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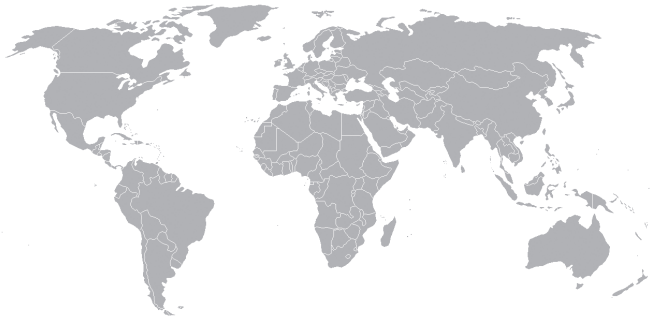

Aerobic exercise training modulates bone mineral status in patients with chronic obstructive pulmonary disease

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) appears to be associated with low bone mineral density (BMD) due to long-term use of corticosteroids as a result patients with COPD are at risk for osteoporosis-related fractures and worsening pulmonary function.

Objective: The present study aimed to measure the effects of treadmill walking exercises on bone mineral status in patients with COPD.

Methods: Sixty patients with moderate COPD of both sexes, their age ranged from 45 to 58 years. Subjects were divided into two equal groups: training group (group A) received aerobic exercise training on treadmill for six months, where the second group (B) was considered as a control group who received no exercise training. The program consisted of three sessions per week for six months.

Results: The results of this study indicated a significant increase in BMD of the lumbar spine & the radius and serum calcium & significant reduction in parathyroid hormone in group (A), while these changes were not significant in group (B).Also; there was a significant difference between both groups at the end of the study.

Conclusion: Treadmill walking exercise training is an effective treatment policy to improve bone mineral status in patients with COPD.

Keywords: Bone Mineral Density; Chronic Obstructive Pulmonary Disease; Exercises.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a prevalent global disorder (1), associated with high risk of osteoporosis in addition to the high economic burden of the disease medical care (2-4). In United States of America the third cause of death is COPD (5). By 2030 it is expected to have 9 million subjects die from COPD every year (6-7). COPD also affects about 9–10% of adult population (8).

Chronic Obstructive Pulmonary Disease (COPD) is a progressive and partially reversible disorder (8) due to its pulmonary and extra-pulmonary manifestations (9, 10) one of these extra-pulmonary manifestations which affects patients with COPD more than health subjects by two to five folds (11-13), the decline in bone mineral density (BMD) was found to be correlated with the decline in the lung functions (14). Moreover, about 6-70% of COPD patients affected with osteoporosis according to the severity of illness (2). The strength of the handgrip strength was found to be closely related to body lean mass, percentage of fat, fat mass composition and bone mineral density (15).

The regular pharmacological agents for osteoporosis have high cost and unlimited side-effects specially with long term intake which limit their use (16-17), these side-effects of the pharmacological therapy forced the medical care members to the non-pharmacological treatment for COPD (18). Weight bearing exercises of moderate to high intensity have a good role in maintenance of bone mineral status among adult populations (19), therefore exercise training is widely accepted treatment strategy for prevention of osteoporosis (29).

According to data from the Healthcare Cost and Utilization Project, corticosteroids were the most common cause of drug-related complications, accounting for 10% of such complications and 141,000 hospital stays in the United States in 2004(30). Corticosteroids-induced osteoporosis results from suppression of bone formation while bone resorption is promoted(31). Corticosteroids have detrimental effects on function and survival of osteoblasts and osteocytes, and with the prolongation of osteoclast survival, induce metabolic bone disease(32). Moderate or high doses of inhaled corticosteroids are associated with increased risk of osteoporosis(33). Long-term low-dose inhaled corticosteroids use increases the rate of bone marrow density (BMD) loss in patients with chronic obstructive pulmonary disease(34).

The aim of this study was to measure bone mineral status response to 6 months aerobic exercise program among patients with chronic obstructive pulmonary disease.

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MATERIALS AND METHODS

Subjects

Sixty patients with moderate COPD of both sexes (38 males & 22 females), their age ranged from 45 to 58 years old. The chronicity of COPD was not less than 10 years. Participants taking bronchodilator therapy in addition to inhaled beclomethasone dipropionate or budesonide in doses ranged from 1000 to 1600 µg/day. After a detailed demographic and clinical history, a spirometry was performed using Spirometer (Spirovit-SP10, Switzerland) in all patients and FVC and FEV1 were expressed as a percentage of predicted. Diagnosis and staging of COPD was according to GOLD criteria (35).Peripheral blood was collected in the morning under fasting conditions, and the plasma concentrations of calcium and parathyroid hormone (PTH) were measured by routine assays. All participants were asked to read and sign an informed consent document prior to participation. Exclusion criteria include endocrinal, renal, liver, cardiac disorders, obesity, diabetes and other chest disease rather than COPD, fractures occurring within the six months preceding the start of the study, disorders of bone metabolism such as osteoporosis and pregnancy, lactation, inadequate contraceptive precautions, amenorrhea or a history of irregular menstrual cycles during the 12 months preceding the start of the study and treatment with any medication likely to influence bone metabolism. All the patients who participated in the study were nonsmokers and continued in their ordinary diet throughout the study.

Following pre-training testing, a randomized block procedure was used to assign qualified participants into two equal groups; group (A) received treadmill walking exercise training. The second group (B) was asked not to participate in any structured exercise program for the duration of the study. This study was approved by the Scientific Research Ethical Committee, Faculty of Applied Medical Sciences at King Abdulaziz University.

Measurements

1. Bone mineral density measurements: Dual Energy X-Ray Absorptiometry ((DXA) GE Lunar Prodigy enCORE software version 8.80, GE Medical Systems, Madison WI) was used to assess the BMD of lumbar spine (L2-L4) and the forearm (33% radius) sites assessed at baseline and after the eight month training period. Subjects removed all metal and plastic before being positioned on the DXA table.

2. Chemical analysis: After fasting for 12 hours blood sample will be taken from each subject in clean plane tubes and for other diagnosis different types of anticoagulant will be used such as K2EDTA, Lithium heparin, and Na2 Citrate. Parathyroid hormone (PTH) and serum calcium were measured in serum with an ELISA (Diagnostics Systems Laboratories, Inc., Webster, TX).

All measurements of bone mineral density (BMD) of lumbar spine & radius, serum calcium, parathyroid hormone, triglycerides, HDL-c, LDL-c, leptin, TNF-α, IL-2, IL-4, IL-6 and BMI were done before the starting of the study (pre-test) and after six months at the end of the study (post-test).

Procedures

Following the previous evaluation, all patients were divided randomly into the following groups:

1. Group (A): Thirty patients with COPD of both sexes (18 males & 12 females) received moderate intensity aerobic exercise training program. The training program consisted of treadmill exercise of progressive increasing intensity and frequency. The starting walking of the treadmill speed was 5 kilometer/hour and at 2 degrees angle of inclination. Then gradually increased at 2 minute intervals until reaching the initial intensity of 60% of the maximal heart rate. Then increased gradually until reaching 80% of the maximal heart rate by the end of the six months. The duration of each session was 30 minutes, included warming up for 5 minutes, 20 minutes for the active stage of training and finally 5 minutes for the cooling down. This training was repeated times per week for six months.

2. Group (B): Thirty patients with COPD of both sexes (20 males & 10 females) were asked to maintain their ordinary current life style for six months.

Statistical analysis

Mean values of the investigated parameters was compared by student paired «t» test. While, the unpaired» test was being used to compare between the two groups (P<0.05).

Results

Both study groups were considered homogeneous regarding the demographic and baseline variables (table 1). The results of this study indicated a significant increase in BMD of the lumbar spine & the radius and serum calcium & significant reduction in parathyroid hormone in group (A), while these changes were not significant in group (B) (Table 2 and3). Also; there was a significant difference between both groups at the end of the study (Table 4).

Table 1: *Mean value of baseline and demographic data for participants in both groups.*

	Mean ± SD		Significance
	Group (A)	Group(B)	
Age (year)	49.43 ± 6.57	47.88 ± 5.63	P >0.05
Gender (male/ female)	18/12	20/10	P >0.05
Weight (kg)	68.12 ± 5.24	70.51 ± 6.11	P >0.05
Height (cm)	170.84 ± 6.13	172.18 ± 7.32	P >0.05
BMI (kg/m2)	24.26 ± 3.42	23.51 ± 3.87	P >0.05
FVC (L)	2.48 ± 0.79	2.53 ± 0.86	P>0.05
FEV1 (L)	1.41 ± 0.85	1.36 ± 0.74	P>0.05
FEV1/FVC (%)	51.22 ± 6.73	50.65 ± 8.19	P>0.05
MVV (L/minute)	48.93 ± 8.68	46.87 ±7.21	P>0.05

BMI = Body mass index; FVC = forced vital capacity; FEV1= forced expiratory volume in the first second; FEV1/FVC = Ratio between forced expiratory volume in the first second and forced vital capacity; MVV= Maximum voluntary ventilation.

Table 2: *Mean value and significance of serum calcium, parathyroid hormone, BMD of lumbar spine and BMD of radius in group (A) before and at the end of the study.*

	Mean ± SD		T-value	Significance
	Before	After		
Serum Calcium (ng/dl)	8.35 ±1.26	10.57 ± 1.19*	7.11	P <0.05
Parathyroid Hormone (ng/dl)	14.52 ± 2.41	12.15 ± 2.13*	7.26	P <0.05
BMD of lumbar spine (mg/cm)	122.16 ± 10.54	147.63 ± 12.81*	8.75	P <0.05
BMD of radius (mg/cm)	257.13 ± 15.72	323.42 ± 17.95*	10.28	P <0.05

BMD: Bone marrow density; (*): indicates a significant difference, P < 0.05.

Table 3: *Mean value and significance of serum calcium, parathyroid hormone, BMD of lumbar spine and BMD of radius in group (B) before and at the end of the study.*

	Mean ± SD		T-value	Significance
	Before	After		
Serum Calcium (ng/dl)	8.43 ± 1.24	8.31 ±1.17	0.82	P >0.05
Parathyroid Hormone (ng/dl)	14.48 ± 2.34	14.65 ± 2.46	0.97	P >0.05
BMD of lumbar spine (mg/cm)	124.36 ± 11.27	122.98 ± 11.23	1.76	P >0.05
BMD of radius (mg/cm)	261.58 ± 14.65	257.12 ± 14.51	1.85	P >0.05

BMD: Bone marrow density.

Table 4: *Mean value and significance of serum calcium, parathyroid hormone, BMD of lumbar spine and BMD of radius in group (A) and group (B) at the end of the study.*

	Mean ± SD		T-value	Significance
	Group (A)	Group (B)		
Serum Calcium (ng/dl)	10.57 ± 1.19*	8.31 ±1.17	6.93	P <0.05
Parathyroid Hormone (ng/dl)	12.15 ± 2.13*	14.65 ± 2.46	6.52	P <0.05
BMD of lumbar spine (mg/cm)	147.63 ± 12.81*	122.98 ± 11.23	7.41	P <0.05
BMD of radius (mg/cm)	323.42 ± 17.95*	257.12 ± 14.51	9.86	P <0.05

BMD: Bone marrow density; (*): indicates a significant difference, P < 0.05.

DISCUSSION

Chronic obstructive pulmonary disease appears to be associated with low bone mineral density (BMD) and studies recently showed that weight bearing exercise training can increase mineral bone density and quality of life, so this study aimed to evaluate the efficacy of treadmill walking exercises on bone mineral status in patients with COPD. The results of this study indicated a significant increase in BMD of the lumbar spine & the radius and serum calcium & significant reduction in parathyroid hormone in group (A), while these changes were not significant in group (B) which means that treadmill walking exercise training is an effective treatment policy to improve bone mineral status in patients COPD, these results agreed with many previous studies in this area.

Lester et al. stated that training interventions of longer duration (6–36 months) have consistently reported positive bone mineral density increases, whereas those of shorter durations (< 6 months) have failed to show similar adaptations (36). Also, Nordstrom et al. reported that athletes who participate in weight-bearing activities have higher BMD than sedentary controls (37). While, Bonaiuti et al. stated that all prescribed exercise programs, including aerobic exercise, resistance exercises or walking are effective at 1 year or more in slowing loss of bone marrow density. Fast walking is recommended as the best prevention and treatment strategy for osteoporosis in postmenopausal women as it is most similar to activities of daily living and may produce the greatest compliance (38). However, Hind et al. reported that regular weight-bearing exercise sessions, two to three times weekly, over a period of at least 6 months in pre- or early pubertal children with cystic fibrosis improves BMD (39). While, Remes et al. said that physical activity is an important factor in attaining peak bone mass (40). Also, Lin et al. stated that weight-bearing exercise had a greater positive effect on BMD than the non-weight-bearing exercise (41). Moreover, Douchi et al. confirmed that lumbar spine BMD increased significantly in individual studies of strength training with/without endurance exercise training (42). Finally, weight bearing exercise is universally recognized as a major and effective prophylaxis against osteoporosis, to firstly stimulate bone accretion during growth; secondly, to stimulate bone accretion once bone loss has occurred and thirdly, to prevent bone loss (39).

The possible mechanism by which exercise maintains the skeletal integrity are: changes in the biochemical structure of the blood by altering the level of its component which has a role in the integrity of normal skeletal and mechanical load of the exercise which can modify and increase bone mass. The rise in serum calcium is mainly due to the effects of exercise induced acidosis. So, when the parathyroid hormone falls the excess hydrogen ions reversibly displace calcium ions from imidazole groups of the albumin molecule, this causing the serum calcium to rise (43). The increase in bone mineral density after exercise may be due to increase in serum calcium associated with decreased parathyroid hormone following exercise training (44).

In conclusion, treadmill walking exercise training is an effective treatment policy to modulate bone mineral status in patients with chronic obstructive pulmonary disease.

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