Effect of High Frequency, Low Magnitude Vibration on Bone Density and Lean Content in Children with Down Syndrome

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ABSTRACT

Purpose: to examine the effects of high frequency, low magnitude vibration on bone density and muscle content in children with Down syndrome.

Design: Experimental study (randomized control trial)

Subjects: Thirty children with DS from both sexes, ranging in age from 4 to 7 years. They were divided randomly into two groups of equal number A (control) and B (study)

Procedure: Evaluation before and after three months of treatment for each child of the two groups was conducted via using dual X-ray absorptiometry (DXA). Group A received a selected exercise program, while group B received the same exercise program given to group A in addition to proprioceptive stimulation in the form of whole body vibration (WBV) training.

Results: Significant improvement was observed in the two groups when comparing their pre and post-treatment mean values. The mean ± SD of BMD post treatment for control group was 0.75 ± 0.03 and that for study group was 0.79 ± 0.03. The mean difference between both groups was -0.04. There was a significant difference between control and study groups in BMD post treatment.

Conclusion: mechanical vibration seems to improve BMD and muscular content in DS children making the treatment of osteoporosis possible.

Keywords: *Down Syndrome (DS), Bone Mineral Density (BMD), Vibration*

INTRODUCTION

Peak bone mass, which is achieved soon after the end of sexual development, is the most important determinant of bone mass and osteoporosis later in life [1-2]. Children with disabilities such as cerebral palsy (CP) and Down syndrome are particularly vulnerable to deficits in bone mass accretion due to decreased mobility and weight-bearing which reduces mechanical loading of the skeleton. [3-4]

BACKGROUND

Down syndrome (DS) is one of the few disabilities that carries with it the certainty of delays in all of the developmental domains.[5] In the United States, DS occurs approximately 1.36 times in every 1,000 live births.[6] Down syndrome is a common cause of cognitive deficits in childhood [7] and results in significant delays in the onset of motor skills, including qualitative differences in movement patterns, compared with the typical development in children without DS.[8-9]

Most patients with Down syndrome require treatment during childhood because of mental or growth retardation. Hypotonia, and nutritional and hormonal deficiencies at critical times of bone-mass accretion, namely in infancy and adolescence, have a major role in the impairment of peak bone-mass accrual and correlate with osteoporosis.[10]

Whole body vibration has shown promise as an alternative method for stimulating both increases in bone mass and improvements in muscle performance[11-12]. Animal studies have demonstrated that low-magnitude, high-frequency vibration can increase bone mass and bone strength and prevent bone loss [13-14]. Studies in humans have also shown a benefit to bone in post-menopausal women [11] and a benefit to both bone and muscle in young women, ages 15-20 years, with low bone density [15]. In children with disabilities, a small pilot study found those 6 months of low-magnitude; high-frequency (0.3g, 90 Hz) whole body vibration increased in bone density and prevented bone loss in the proximal tibias of a heterogeneous group of participants [16].However whole body vibration (WBV) seems to be beneficial to improve BMD in disabled children[13-14]

The purpose of this study was to examine the effects of high frequency, low magnitude vibration on bone and muscle in children with Down syndrome. We were interested in this group because they are at the age which is considered critical period at which children have the most potential to accumulate bone [17].

METHOD

Participants

Thirty infants with DS of both sexes from the Outpatient Clinic of The Faculty of Physical Therapy and The National institute of Neuromotor disorders were recruited to participate in the study. They were divided into two groups of equal numbers (control group and study group).

Inclusion criteria**:**

The participants were children with DS ages 4-7 years who were able to stand for 10 minutes without handheld support.

Exclusion criteria

- The presence of a seizure disorder
- Vision problems.
- Any other medical conditions that would severely limit a child's participation in the vibration intervention.

INTERVENTION

Children in the control group received a specially selected physiotherapy program for 3 months which include: facilitation of equilibrium and protective reactions, stimulatory techniques and muscle strengthening & endurance training.

Children in the study group received the same selected physiotherapy program in addition to proprioceptive stimulation in the form of whole body vibration (WBV) training using a special device for 3 months.

Fig. 1. Whole Body Vibration Device.

Whole Body Vibration (WBV) Device (Fig.1) (serial no. 0251460, manufactured in China 2005), designed to provide vibration and proprioceptive stimulation. It enables the therapist to check the time and speed through display. It consists of the following parts:

(a) Transverse frame.

(b) Platform board.

(c) Right and left handles.

Each child in both groups was evaluated before and after three months of treatment by Dual Energy X-ray Absorptiometry (DEXA) (for measuring bone mineral density of total body and total body lean content by using a standard technique for measuring bone mineral content with very low dose of radiation of acceptable precision using bone mineral content in grams (gm) by area of bone measured (cm2) and will express density as grams/ cm2.

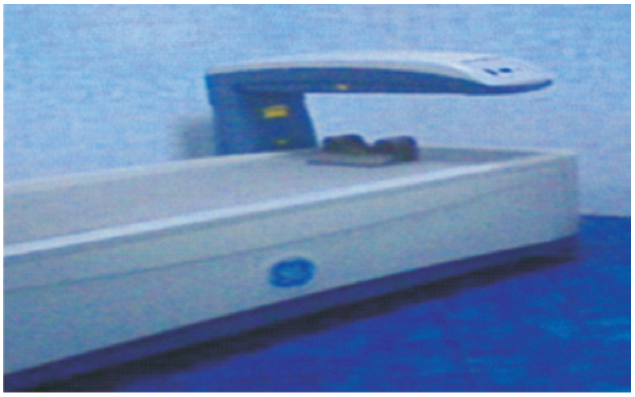

Fig. 2. Bone mineral density testing apparatus (DXA)

RESULTS

Comparisons of pre and post treatment mean values of BMD and lean content for control group and study group revealed significant improvement.(Table 1, figure 3).

Table (1)

Test Parameters	Control group			Study group		
	Mean		P	Mean		P
	Pre	Post		Pre	Post	
BMD	0.70 ± 0.01	0.75 ± 0.03	0.0001	0.71 ± 0.02	0.79 ± 0.03	0.0001
Lean content	5.79 ± 0.2	6.42 ± 0.3	0.0001	5.8 ± 0.17	6.67 ± 0.25	0.0001

Post treatment mean values of BMD for both groups (control and study) were compared .The mean value ± SD of BMD post treatment for control group was 0.75 ± 0.03 and that for study group was 0.79 ± 0.03. The mean difference between both groups was -0.04. There was a significant difference between control and study groups in BMD post treatment (p = 0.007). (figure 3).

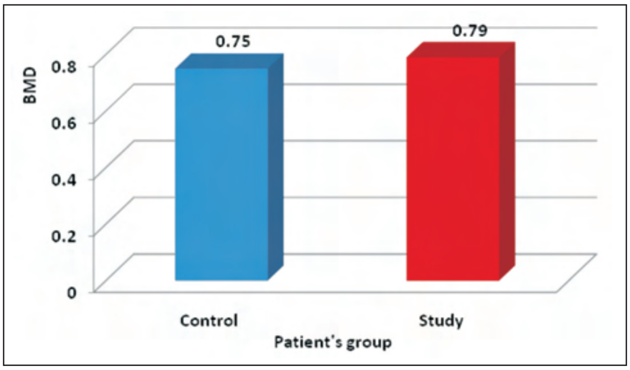

Fig (3): Post treatment mean values of BMD in control and study groups.

Post treatment mean values of Lean for both groups (control and study) were compared. The mean value ± SD of lean post treatment for control group was 6.42 ± 0.3 and that for study group was 6.67 ± 0.25. The mean difference between both groups was -0.25. There was a significant difference between control and study groups in lean post treatment (p = 0.02). (figure 4).

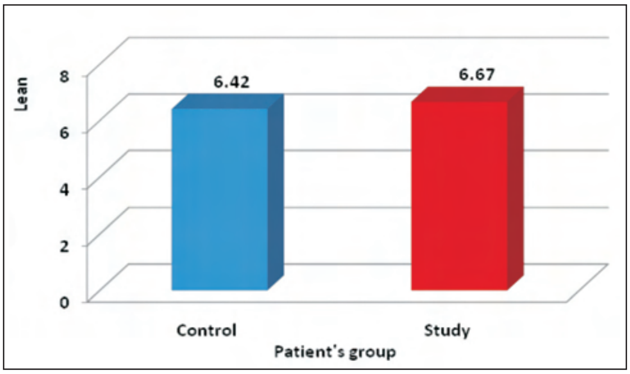

Fig (4): Post treatment mean values of lean in control and study groups.

DISCUSSION

In this study, the primary purpose was to investigate whether the vibration intervention in children with Down syndrome is beneficial to bone mineral density and muscular content or not.

Low bone mass and the associated increased fracture rates are clinical features that complicate DS[10].As the life expectancy of individuals with DS has increased to greater than age 50 [18-19], the bone health of DS patients has become an important medical issue. With the increasing life expectancy, many concerns regarding the risk of osteoporosis have been raised [20-21-22]. In fact, the accrual of bone mass during childhood and adolescence may reduce osteoporosis risk later in life and low bone mass in young adulthood is a strong risk factor for later osteoporosis and fracture [23-24].

Several investigators reported that, adults (and children) with DS have lower bone mass, expressed as BMD, especially in the lumbar spine, compared with their peers without mental retardation or with mental retardation but without DS. [20-25-26-27-28]

Dual radiograph absorptiometry (DXA) is the most widely used method for assessment of BMD and is considered the "gold standard". DXA uses 2 different radiographic energies to record attenuation profiles at 2 different photon energies. Attenuation is largely determined by tissue density and thickness. At a low energy, bone attenuation is greater than soft tissue attenuation. At high energy, they are similar. This allows the distinction between bone and soft tissue. The energy absorption of the 2 different energy radiographic beams is used to provide estimates of the amounts of bone mineral[29]

The results of the current study at the end of treatment period, showed a significant improvement in the measuring variables in both study groups, but in favor to study group. Also the percentage of improvement of the measuring variables was higher in study group than control group.

Mechanical vibration is a traditional and safe physical therapy modality that is widely accepted in diagnosis and treatment of the disease, rehabilitation and sports medicine.[30-31].In the skeletal system, the diagnosis and treatment is mainly based on cytological and zoological research. Previous animal experiments showed that mechanical vibration with appropriate frequency can affect energy metabolism, gene activation, secretion of growth factors, and cell matrix synthesis of bone cells.[32-33] Theoretically, mechanical vibration can increase bone mass in the human skeleton as well.

It was showed that the 8-month course of vibratory exercise using a reciprocating plate is effective to improve hip BMD and balance. A few studies have shown recently the effectiveness of the up-and-down plate for increasing bone mineral density (BMD). [34]

With appropriate frequency, mechanical vibration can affect energy metabolism of bone cell, gene activation and secretion of growth factors, and synthesis of other cell matrix.[35-36].Under appropriate conditions, vibration can increase the synthesis of DNA in cultured cartilage cells and polysaccharide protein, and the proliferation and differentiation of osteoblasts also can be greatly accelerated[37,38] making the treatment of osteoporosis and osteoarthritis possible.[39]

Whole body vibration (WBV) has become a popular method of neuromuscular training due to the recent emergence in the benefits of vibration on neuromuscular performance. These benefits have included improved strength, jump height, power, flexibility, and balance [40-41].For this reason, it is believed that strength training with WBV may provide superior training outcomes (i.e., increased strength development) compared to traditional strength training methods alone [42-43]. However, many of the studies that indicated beneficial outcomes were either acute studies or training studies that used direct methods of vibration applied to the muscle belly or tendon as opposed to WBV. Therefore, little is known about the training-related effects of WBV on strength development and neural activation.

CONCLUSION

Recently, there has been increased interest in the use of vibration as a form of exercise training for handicapped children. This study found that children with Down syndrome exposed to vibration showed improvements in BMD and lean content as compared to traditional exercise programs and that vibration provides additional benefit to traditional exercise programs. Additional studies are needed to determine safe and effective parameters for vibration training in different age groups.

ACKNOWLEDGEMENT

The authors would like to express their appreciation to all children and their parents who participated in this study with all content and cooperation.

Ethical clearance

All subjects were informed about the study procedure and signed consent forms approved by the local research ethical Committee for the Protection of Human Subjects, at Faculty of physical therapy, Cairo University.

Conflict of Interest

There is no interest of conflict with any organization, and this research is not funded.

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