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ORIGINAL RESEARCH

THE EFFECT OF A 12-WEEK LOW-IMPACT EXERCISE PROGRAM IN BONE MINERAL DENSITY IN ADULT MALES AND FEMALES WITH QUADRIPLEGIC CEREBRAL PALSY.

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ABSTRACT

The purpose of this study was to examine the effect of an intervention physiotherapy program in adult males and females with cerebral palsy on bone mineral density. 10 adults (7 males/3 females) with quadriplegic cerebral palsy (CP) consisted the experimental group and 10 people (7males/3 females) serving as control group took part in the study. Measurements including bone mineral density (g/cm^2) assessment with DEXA absorptiometry of lumbar spine were tested before and after a 12-week physical low-impact program. Treatment provided by community trainers consisted of conscious movement control and low-impact resistance training 3 times a week. The study revealed the following: The pre-test and post-test examined variables of both groups were within normal limits. CP patients group had significantly higher levels of bone density in their lumbar spine after the intervention program compared to baseline values. The same trend was not found for the case of control group. The BMD in the selected area of the experimental group was increased about 7% compared to baseline values and this was statistically significant ($p < 0.05$). The results support application and development of the treatment concept and highlight that physical activity at its simple status can increase BMD in CP patients. If sustained, the increases in BMD may reduce the risk of osteoporotic fracture and augments the quality of life of these people

Key words: cerebral palsy; quadriplegic; bone mass; physiotherapy

INTRODUCTION

Quadriplegic subjects present extensive muscle mass paralysis which is responsible for the dramatic decrease in bone mass, increasing the risk of bone fractures. Osteopenia, or low bone mineral density (BMD), is quite prevalent in this category of patients with moderate to severe cerebral palsy (CP) (1). Osteopenia, combined with other factors such as stiff joints, poor balance leading to falls, small diameter bones, accounts for the frequent fractures observed in this population. Subjects who suffer a spinal cord injury (such as quadriplegic ones) present a significant reduction of physical capacity (2-4) and muscle contraction or mechanical load (5) resulting in a dramatic decrease in bone mineral density (BMD) and this in turns results in increased bone

fragility and risk of fractures. There has been much effort to find an efficient treatment to prevent or reverse this significant bone loss. Dual-energy X-ray absorptiometry (DEXA) has been extensively used to evaluate BMD and to monitor the effects of treatment on bone sites (6). There is some evidence that effective interventions may exist. Based on a small series of children with CP, it has been suggested that physical therapy (7) may increase BMD. BMD measurement in the lumbar spine can usually be measured in children and young adults with quadriplegic CP, provided they have not had spinal fusion.

We, therefore, in view of the lack of studies on this topic, decided to perform a therapeutic low-impact program in a group of well-defined adult patients with quadriplegic CP in order to evaluate the effect of this 12-week program on the bone mass of quadriplegic subjects. The hypothesis is that there are changes in BMD after this program in CP patients.

METHODS

Patients and controls

Ten patients (three women and seven men) with traumatic paraplegia were chosen. They all voluntarily consented to participate in the study. The criteria of participants in this study included people who suffered from paraplegia and were wheelchair-supported. In addition, 10 sex and age matched (3 women and 7 men) healthy adult controls, randomly selected from the regional population register of the same geographical area were also included. All subjects were required to sign an informed consent document approved by the Aristotle University of Thessaloniki. The age of the cerebral palsy (CP) patients was 28.7 ± 3 years (mean \pm SD) and of the controls 29.4 ± 2.9 years. All the characteristics of participants are presented in table 1.

All participants were living independently in their own homes, without any difference in civil status between patients and controls. The inclusion criteria for the study were the following: diagnosis of CP within 3 years of study participation, 18 years of age or older, medical clearance from the primary care physician to participate in an exercise program and wheelchair-supported. Potential participants were excluded if there were physician-determined major medical problems such as cardiac dysfunction, musculoskeletal impairments or excessive pain in any joint, depression, gastrointestinal or endocrine disease, and if they had insufficient endurance to participate in exercise program 3 times a week for at least 30-minute session. The criteria were the same for the CP patients and the controls, with the exception of CP symptoms.

Procedures

All subjects with CP (10) completed the intervention program which lasted 12 weeks. The emphasis of the exercise program was to dynamically load the axial skeleton at the lumbar spine sites using home-based, low-impact exercises. At baseline, subjects in the exercise group attended a series of induction meetings during which the correct exercise techniques were demonstrated and a supporting resource package was provided.

Each exercise session involved a 5-minute warm-up consisting of general whole body pulse-raising and mobility-promoting activities, followed by preparatory stretching of muscles being worked during the main session. A 5-minute period of pulse-lowering activity and stretching was performed after the exercises were completed. The main section of the home-based program was comprised of 8 to 10 low-impact exercises. Exercises were focused on the lumbar region, consisting of dynamic muscular conditioning of the major muscle groups of the trunk, erector spinae, and muscles of the anterior abdominal wall. Repetitions were 10-12 and sets were designed 3 to 4 for each exercise. In addition to this, gait on specific apparatus was performed as frequent as possible. Subjects were asked to exercise at least twice a week, with a minimum of 10 sessions per month considered necessary for full compliance. Additional meetings were held at 4th and 8th 9 week to provide motivation and support for exercising individuals and to supervise the increase in training intensity. Intensity of exercise was increased by developing the core exercises, increasing the number of repetitions of each exercise, advancing body positions to increase resistance to movement (lever principles), and using resistive tubing or free weights. The program was intentionally flexible to allow individuals of different fitness levels to reach an exercise overload effect.

Subjects in all groups were allowed to continue their customary exercise routines. They were asked, however, not to change their exercise routines.



Picture 1. Application of physiotherapy program into a CP patient (wheelchair quadriplegic)



Picture 2. Quadriplegic patient during exercise application (gait)

Data collection

Data were collected before intervention and immediately after completion of exercise program. Subjects began exercise within 1 to 2 weeks after the baseline assessment. All subjects took their customary medications at the same time relative to each assessment.

Assessments

Bone mineral density

BMD (g/cm^2) was measured at baseline and after 12 weeks at the lumbar spine (L2–L4) by dual energy x-ray absorptiometry (Lunar DPX, Lunar software version 3.1; Lunar Radiation Corp., Madison, WI). All measurements were performed by a single trained operator; the coefficient of variation of dual x-ray absorptiometry was 0.5% at the lumbar spine. DXA measures of BMD are particularly difficult to obtain in this population because of contractures, metallic fixation devices, and motion artifact that result from involuntary muscle spasms and an inability to cooperate. For these reasons, lumbar spine BMD measurements were taken after absolute cooperation between the patient and the examiner.

Body weight and height

Body weight was assessed in all participants before and after the intervention program, when lightly dressed and without shoes, using a calibrated analogue scale. The assessments were made in the morning. The participant's height was assessed when they were in a standing position without shoes.

Table 1. Characteristics of CP patients and control group.

	CP	Controls
Characteristics		
Patients	10	10
Sex(male/female)	7/3	7/3
Age (years)	28.7± 3	29.4± 2.9
Body weight (kg)	77.5± 3.8	77.4± 4.4
Height (cm)	174± 5.3	174.7± 6.1

Statistical analysis

The results are presented as mean and standard deviation (mean± SD). Changes during the 12 weeks were calculated and compared between groups using Student's unpaired *t* tests with 95% confidence intervals (CIs). The Mann–Whitney *U* test was used when the data were not normally distributed. Two-tailed significance tests were used in all the statistical analysis. The Statistical Package for Social Sciences (SPSS 16 Inc., Chicago, IL) was used for the analysis.

RESULTS

Bone mineral density

The BMD of the lumbar spine (L2-L4) increased from baseline to the last visit in the case of CP patients ($p < 0.05$) but this did not occurred in control group. The BMD was not statistically different between the two groups in baseline ($p > 0.05$). All the available data are presented below in table 2.

Table 2. Bone mineral density (BMD) in CP patients and in controls at the two investigated periods.

DEXA	Baseline	After			Baseline	After		
	CP n=10, mean ± SD		<i>p</i>	%Diff	Controls n=10, mean ± SD		<i>p</i>	%Diff
Lumbar spine BMD (g/cm ²)	1.10±0.17	1.17±0.22	0.03*	+6.8	1.19±0.1	1.18±0.1	ns	-0.5

NOTE. At baseline there were no significant differences between the two groups ($p > 0.05$) Results are presented as mean (SD).

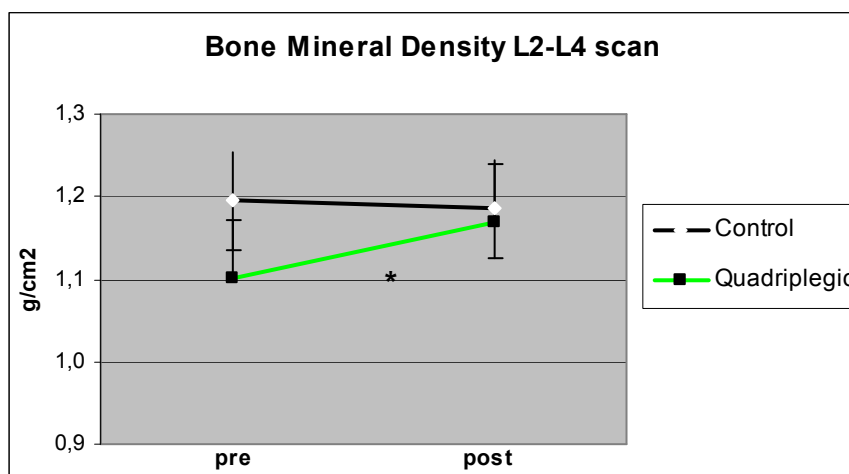


Figure 1. Bone mineral density (BMD) of L2-L4 in CP patients (quadriplegics) and in controls before and after the intervention program.

DISCUSSION

The limitation of the current study is the relatively small number of CP patients. On the other hand, there is a well-matched design for age and group and in addition to this all participants were investigated by the same team and by well-defined instructions. We measured the BMD of the lumbar spine. Significant increment (6.8 %) as a result of intervention program was found in paraplegic patients. Our results show that a 12-week low-impact exercise program may have a positive effect on BMD at the spine in quadriplegic patients.

Several studies have examined bone density in CP (8-10). Inevitably, quadriplegic patients are usually correlated with lower levels of BMD (11) Most individuals in the experimental group presented an increase in BMD suggesting that low-impact training, even with 30-50% body weight support, was efficient in improving the bone mass of chronic quadriplegics.

However, a low-impact program was chosen for our study because it could be performed readily at home without special equipment or supervision and was unlikely to lead to training injuries or fracture in patients with established osteoporosis. The exercises were site specific for the hip and lumbar spine, with body positions and additional resistive devices used in intensive bouts of exercise to produce strain and osteogenic stimulus in these areas. In view of our results, we conclude that prescription of a low-impact exercise program is feasible in quadriplegic patients and is a potentially effective method of increasing BMD. The exercises were simple to perform by people of varying levels of fitness and required only minimal instruction, supervision, and monitoring. Future studies should address methods of increasing uptake and compliance with exercise in this high-risk group and study the effect of more intense modes of exercise training.

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