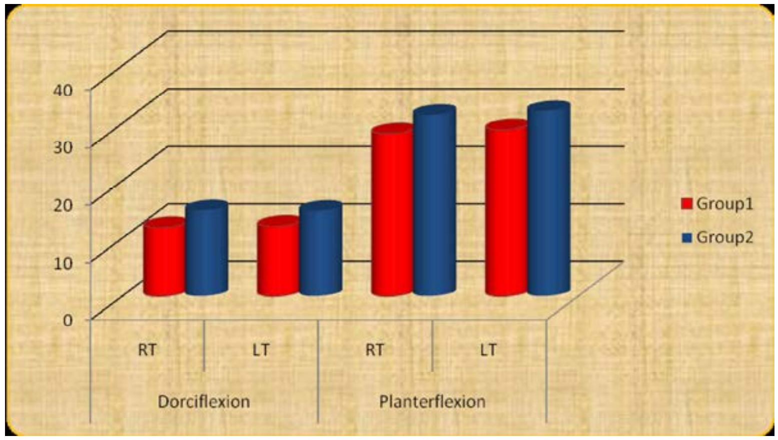

Fig 1: Comparison of mean values of ankle ROM forboth groups

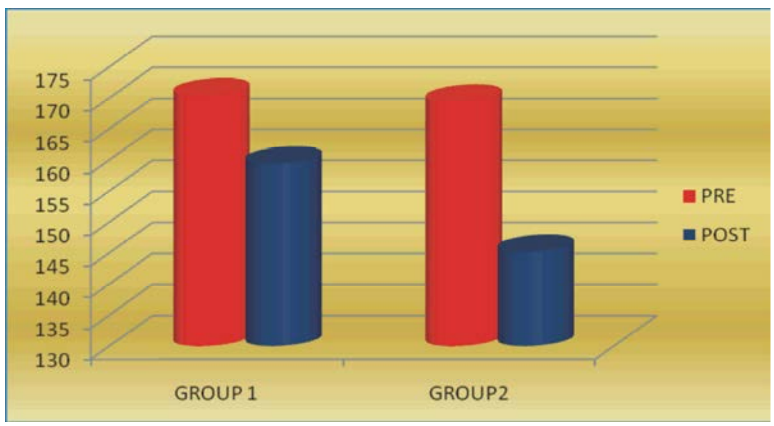

Fig 2: Comparison of mean values of foot functional disability between both groups before and after treatment

The main findings of this study were that both exercise and pulsed magnetic field produced significant improvement of all balance measurements, ankle ROM and reduction of foot function disability with the more significant increase in children in the magnetic field group compared with the children in the group whom received exercise only. The present study showed that electromagnetic field played a very important role in increasing ankle joint stability, ankle joint ROM and decreasing of the foot dysfunctions in patients with juvenile rheumatoid arthritis.

The potential mechanisms that might account for the observed results include: First, the physiological mechanism for pain relief by the magnetic field may be attributed to reversible blockage of action potential firing including blocking of sodium dependent action potential firing of sensory neurons and calcium dependant response to the irritant. Moreover the presynaptic inhibitory effect of magnetic field and reducing of the pain fiber excitability should be considered as pain refining intervention [24].

Second, the molecular mechanism of the magnetic field involves conformational changes in the ion channels and/or neural membrane. Also the ability of magnetic field to modulate the action of hormones, antibodies and chemical neurotransmitters at some receptor sites of certain cell types enhancing its function in pain reduction[25].

In contrast to other physical therapy modalities which may evoke hyperthermia and proteolysis enzyme activity which increases the cartilage destruction and potentially induces swelling, pulsed electromagnetic field applications may be athermally. Besides its ability to closely mimic the effects of mechanical stimuli, pulsed magnetic field could be specially useful for those patients who cannot exercise readily without pain [26].

In addition, the application of PEMF could enhance the chondrocytes activation in such way so as to promote proteoglycan and collagen synthesis. Also it may help with the repair of bone damage, which may be causing or perpetuation the development of arthritis. Thus the application of pulsed electromagnetic field in treating patients with rheumatoid arthritis causing sedative, anti-inflammatory, bone and soft tissue repair without adverse side effect or undue physical strain to the joint that might preserve the joint integrity [27].

The results of this study may be explained by Hulm *et al*. [28] who revealed that, application of magnetic field might promote favorable cellular,subcellular and molecular transcription within the damaged cartilaginous and bony tissues. So pulsed magnetic field can stimulate both bone and cartilage cell repair and maintenance that improving the joint function and integrity.

The improvement reported injoint range of motion can be attributed to the increase in lean muscle mass in both groups that received exercise therapy in the form of passive stretching, strengthening exercises, in form of bicycle ergometer and this comes in accordance with studies that revealed that exercise therapy can increase joint range of motion, endurance, muscles trength and coordination and can improve joint stability [29].

The reduction of the footfunctional disability in this study was attributed to the positive anti-inflammatory and analgesic effects of magnetic field which lead to decrease pain, increase ankle ROM with a parallel effect on the functional disability. These results were greatly supported by the work of Fischer *et al*. [30] who reported that pulsed EMF therapy has a beneficial effects on the joint blood flow leading to reduction of the inflammation, enhancing bone and cartilage healing and providing greater joint mobilityif it was applied over a longer period of 8-12 weeks.

These results can be supported by the study of Deracoglu *et al*., 2005 who concluded that, The improvement of functional performance in both groups might be as a result of the improvement of dynamic stabilization by synergistic and synchronous working of the lower limb musculature and increase the level of coordinated muscles contraction in response to regular proprioceptive training which facilitate the neuromuscular connection [31].

The controversy and conflicting results about the effect of PMF (Pulsed Magnetic field) application may be due to lacks of clear understanding mechanism of action, differences in pathological conditions and various types of magnetic stimulation. Whether static or pulsed, various parameters of treatment sessions, duration of treatment, frequency and techniques of application [32]. Further researches are needed to investigate effect of Pulsed Magnetic field on different arthritis types and on different age groups.

CONCLUSION

The findings of the present study support the hypothesis that pulsed magnetic field offers potential benefits in treating patients with JRA through improvement of the ankle ROM and help neuromuscular restoration of balance and subsequently improve the foot functional activity.

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