

Bone metabolism and hand grip strength response to aerobic versus resistance exercise training in non-insulin dependent diabetic patients

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Abstract

Background: Diabetes mellitus has been shown in many studies to be associated with reduced bone mass and an increased risk of fracture. Currently, our understanding of how to use exercise effectively in diabetic patients in prevention of osteoporosis is incomplete and has prompted our interest to identify the type of effective osteogenic exercise.

Objective: The aim of this study was to compare the changes in handgrip strength and bone metabolism after 6 months between aerobic and resistance exercise training in non-insulin dependent diabetic patients in Jeddah area.

Materials and methods: One hundred non-insulin dependent diabetic male patients participated in this study and were divided into two equal groups; the first group (A) received aerobic exercise training, where the second group (B) received resistance exercise training. The program consisted of three sessions per week for six months.

Results: The mean values of serum calcium and Hand grip strength were significantly increased, while the mean values of parathyroid hormone were significantly decreased in both groups. Also, there were significant differences between mean levels of the investigated parameters in group (A) and group (B) after treatment.

Conclusion: Aerobic exercise training on treadmill is appropriate to improve markers of bone metabolism and hand grip strength in non-insulin dependent diabetic patients.

Keywords: Aerobic exercise, resistance exercise, bone mineral density, non-insulin dependent diabetes.

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Introduction

Bone metabolism defects are observed in patients with type 2 diabetes more frequently than in age-matched healthy controls¹. Various effects of type 2 diabetes on bone metabolism and bone turnover have been previously reported²⁻⁴. The incidence of type 2 diabetes and osteoporosis increases worldwide. It is well established that type 2 diabetes mellitus is associated with an increased incidence of osteoporosis and hip and vertebral fractures^{4,5}. A relationship between diabetes and bone metabolism is becoming increasingly recognized⁴. Several studies indicated that hyperglycemia induced a low turnover bone with osteoblast dysfunction^{7,8}. Previous

studies showed that serum osteocalcin was elevated in patients on treatment for diabetes mellitus, while bone specific alkaline phosphatase was reduced. These findings suggest that hyperglycemia affects osteoblast function and bone formation^{9,10}.

Diabetes and osteoporosis are common and complex disorders with an enormous health burden. These conditions can be often associated, especially in middle-age and elderly individuals, with a further worsening of the mortality and morbidity of affected patients⁴. This association is probably due to detrimental effects of impaired glucose metabolism on bone health as well as to an increased risk of falls or other traumas, frequently reported in diabetic patients^{11,12}.

The handgrip strength was most importantly related to body composition (lean mass, fat mass and % fat). Bone mineral density (BMD) of lumbar spine (L1-L4), femoral neck, and total body mass were measured by dual-energy X-ray absorptiometry. Marian et al, suggested that strategies aiming to improve muscle strength and lean mass must contribute to the bone health¹³.

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The prevalence and risk for osteoporosis among women ≥ 50 years old is estimated to increase to approximately 35 million, by the year 2015¹⁴. While there are many pharmacologic agents available for the prevention of osteoporosis, widespread and long term use of these agents is limited due to side-effects, costs¹⁵ and poor long term compliance¹⁶. Therefore, it is essential that non-pharmacologic strategies to prevent osteoporosis continue to be evaluated¹⁷.

The American College of Sports Medicine (ACSM) recommends regular weight-bearing endurance activities in conjunction with resistance activities for preserving bone mass¹⁸. While, Greendale et al, proved that physical activity seems to stimulate bone accretion in a dose-dependent manner with a low threshold home activity are important for osteoporosis prevention¹⁹. Therefore, the aim of this study was to compare the changes in handgrip strength and bone metabolism after 6 months between aerobic and resistance exercise training in non-insulin dependent diabetic patients in Jeddah area.

Patients and methods

Subjects

One hundred non-insulin dependent diabetic male patients were enrolled in this study, their age ranged from 40 to 55 years. All volunteers were asked to read and sign an informed consent document prior to participation. Patients who are smokers, having any endocrine, musculoskeletal, renal, liver, cardiac disorders, obesity, chest diseases, any medication likely to influence bone metabolism or other pathologic processes were excluded. All participants were tested for serum calcium and parathyroid hormone before the treatment and after 6 months at the end of the study. Following pre-training testing, a randomized block procedure were used to assign qualified participants into 2 equal groups; group (A) received aerobic exercise training. The second group (B) received resisted exercise training. All participants were free to withdraw from the study at any time.

Measurements

1. Laboratory analysis:

Fasting venous blood samples were drawn between 7.30 and 9.30 a.m. After collection, blood samples were collected in tubes containing EDTA, and serum samples were clotted at room temperature for 90 min and then centrifuged for 10 min at 1000 \times g. Samples were ali-

quoted and stored at -80°C until analysis. Parathyroid hormone (PTH) and serum calcium: Intact PTH was measured in serum with an ELISA (Diagnostics Systems Laboratories, Inc., Webster, TX). The intra-assay CV was 5.0% and the inter-assay CV was 6.0%.

2. Grip strength assessment:

Hand grip strength of the dominant hand was measured using three successive repetitions with a Jamar hand dynamometer (Sammons Preston Rolyan, Cedarburg, WI, USA). The elbow was flexed at a 90° angle and not allowed to contact any body part. Resting time between subsequent measurements was 30 seconds²⁰. The mean value of the two best performances was used in the analyses. Hand grip was used as an index of general muscle strength.

Measurements of PTH, calcium and hand grip strength were taken 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. Patients in group (A) were submitted to a 40 min aerobic session on a treadmill (the initial, 5-minute warm-up phase performed on the treadmill (Track master 400E, gas fitness system, England) at a low load, each training session lasted 30 minutes and ended with 5-minute recovery and relaxation phase) either walking or running, based on heart rate, until the target heart rate was reached, according to American College of Sport Medicine guidelines. The program began with 10 min of stretching and was conducted using the maximal heart rate index (HRmax) estimated by: $220 - \text{age}$. First 2 weeks = 60–70% of HRmax, 3rd to 12th weeks = 70–80% of HRmax.²¹.

2. Patients in group (B) were submitted to a 40 min session of resistance training. The program began with 10 min of stretching and was conducted with exercises done on eight resistance machines (Nautilus Sports/Medical Industries, Independence, VA, England). The resistance machines were used: chest press, bicep curl, triceps extension, lower back, abdominals, leg press, leg curl and leg extension. Subjects performed three sets of 8–12 repetitions, with 60 s of rest between each set. Resistance was increased by five pounds after the subject was able to complete three sets of eight repetitions

on three consecutive days. Subjects were trained using between 60 and 80% of their one maximal repetition weight (1-RM)²².

Statistical analysis

The mean values of PTH, calcium and hand grip strength obtained before and after three months in

both groups were compared using paired "t" test. Independent "t" test was used for the comparison between the two groups (P<0.05).

Results

The two groups were considered homogeneous regarding the baseline descriptive characteristics (Table 1).

Table (1): Comparison of clinical data between both groups.

	Group (A)	Group (B)
Age (year)	47.76 ± 5.32	48.91 ± 5.85
BMI (kg/m²)	30.74 ± 3.61	31.33 ± 4.12
Fat mass (kg)	20.31 ± 4.11	21.40 ± 3.94
HBA_{1c} (%)	6.92 ± 1.35	7.14 ± 1.19
Albumin (gm/dl)	3.73± 0.86	3.87± 0.78
FPG (mg/dL)	135.45 ± 11.42	137.60 ± 10.43
Hb (gm/dl)	12.15± 1.57	12.04± 1.31
Total Bilirubin (mg/dl)	1.41± 0.76	1.45± 0.82
SBP (mm Hg)	125 ± 12.63	127 ± 12.96
DBP (mm Hg)	83 ± 7.92	85 ± 8.21
TC (mg/dl)	192.3012.86	194.5313.65
HDL-c (mg/dl)	34.542.71	33.352.49
LDL-c (mg/dl)	132.939.78	133.278.94
TG (mg/dl)	154.1510.21	155.619.83

BMI = Body Mass Index

Hb = Hemoglobin

FPG= Fasting Blood Glucose

SBP= Systolic blood pressure

DBP= Diastolic blood pressure

HBA_{1c} = glycosylated hemoglobin

TC= Total cholesterol

HDL-c= High density lipoprotein cholesterol

TG= Triglyceride

LDL-c= Low density lipoprotein cholesterol

(*) indicates a significant difference between the two groups, P < 0.05.

The mean values of serum calcium and hand grip strength were significantly increased, while the mean values of parathyroid hormone were significantly de-

creased in group (A) received aerobic exercise training and group (B) received resistance exercise training (Table 2 & 3).

Table (2): Mean value and significance of Serum Calcium, Parathyroid Hormone and Hand grip strength in group (A) before and after treatment.

	Mean \pm SD		T-value	Significance
	Before	After		
Serum calcium (ng/dl)	8.26 \pm 1.47	10.91 \pm 1.36	6.52	P <0.05
Parathyroid hormone (ng/dl)	14.91 \pm 2.85	11.52 \pm 2.61	6.61	P <0.05
Hand grip strength (mmHg)	138.45 + 8.61	172.74 + 7.78	8.93	P <0.05

Table (3): Mean value and significance of Serum Calcium, Parathyroid Hormone and Hand grip strength in group (B) before and after treatment.

	Mean \pm SD		T-value	Significance
	Before	After		
Serum calcium (ng/dl)	8.14 \pm 1.52	9.37 \pm 1.42	3.41	P <0.05
Parathyroid hormone (ng/dl)	14.63 \pm 2.97	13.12 \pm 2.75	3.62	P <0.05
Hand grip strength (mmHg)	134.98 + 7.96	155.24 + 7.18	5.25	P <0.05

Also, there were significant differences between mean levels of the investigated parameters in group (A) and group (B) after treatment (Table 4).

Table (4): Mean value and significance of Serum Calcium, Parathyroid Hormone and Hand grip strength in group (A) and group (B) after treatment.

	Mean \pm SD		T-value	Significance
	Group (A)	Group (B)		
Serum calcium (ng/dl)	10.91 \pm 1.36	9.37 \pm 1.42	3.34	P <0.05
Parathyroid hormone (ng/dl)	11.52 \pm 2.61	13.12 \pm 2.75	3.16	P <0.05
Hand grip strength (mmHg)	172.74 + 7.78	155.24 + 7.18	4.35	P <0.05

Discussion

In recent decades, quality of life and life expectancy of non-insulin dependent diabetic patients have been improved by better quality in treatment. Recently, new concerns have been directed to the reduced bone density in non-insulin dependent diabetes mellitus becoming an escalating burden worldwide due to an increased in life expectancy. Also, non-insulin dependent diabetic patients have lower levels of fitness and strength than their healthy peers. The physical therapist, along with the non-insulin dependent diabetes mellitus care team, can assist in preparing an individual to begin or progress to a physical activity program that enhances fitness level, body composition and overall well-being. This study aimed to compare the effects of aerobic treadmill walking exercises and resistance exercises on markers of bone metabolism and hand grip strength in male patients with non-insulin dependent diabetes mellitus.

The results of the present study concerning the mean values of serum calcium were significantly increased, while the mean values of parathyroid hormone were significantly decreased in group (A) and group (B). Also, there were significant differences between mean levels of the investigated parameters in group (A) and group (B) after treatment. These results agreed with Bradney et al. and Welton et al. reported that weight-bearing exercise is critical to ensure adequate bone mass accrual in childhood and may be even more important than dietary calcium intake^{23,24}. However, Lanyon et al., said that the exact mechanism by which weight loading increases bone mass is not known but is likely related to dynamic strains in bone tissue regulating bone formation and resorption.⁶ Unusually high strains and high strain rates are particularly osteogenic²⁵.

Also, Lester et al., conducted a previous study to determine whether aerobic, resistance, or combined aerobic and resistance exercise programs conducted over eight weeks and compared to a control group could produce changes in biochemical markers of bone turnover indicative of bone formation. Biomarkers of bone formation were increased in the resistance and combined groups, while biomarkers of bone resorption were decreased and increased, respectively, after training in all groups. Small changes in BMD were observed in the distal tibia in the Aerobic and Combined groups, respectively. The results of the present study demonstrate

that participation in an eight week physical training program that incorporates a resistance component by previously inactive young women results in alterations in biomarkers of bone remodeling indicative of increased formation without substantial alterations in markers of resorption²⁵.

Finally results of the present study concerning the mean values of hand grip strength were significantly increased in group (A) and group (B). Also, there were significant differences between mean levels of the investigated parameters in group (A) and group (B) after treatment. These results approved by Marin et al.²⁶, stated that Body weight was strongly and positively related to BMD in all sites, but the most important component of body composition was lean mass, also significantly related to all BMD sites, whereas fat mass was weakly related to the femoral neck BMD. The handgrip strength was most importantly related to lumbar spine, femoral neck, and total body BMD¹³.

Conclusion

Aerobic exercise training on treadmill is appropriate to improve markers of bone metabolism and hand grip strength in patients with non-insulin dependent diabetic patients.

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