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Effect of Resistance Exercises on Nitric Oxide Level in Type 2 Diabetes

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Abstract: Nitric oxide is a potent signaling molecule, a key determinant of endothelial function, metabolic and vascular health. The correct function of the endothelium depends on the nitric oxide generation rate. Diabetes mellitus type-2 contributes to atherogenesis by inducing endothelial cell injury and dysfunction. The study was conducted to measure the effect of resistive training on the level of nitric oxide (No*x*) in type 2 diabetes. The values were measured before and after the program. Twenty subjects volunteered to follow a program of 12 weeks of moderate resistive training 3 times per week. Results revealed that there was a significant improvement in the values of nitric oxide at the end of the exercise program. In conclusion, the resistive exercises had a significant effect on the nitric oxide level in types 2 diabetes.

Key words: Endothelial Function · Atherogenesis · Cardiovascular Disease

INTRODUCTION

Diabetes mellitus (DM) is defined as a metabolic disorder characterized by the presence of hyperglycemia due to defective insulin secretion, defective insulin action or both. The chronic hyperglycemia of diabetes is associated with relatively specific long-term microvascular complications affecting the eyes, kidneys and nerves, as well as an increased risk for cardiovascular disease [1].

Type 2 diabetes mellitus (T2DM) is characterized by an inability to maintain glucose homeostasis during rest and most daily activities. A precursor to T2DM is insulin resistance, in which major tissues such as the muscle become desensitized to insulin, thereby resulting in elevated fasting and basal levels of blood glucose and/or excursions into hyperglycemia [2].

Type 2 diabetes mellitus is independently associated with an increased risk for cardiovascular diseases that is primarily due to the early development of advanced atherosclerotic vascular changes. Vascular endothelial and smooth muscle cell dysfunction as well as large arterial stiffness are considered to be markers of subclinical atherosclerosis with a significant prognostic role in high risk populations [3].

Endothelial dysfunction is the term used to refer to an impairment of endothelium-dependent vasorelaxation caused by a loss of nitric oxide (NO) bioactivity in the vessel wall. Impaired endothelium-dependent vasodilatation, which appears as an early event in the pathogenesis of atherosclerosis, has profound prognostic implications for adverse cardiovascular events and clinical outcomes [4].

Hyperglycemia, insulin resistance and elevated free fatty acids trigger systemic inflammation and impair NO bioavailability, leading to impaired endothelial function. Insulin is a normal regulator of endothelial nitric oxide synthase activation and NO production through successive phosphorylation. Insulin resistance in DM attenuates this pathophysiological process and suppresses the normal NO secretion. Within the pathophysiological alterations of DM, free fatty acids are typically elevated. Consequently, NO bioavailability is further impaired, whereas oxidized low-density lipoprotein formation is enhanced [5].

This study was conducted to evaluate the effect of resistive training on nitric oxide level in type 2 diabetic subjects.

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MATERIALS AND METHODS

The study was conducted on twenty subjects for 12 weeks. Subjects were randomly selected from the General Hospital of Kom-Hamada AL-Buhira Governorate.

The Inclusion Criteria were:

- All subjects were type 2 diabetic, controlled with oral hypoglycemic drugs.
- All subjects were between 50-60 years old.
- All subjects suffered from diabetes for at least 5 years.

The Exclusion Criteria were:

- Insulin controlled blood glucose level.
- Cardiac diseases (hypertension higher than 140/100 mmHg, ischemic heart diseases).
- Renal, liver, or thyroid diseases.
- Physical impairments preventing following the study program.

Assessment Tool:

- Laboratory analysis for nitric oxide level in blood. The procedure underwent twice, before and after the end of the exercise program.

Exercise Program: Subjects joined a resistance exercise program using various weights, according to the following parameters:

- Mode: Resistance exercises for the following muscles (quadriceps, hamstrings, hip abductors, biceps and triceps).
- Repetition: 1 bout each consists of 8-10 sets for every individual muscle.
- Duration: twenty minutes in total.
- Intensity: moderate (50% of 1-repetition maximum [1-RM])
- Frequency: 3 times per week for 12 weeks.

Data Analysis and Statistical Design:

- Descriptive statistics and t-test were conducted for the mean age, weight, height and BMI.
- Paired t test for comparison between pre and post treatment measures.
- The level of significance for all statistical tests was set at $p < 0.05$.

RESULTS

General Characteristics of the Subjects: Twenty subjects suffering from type 2 diabetes were included in this study. They received resistance exercises. Their mean ± SD of age, weight, height and BMI were 55.8 ± 2.65 years, 84.2 ± 7.39 kg, 160.8 ± 3.32 cm and 32.54 ± 2.23 kg/m² respectively as shown in Table (1).

Pre and Post Treatment Mean Values of NO: The mean ± SD of NO pre-treatment was 10.97 ± 0.94 micromol/L while post treatment was 77.37 ± 4.57 micromol/L. The mean difference was -66.4 micromol/L and the percent of change was 605.28%. There was a significant increase in post treatment mean value of NO compared with pre treatment ($p = 0.0001$) (Table 2).

Table 1: Descriptive statistics and t test for the mean age, weight, height and BMI

	$\bar{x}$± SD	MD	t- value	p-value	Sig
Age (years)	55.8 ± 2.65	-0.3	-0.23	0.81	NS
Weight(kg)	84.2 ± 7.39	-0.45	-0.14	0.89	NS
Height(cm)	160.8 ± 3.32	-1	-0.55	0.58	NS
BMI(kg/m²)	32.54 ± 2.23	0.26	0.25	0.8	NS

$\bar{x}$: Mean SD: Standard Deviation MD: Mean difference
t value: Unpaired t value P value: Probability value
NS: Non significant

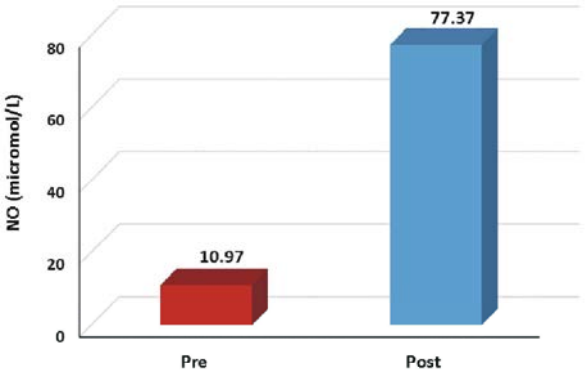

Fig. 1: Pre and post treatment mean values of NO

Table 2: Comparison between pre and post treatment mean values of NO.

	NO (micromole/L)					
	$\bar{x}$± SD	MD	% of change	t- value	p-value	Sig
Pre	10.97 ± 0.94	-66.4	605.28	-42.17	0.0001	↑S
Post	77.37 ± 4.57					

$\bar{x}$: : Mean, MD: Mean difference, p value : Probability value
SD : Standard deviation, t value : Paired t value, S: Significant

DISCUSSION

This study was conducted to measure the effect of resistance training on nitric oxide level in type 2 diabetic subjects. Twenty volunteers aging between 50-60 years old participated in this study. They joined a resistance exercise program of 12 weeks 3 times per week, between November 2014 and January 2015.

Nitric oxide levels were measured before and after the 12 weeks exercise program. The analysis of these results showed a significant improvement in the level of nitric oxide.

Recent studies have demonstrated that exercise is an efficient non-pharmacological treatment to dysfunctions in the endothelium, especially because of its chronic effects in the enhancement of Endothelial Nitric Oxide Synthase and subsequent NO production [6].

A study of six months period was designed to assess the effect of regular aerobic training exercise on endothelium-dependent arterial dilatation in Chinese men with impaired fasting glucose. The results showed that endothelium-dependent arterial dilation in sedentary patients with impaired fasting glucose was significantly improved over the 6-month exercise training period [7].

Montero *et al.* [8] conducted a study to measure the effect of 14 weeks of regular aerobic exercise training on flow-mediated dilation (FMD) of the brachial conduit artery, as an indicator for endothelial function in type 2 diabetes mellitus subjects. The results were that exercise training alone improved FMD, showing its capacity to restore arterial endothelial function in T2DM subjects.

These results were contrary with the results of Kwon *et al.* [9]. They designed a study to measure the effects of aerobic exercise versus resistive training on the endothelial functions measured by flow-mediated dilation in Korean diabetic women. The results revealed that aerobic exercise appears to be more beneficial than resistance exercise for improving endothelial function in type 2 diabetes mellitus.

From the previous one can conclude that resistance training can improve the level of nitric oxide levels in type 2 diabetic subjects.

CONCLUSIONS

Resistance training has a positive effect on nitric oxide levels in type 2 diabetic subjects. This study suggests the resistance training as an effective intervention to improve nitric oxide levels in type 2 diabetic subjects.

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