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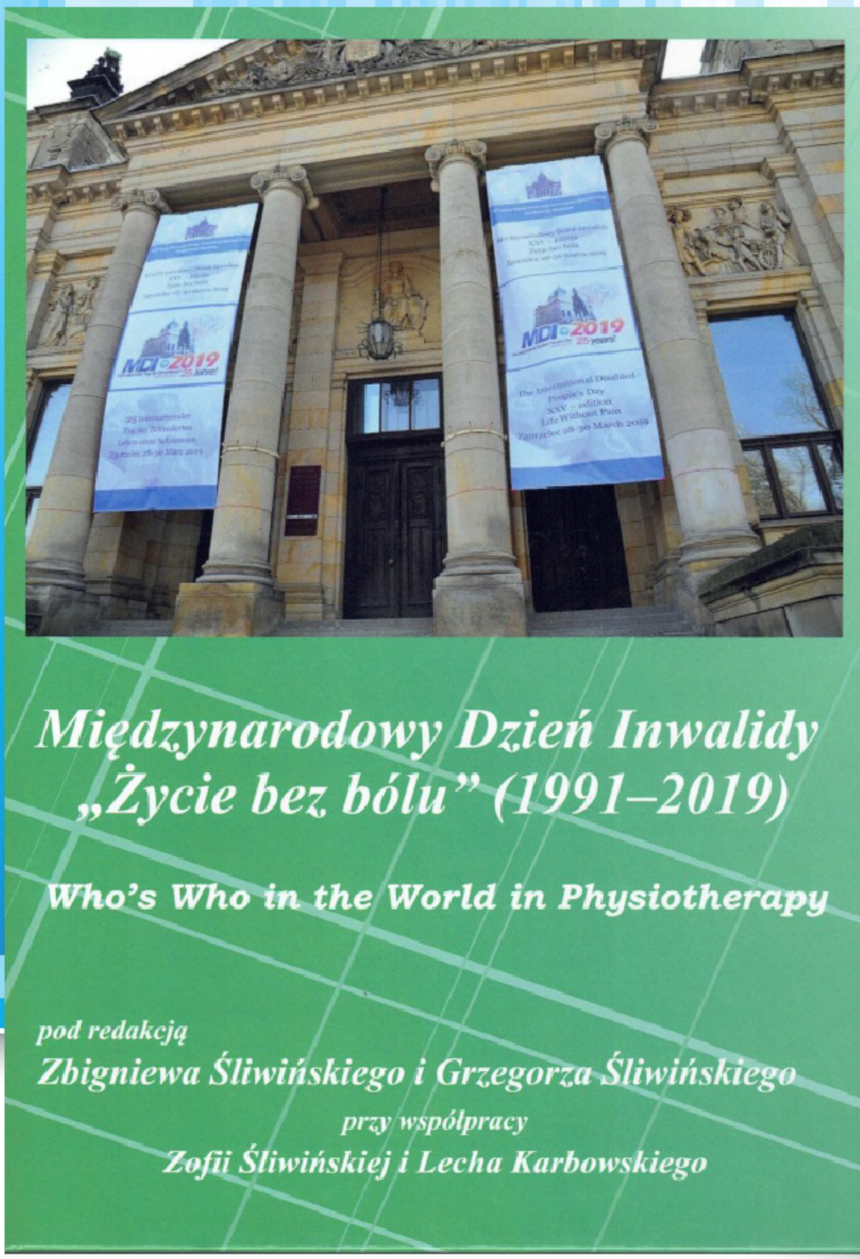

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Whole body vibration versus pulsed magentic field on bone denisty in spastic diplegic children: A randomized controlled trial

Porównanie wpływu wibracji całego ciała i pulsującego pola magnetycznego na gęstość kości u dzieci z diplegią: randomizowana, kontrolowana próba

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Abstract
Background and Purpose. Despite the well-known benefits of whole body vibration and pulsed magnetic field on bone density in spastic diplegic children, none of the former studies had evaluated the difference between both techniques on bone density in spastic diplegic children. Therefore the aim of this study was to evaluate the difference between whole body vibration and pulsed magnetic field during the application of a selected exercises program on bone density in children with spastic diplegic cerebral palsy. Materials and Methods. Thirty spastic diplegic children participated in this study. They were classified randomly into two groups of equal numbers, group A and group B. DEXA was used to evaluate bone density and muscle lean in the two groups before and after three successive months of application of the treatment programs. Group A received whole body vibration and selected exercises program. Group B received the same exercises program given to group A plus pulsed magnetic field. Results. Comparing The pre-treatment results revealed non significant difference in all the measuring variables between the two groups. In comparing the pre and post-treatment results for both groups revealed significant improvement in all measured variables. Post treatment results between two groups show no difference. Conclusion. It can be concluded that, whole body vibration and pulsed magnetic field can be considered as an effective modality in improving bone mineral density and can be used safely in the treatment program of spastic diplegic cerebral palsied children.

Key words:
cerebral palsy, diplegia, bone density, whole body vibration, pulsed magnetic field

Streszczenie
Informacje wprowadzające i cel. Pomimo dobrze znanych korzyści płynących ze stosowania wibracji całego ciała i pulsującego pola magnetycznego na gęstość kości u dzieci z diplegią, żadne z wcześniejszych badań nie oceniało różnicy między obiema technikami w zakresie gęstości kości u dzieci z diplegią. Dlatego celem niniejszej pracy była ocena różnicy między zastosowaniem wibracji całego ciała a pulsującego pola magnetycznego podczas stosowania wybranego programu ćwiczeń na gęstość kości u dzieci ze spastycznością i porażeniem mózgowym w postaci diplegii. Materiały i metody. W badaniu wzięło udział 30 dzieci z diplegią. Zostały one losowo podzielone na dwie równe grupy, grupę A i grupę B. Do oceny gęstości kości i beztłuszczowej masy mięśniowej w dwóch grupach przed i po trzech kolejnych miesiącach stosowania programów terapeutycznych zastosowano metodę DEXA. Grupa A była poddawana wibracjom całego ciała i wybranemu programowi ćwiczeń. Grupa B była poddawana temu samemu programowi ćwiczeń, co grupa A oraz pulsującemu polu magnetycznemu. Wyniki. Porównanie wyników przed leczeniem ujawniło nieistotną różnicę we wszystkich zmiennych pomiarowych między dwiema grupami. Porównanie wyników przed i po leczeniu dla obu grup wykazało znaczną poprawę we wszystkich mierzonych zmiennych. Wyniki po leczeniu między dwiema grupami nie wykazują różnicy. Wniosek. Można stwierdzić, że wibracje całego ciała i pulsacyjne pole magnetyczne mogą być uważane za skuteczny sposób poprawy gęstości mineralnej kości i mogą być bezpiecznie stosowane w programie leczenia dzieci ze spastycznością i porażeniem mózgowym w postaci diplegii.

Słowa kluczowe
porażenie mózgowe, diplegia, gęstość kości, wibracje całego ciała, pulsacyjne pole magnetyczne

Introduction

Cerebral palsy (CP) is a sensory – motor disorder associated with pathology of the normal postural reflex mechanism and the sensory input system proprioception the receipt of information about changes in joint position is closely associated with control of motion and posture [1].
Children and adolescents with cerebral palsy with moderate to severe functional limitations can be vulnerable to low bone mineral density because of decreased mobility, decreased growth rate, inadequate nutrition, use of anticonvulsants, low vitamin D levels, and irregularities in skeletal maturation [2].
Spastic diplegia is the most prevalent type of cerebral palsy, it accounts for about half of the total incidence of cerebral palsy. It is the principal of cerebral palsy in preterm infants. In one series it represents 80% of preterm infants and in a new series it represents 18% of the overall cerebral palsy population [3].
Low bone density represents a condition characterized by low bone mass and structural deterioration of bone tissue. Leading to bone fragility and an increased susceptibility to fractures of hip, spine and foot [4].
Whole – body vibration (WBV) was recently introduced as a novel way to improve proprioceptive sense, bone density, posture, balance, and motor skills. Vibration may directly stimulate muscle spindles and Golgi tendon organs [5].
In children with disabilities, a small pilot study found that 6 months of low-magnitude, high-frequency (0.3 g, 90 Hz) whole body vibration increased bone density and prevented bone loss in the proximal tibias of a heterogeneous group of participants [6].
Magnetic fields were applied to promote bone healing, treat osteoarthritis and inflammatory diseases of the musculoskeletal system, decrease pain and enhance healing of ulcers. This demonstrates how much magnetic field is beneficial for the field of physical therapy [7].

Materials and Methods

Study Design

The study was designed as a prospective comparative design. Ethical approval was obtained from the institutional review board at the Faculty of Physical Therapy, Cairo University before study commencement[No: P.T. REC/012/002422]. It was conducted between August to December. 2020.

Participants

A convenient sample of thirty spastic diplegic cerebral palsied children from both sexes 15 female and 15 males, their ages was be ranged from 5 to 8 years was selected from the outpatient clinic of the Faculty of Physical Therapy, Cairo University. They were enrolled and assessed for their eligibility to participate in the study. Accordingly, all selected subjects were informed with the training program. Some spastic diplegic children were excluded from the study if they was not able to understand and follow verbal commands and instructions included in both test and training, If they had fixed deformity of both lower limbs and upper limbs, acute infection or recent positive Covid-19.

Randomization

A written form of informed consent was taken before participation of the spastic diplegic children in this study, in a way that ensures their parents confidentiality. Informed consent was obtained from each parent after explaining the study's nature, purpose and benefits, informing them of their right to refuse or withdraw at any time, and about the confidentiality of any obtained information. Anonymity was assured through coding of all data. The spastic diplegic children were randomly divided into 2 groups (A and B) using computer generated random numbers. Distribution was hidden in sequentially numbered opaque envelopes [8].

Outcome measures

DEXA

Dual Energy X-ray Absorptiometry (DEXA) technique will be used to measure bone mineral density of the neck of femur of lower limb and spine using bone mineral content in gram (gm) by measured area (cm^2). During this test, each child of the two groups will be allowed to lie on a padded platform for a few minutes while an imager — a mechanical device — passes over the child body without touching him/her, it emit radiation through the exposed part of the child body(neck of femur and spine).
The equipment converted the information received by the detector in the mechanical device into an image of the neck of femur and spine and analyzed the quantity of the bone the body contained. The results were reported as total amount of bone mineral density of the neck of femur and spine, which is the amount of bone per unit of the skeleton area.

Modified Ashworth Scale

The modified Ashworth scale was used to quantify the degree of spasticity that was evaluated by passive movement for both limbs while the child was completely relaxed, lying supine on a mat with head in mid position. The test was repeated 3 times and the mean record was taken to refer accurately to the degree of spasticity to select CP children having 1 to +1 grades.

Gross Motor Function Measure (GMFM)

Each child in both groups were evaluated by using Gross Motor Function Measure Scale (GMFM) to determine their level of performance in different items of standing dimension. This scale is the first standardized instrument that was constructed and validated to measure changes in gross motor function over time in children with CP [9].
- The test includes 88 items that assess motor function in five dimensions (1) lying and rolling; (2) sitting; (3) crawling and kneeling; (4) standing "which our work focused on it"; (5) walking, running and jumping.
- Each GMFM item is scored on a four-point Likert scale. Values of 0,1,2,3 are assigned to each of the four categories (The scoring key is provided as general guidelines):

0 = Does not initiates.
1 = Initiates (> 10% of the task).
2 = Partially completes (10% to > 100% of the task).
3 = Completes (100% task completion).

Intervention

For the group A

Each child in this group will receive a selected exercises directed towards improving bone density of the child for 1 hour, in

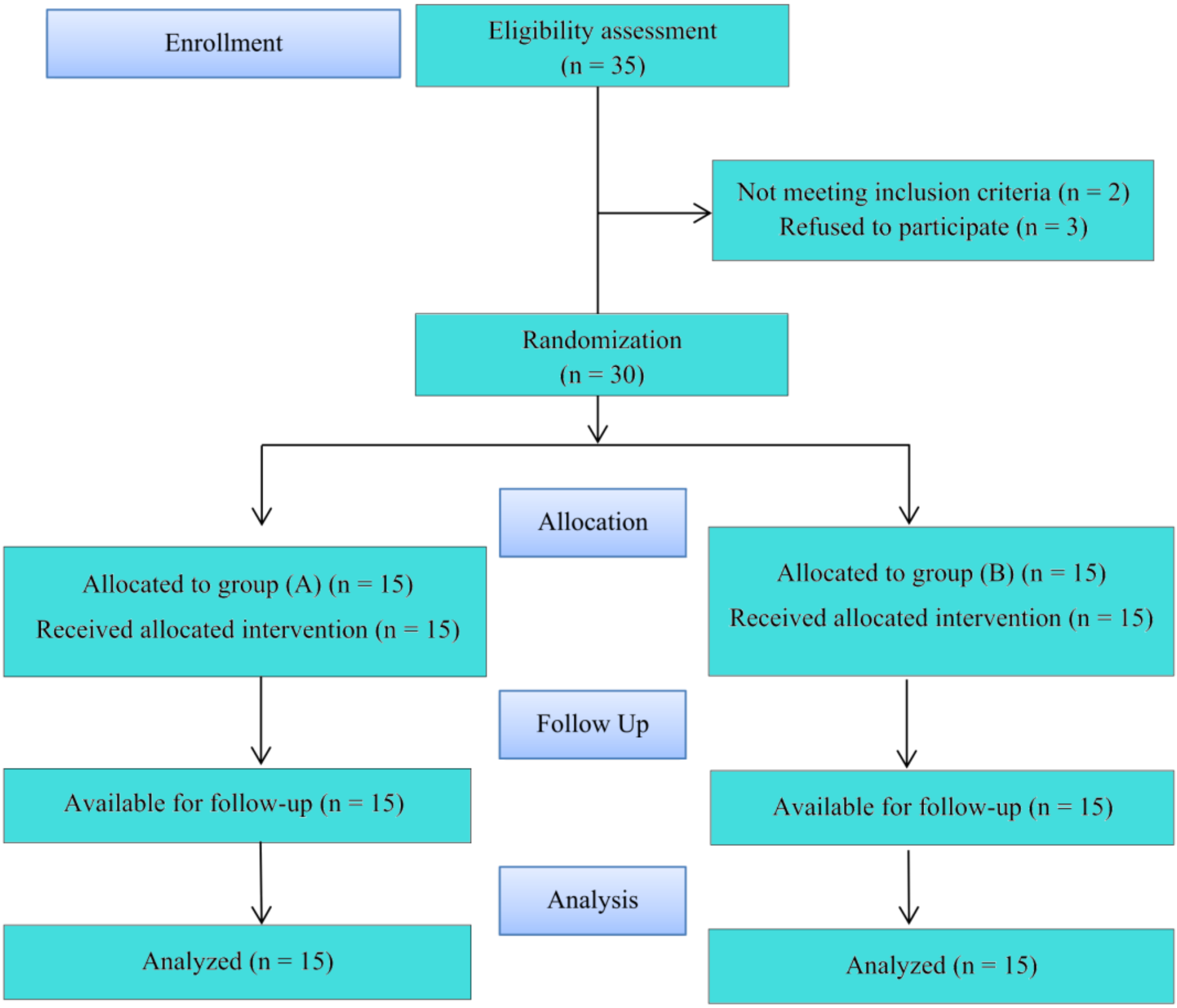

Figure 1. Flow chart of the study

addition to standing on vibrating platform for 10 minutes three times per week for three months [10].

For the group B

Each child in this group will receive the same exercise program given to child in the previous group for 1 hour, in addition to pulsed magnetic therapy for 30 minutes three times per week for three months[11].

This exercise program depends on:

1. Inhibition of released primitive reflexes.
2. Facilitation of normal movement patterns.
3. Equilibrium righting and protective reactions training.
4. Stretching exercise for tight muscles (iliopsoase, hip adductors, hamstrings and calf muscles).
5. Weight bearing exercises to increase bone mineral density.
6. Gait training exercises.

The treatment program consists of

A. The physical therapy program was based on neurodevelopmental technique and directed toward inhibiting abnormal postural control patterns and facilitation of righting, equilibrium and protective reactions and facilitation of functional abilities standing one leg on a height, squatting on both child lower limbs and walking.

B. Facilitation of weight bearing to improve bone mineral density and muscle strength:

• Standing with manual support at both knees with wide base of support, then narrow base, then walk standing, then weight shift to side ways.
• Standing holding on wedge, and standing frame, the therapist sat back to the child while support both knees.
• Disturbance from standing posture, the child was suddenly pushed to different directions, therapist sat back to the child prevent him or her from falling.

• Push up on both upper limbs child prone on both upper limbs make elbow flexion and extension therapist sat back to the child raise lower limbs and hold both elbows by his hands.
• Standing one leg on a height the other limb extended, therapist sat back to the child holding both knees.
• Squatting on both child lower limbs then make both knees extension therapist sat back to the child holding both knees.
C. Facilitation of postural mechanism:
• From sitting on ball, while tilting it slowly in all directions (forward, backward, and sideways) therapist sat back to the child holding his pelvis.
• From standing on tilting board, while tilting it slowly in all directions therapist sat in front or back of the child holding both knees or ankles.

Statistical analysis

Descriptive analysis using histograms with the normal distribution curve showed that Gross motor function measure (GMFM), Bone mineral density of femur, bone mineral density of L_2-L_4, and muscle lean were normally distributed and not violates the parametric assumption for the measured dependent variable. Additionally, testing for the homogeneity of covariance revealed that there was no significant difference with p values of > 0.05. The box and whiskers plots of the tested variable were done to detect outliers and showed no outliers. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed for Gross motor function measure (GMFM), Bone mineral density of femur, bone mineral density of L_2-L_4, and muscle lean. Accordingly, 2×2 mixed design MANOVA was used to compare the tested variables of interest at different tested groups and measuring periods. With the initial alpha level set at 0.05.

Result

As indicated by the independent t test, there were no significant differences (p > 0.05) in the mean values of age, height and body mass between both tested groups (Table 1).

Table 1. Physical characteristics of participants in both groups (A & B)

Characteristics	Group A Mean ± SD	Group B Mean ± SD	Comparison t-value	Comparison P-value	Significance
Age [years]	6.5 ± 0.94	6.3 ± 0.9	0.591	0.599	NS
Height [cm]	107.4 ± 9.89	109.4 ± 9.17	−0.574	0.874	NS
Body mass [kg]	19.4 ± 3.29	19.2 ± 3.56	0.16	0.571	NS

**SD: standard deviation, P: probability, S: significance, NS: non-significant.*

Statistical analysis using 2x2 mixed design MANOVA indicated that there were no significant effects of the tested group (the first independent variable) on the all tested dependent variables; Gross motor function measure (GMFM), Bone mineral density of femur, bone mineral density of L_2-L_4, and muscle lean (F = 0.186, p-value = 0.944). However, there were significant effects of the measuring periods (the second independent variable) on the tested dependent variables (F = 49.05, p-value = 0.0001*). However, the interaction between the two independent variables was no significant, which indicates that the effect of the tested group (first independent variable) on the dependent variables was no influenced by the measuring periods (second independent variable) (F = 1.297, p-value = 0.298) there was significant diference in all variables within groups and non significant diferrence in all variables between both groups (Table 2).

Table 2. represents pre and post treatment values of group A and group B

		Group (A) n = 30	Group (B) n = 30	Group A Vs. Group B p- value*
Gross motor function measure (GMFM)	Pre test	27.6 ± 3.75	28.06 ± 4.02	0.745
	Post test	33.26 ± 3.75	34.66 ± 2.94	0.265
	% of change	20.5%	23.52%	
	p- value*	0.0001*	0.0001*	
Bone mineral density of neck of femur	Pre test	0.46 ± 0.12	0.44 ± 0.10	0.732
	Post test	0.49 ± 0.12	0.5 ± 0.12	0.942
	% of change	6.52%	13.63%	
	p- value*	0.0001*	0.0001*	
Bone mineral density of L2-L4	Pre test	0.47 ± 0.09	0.45 ± 0.10	0.581
	Post test	0.53 ± 0.09	0.52 ± 0.10	0.806
	% of change	12.76%	15.55%	
	p- value*	0.002*	0.0001*	
Muscle Lean	Pre test	13377.53 ± 5256.62	13361.46 ± 5820.32	0.994
	Post test	17430.73 ± 6315.77	16809.33 ± 5550.49	0.777
	% of change	33.66%	25.80%	
	p- value*	0.0001*	0.0001*	

**Significant level is set at alpha level < 0.05 SD: standard deviation; MD: Mean difference p-value: probability value*

Discussion

Cerebral palsy encompasses a number of non- progressive encephalopathy's of varied etiology. It usually presents at birth or in early infancy, and is the most common cause of physical immobility in childhood. The common features of the condition are impairment in muscle function, reduced muscle power, bone mass and osteoporosis, as well as varying degrees of impaired mobility so it is very important to solve these problems [12].

Children and adolescents with cerebral palsy with moderate to severe functional limitations can be vulnerable to low bone mineral density because of reduced mobility, decreased growth rate, inadequate nutrition, use of anticonvulsants, low vitamin D levels, and irregularities in skeletal maturation [2].

Choosing bone density for evaluation in this study may be explained by Munns and Cowell [13] who stated that, Low bone mineral density in diplegic patients may be caused by a failure to develop adequate bone during growth resulting in suboptimal peak bone mass and/or by poor bone retention. The incidence of low bone mineral density in moderate to severe diplegic patients increases with age. By 10 years of age, > 95% of non-ambulatory children with severe diplegic cerebral palsied children have low bone mineral density.

The present study included thirty spastic type of diplegic form of CP which constitutes the major form among spastic CP. This finding was reported by Tong et al. [3] who stated, that spastic diplegia is the most prevalent type of cerebral palsy, it accounts for about half of the total incidence of cerebral palsy. It is the principal of cerebral palsy in preterm infants. In one series it represents 80% of preterm infants and in a new series it represents 18% of the overall cerebral palsy population.

In addition to Binkley et al. [14] who stated that, most children with spastic diplegia have low bone mineral density leads to joint contracture, spinal deformity, gait abnormalities, positioning restrictions, uncontrolled movements and high risk to fractures.

Whole Body Vibration stimulation is used to improve stretching, strength, power and endurance along with the benefits of increased blood flow in contracting muscles. Studies show major improvements of 10% to 30% in bone density, increased muscle strength and motor recruitment enhancement [15]. So it is essential to seek an ideal physical therapy program to help in solving such widespread

In this study the mean chronological age of the selected spastic diplegic cerebral palsied children of group A and B was (6.5 ± 0.94) (6.3 ± 0.9) years; respectively. This comes in agreement with Koop and Green. [16] who stated that, independent standing and walking can be delayed up to five of years because of inadequate hip motion and adductor spasticity in spastic diplegic cerebral palsied children.

In addition to that Kolar [17] concluded that the phasic muscles starts their postural control, as the central nervous system mature, theses muscles play an increasing important part in posture and its stabilization, the development of postural function of the phasic muscles is completed by age of six years.

In the present study bone mineral density was assessed by using Dual Energy X-ray Absorptiometry (DEXA) that agreed with Lata and Elliot [18] who reported that bone mineral density most commonly determined by DEXA would best predict fracture risk in patients without previous fracture

In the present study, femoral neck and lumber spine were selected to be assessed by DEXA as previously studied by Eid., et al. [19] who measured bone density at neck of femur, lumber spine, arms and total body bone mineral density.

In the present study, both groups received a specially designed physical therapy program that included weight bearing exercises, stretching exercise for tight muscles, gait training, facilitation of protective reaction, facilitation of righting and equilibrium reaction.

With comparing the pre and post-treatment results for group A, it revealed significant improvement in bone mineral density in neck of femur and significant improvement in spine, muscle lean and values of GMFM after treatment.

In the present work, group B received the same specially designed physical therapy program given to the group A plus pulsed magnetic field. In comparing the pre and post-treatment results of this group, it revealed significant improvement in neck of femur and significant in lumber spine, muscle lean and values GMFM. by comparing between both groups after treatment there was no difference in neck femur, lumber spine, muscle lean and values of GMFM.

The significant improvement in the median values of muscle lean GMFM in dimension of standing recorded in this group may be due to the strength-building effect of whole body vibration (WBV) therapy, as mentioned by Rauch. [20] who showed a positive effect of a twice-a-week, six months WBV training on GMFM of standing level (dimension D), lumbar spine BMD and bone mass in four CP children.

The improvement in BMD in both groups could be attributed to the effect of the design physical therapy program on bone and connective tissue which adapted to mechanical loading throughout WBV and magnetic field. It contributed to an increase in bone mass and could reduce bone demineralization which occurred with disuse. The results of this study could be explained by the fact that bone is a living tissue that constantly reforms, gaining or loosing strength according to how often it is used. Without mechanical loading, bone looses density and becomes weaker. which agree with Jessup et al. [21] who explain that bones that get regular exercise actually appear good and have more density as exercise actually encourages calcium absorption in bone. Like muscles, bone respond to increase blood flow and it is thought that the increased circulation promoted by exercise helps transport vital nutrients and mineral such as calcium to bones.

The results of the study group which reflected the positive influence of magnetic field on bone mineral density of the femoral neck, and lumber spine could be attributed to Fitzsimmons et al. [22] Who added that, the Pulsed magnetic field could also influence the gating mechanism that control the membrane concentration in lymphocytes and is capable of increasing net calcium flux in transport of various types of ions such as calcium. They also concluded' that PEMFs can increase the calcium human osteoblast cells

This come in accordance with Aaron and Ciombor [23] who studied the effect of exposure to PEMFs on the acceleration of endochondral ossification. Glycosaminoglycan synthesis and Ca uptake were measured. While all of the animals showed significantly increased calcium uptake and glycosaminoglycan synthesis as compared with unexposed controls, stimulation for just the first three days (mesenchymal phase) was found to be as effective in promoting ossicle development as exposure for the full 20 days.

Also, the improvement of BMD in the loaded bones could be attributed to the effect of piezoelectricity of whole body vibration and pulsed magnetic field it may reflect that there no difference between both groups and this comes in agreement with Mackelvie [24] who revealed that the piezoelectrical effect of the bones explains the mechanism on which bone growth, bone structure and bone healing are based. There is a fact that with mild pressure on the bone a weak negative electrical charge is developed and with a mild pulling force on the bone a weak positive electrical charge is developed. This generates electrostatic field across bone which increase serum pumping crossing bone tubules that results in increased bone mineral density.

Pulsed magnetic field and whole body vibration could affect bone mineral density by indirect way through influence on surrounding skeletal muscles which protect underlying bones and their contractions participate in putting minimal loads on bones which produce increased both bone density and strength. This explained by Kemper et al. [25] who revealed that, stress on surrounding sketetal muscles had been shown to provide a stimulus to bone that increase mineralization in areas of new stress in a manner to which bone is not accustomed in order to promote bone strengthening and generating stresses that cross the osteogenic strain threshold

The improvement in BMD in bones can be attributed to exercise increasing mechanical loading, muscular activity and weight bearing. This came in agreement with Janz et al. [26] who concluded that, improvement of BMD at neck of femur can be achieved by maintaining high levels weight bearing.

The results of this study that referred to significance result in bone density in lumber spine and significance results in neck of femur came not communication with Gudjons and Stemmons [27] who stated that, trabecular bone is usually abundant in lumber spine. The proximal femur has a more architecture composed of trabecular and cortical bone BMD increase in trabecular and cortical bone rather than small trabecular. Although the present study demonstrated that there is no difference between whole body vibration and pulsed magnetic field on bone density in spastic diplegic children plus traditional exercise program does not have any adverse effect on bone density between both groups, its short duration represents a major limitation. Therefore, longitudinal studies are necessary to explore the long-term effect of whole body vibration and pulsed magnetic field on bone mineral density on spastic diplegic cerebral palsied children.

Conclusion

From the obtained results of this study, it may be concluded that, there are changes in bone mineral density in neck of femur, lumber spine, muscle lean and median values of GMFM of diplegic cerebral palsied children due whole body vibration and pulsed magnetic field while performing the specially designed physical therapy program. So it can be concluded that, whole body vibration and pulsed magnetic field can be considered as an effective modality in improving bone mineral density and muscle lean and can be used safely in the treatment program of spastic diplegic cerebral palsied children.

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