

## Aerobic Exercises Versus Electrical Stimulation of Acupuncture Points on Glycemic Control and Hypercholesterolemia in Type Two Diabetic Women

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**Abstract:** Chronic hyperglycemia and hyperlipidemia are the leading causes of complications in patients with diabetes. Different non pharmacological treatment are available for controlling the diabetes including diet control, aerobic exercise, resistance exercise and acupuncture. This study was conducted to compare the effect of moderate intensity aerobic exercise versus electrical stimulation of acupoints of diabetes mellitus on the glycemic control and the total cholesterol in type two diabetes mellitus (T2DM). Forty women with T2DM were enrolled in this study with ages ranged from 40 to 50 years. They were assigned randomly into two groups of equal number; group (A) performed moderate intensity aerobic exercise and group (B) who underwent an application of electrical stimulation of acupoints of diabetes mellitus (ST36, LI11 and LV3). Both programs were performed 3 sessions weekly for 12 weeks. Glycosylated haemoglobin (HbA1c) and total cholesterol were measured before and after the study. The results revealed significant improvement in HbA1c and total cholesterol with aerobic exercise and with electrical stimulation of acupoints but there was no significant difference between the two types of treatments. In conclusion, aerobic exercise and electrical stimulation of acupoints could be used as effective adjuncts for the management of T2DM.

**Key words:** Cycling exercise • Acu-TENS • Glycosylated Haemoglobin • Total Cholesterol

### INTRODUCTION

Type two diabetes mellitus (T2DM) is a multifactorial, heterogeneous group of disorders characterized by a deficiency or failure in maintaining normal glucose homeostasis due to inefficient insulin action (insulin resistance at target tissues). More than 90%-95% of all diagnosed cases of diabetes are of this type and the majority of these patients are adults. It is typically associated with obesity, sedentary lifestyle and family history of diabetes [1].

Hyperglycemia is the main finding of T2DM and chronic hyperglycemia is the leading cause of diabetes complications [2]. Glycaemic control is a term that is used to refer to successful treatment of patients with T2DM [3].

Lipid abnormalities are common in patients with T2DM which increased the risk of cardiovascular diseases. Management of lipid abnormalities through

lowering low density lipoproteins cholesterol, elevating high density lipoproteins cholesterol, and lowering triglycerides has been shown to reduce macro vascular disease and mortality in patients with T2DM [4].

Diabetes mellitus carries economic and social burden for both patients and society as it adversely affects personal health, quality of life, life expectancy and has significant implications on the health care system. In Egypt, diabetes is a huge public health problem as there were over 7.5 million cases of diabetes in 2013 and 16.8% of adult population aged from 20 to 79 years has diabetes [1, 4].

Exercise is considered the main component in the management of type two diabetes as it targets the metabolic derangements of diabetes. In the post-absorptive state, moderate exercise decreases the plasma glucose concentration that is followed by increased insulin sensitivity [5, 6].

Acupoints stimulation using transcutaneous electrical nerve stimulation (TENS) with a low stimulation frequency was introduced as an effective method to enhance glucose metabolism [7].

Therefore, the current study was conducted to explore which is more beneficial in improving the glycemic control and the hypercholesterolemia in T2DM women: aerobic exercises or electrical stimulation on acupuncture points of diabetes mellitus.

## MATERIALS AND METHODS

**Subjects:** Forty women with T2DM, aging from 40 to 50 years, were recruited from the outpatient Diabetes Mellitus clinic of Kasr Al-Aini Hospital, Giza, Egypt. The patients were divided randomly into two groups of equal number (each consisted of 20 patients); group (A) performed aerobic exercises on cycle ergometer, while group (B) received electrical stimulation using TENS on acupuncture points of diabetes mellitus. The practical part of the current study was performed in The Outpatient Clinic of Faculty of Physical Therapy, Cairo University from February to June 2015.

**Inclusion Criteria:** Patients participated in the current study have met the following criteria:

- Patients' ages were ranged from 40 to 50 years.
- Patients were diagnosed as non-insulin dependent diabetics from two to five years ago.
- Females patients are only allowed to participate.
- Body Mass Index (BMI) of all patients was  $< 30$  and  $\leq 34.9$  Kg/m<sup>2</sup>.
- Patient fasting blood glucose test result ( $>126$  mg/dl) and glycosylated haemoglobin ( $> 6.5\%$ , 48 mmol/mol).
- Patients have normal blood pressure.
- All patients were maintained in their prescribed medications.

**Exclusion Criteria:** Patients were excluded from the study if they had any of the following criteria:

- Diabetic neuropathy, autonomic neuropathy and nephropathy.
- Orthopedic problems or fractures of lower extremities.
- Severe osteoarthritis in any joint of the lower extremities.
- Haemodynamically unstable patients.
- Central nervous system dysfunction.
- Body Mass Index  $\leq 30$  and  $35 \geq$  Kg/m<sup>2</sup>.
- Patient with skin infection.

All patients have received a through explanation of the objectives and procedures of the study and a written informed consent was signed by each patient before participation in the study. Before starting the program, a complete history and physical examination were taken for all patients with particular attention paid to identify any long-term complications of diabetes.

This study was reviewed and was approved by the Ethics Committee of Faculty of Physical therapy, Cairo University.

## Instrumentations and Procedures for Evaluation

**Identifying the BMI for Each Patient:** Patients' weight and height were measured using standard weight and height scale (floor type, RGT-200, China) and the BMI was identified to fulfill the inclusion criteria according to the formula: BMI=body weight in kilograms/height in meter squared [8].

**Measurement of Glycosylated Haemoglobin and Cholesterol Level:** The level of glycosylated haemoglobin and serum cholesterol level were measured using analyzing chemicals and glycosylated hemoglobin ELISA kits. Venous blood samples were drawn from each patient using disposable plastic syringes which were kept in polypropylene tubes with EDTA and centrifuge was used for separating blood serum. In this study glycosylated hemoglobin was measured in blood using quantitative colorimetric method (Stanbio Glycohemoglobin procedure No.0350). Total cholesterol test was done using the enzyme-linked immunosorbent assay which is a one step colorimetric assay to detect the level of serum total cholesterol. The above procedures were done before and after the completion of the study (12 weeks) for patients of both groups.

## Instrumentations and Procedures for Treatment

**For the Study Group (A):** The patients in this group performed moderate intensity aerobic exercises on bicycle ergometer (Tectrix, USA) which is connected to a digital screen to show the resistance limit, heart rate and pedaling rate. The exercise program consisted of 3 sessions weekly, for 12 weeks. On the first visit, the exercise protocol was explained, the Borg scale for rating of perceived exertion (RPE) was explained for each patient [9] and the patient was allowed to complete a trial on the bicycle ergometer. All exercise sessions were completed under the supervision of the physical therapist. In the exercise protocol, patients were asked to sit for 10 minutes pre exercise for acclimation. The session was initiated as 30 minutes; 5 minutes warm-up and 5 minutes cool-down

in the form of unloading cycling. In between; 20 minutes of cycling at moderate intensity according to Borg Scale (12-14 on the scale). RPE were monitored to ensure patients were exercising at their prescribed intensity throughout the study. Patients were encouraged to increase their exercise time by 5 minutes each two weeks until they reach 40 minutes at the ninth week, which was maintained until the end of the 12 weeks program. The level of blood sugar level was tested for each patient using ACCU-CHEK Aviva Expert meter before the session, if the sugar level was less than 100 mg/dl. Patient was given a chance to take a 15 gm carbohydrate snacks and reassessed 20 minutes later to ensure that the blood sugar level was not dropping below 100 mg/dl before exercise intervention. The exercise precaution was based on recommendation by American Diabetes Association [10].

**For the Study Group (B):** The patients in this group received TENS (model KA-F25, China) on acupoints of diabetes mellitus (ST36, LI11 and LV3 acupoints) for 30 minutes with frequency of 10 Hz and intensity of 5 milliamper (mA) with a discontinuous wave (muscle contraction 7 times with an interval of 8 seconds between contractions, three times weekly for 12 weeks [11]. The electrical stimulation was bilaterally applied to acupuncture points: the electrodes were placed on ST36 (Zusanli, located on the outside of the leg, approximately one hand width below the kneecap, just off the bone, LI11 (Quchi, located in the elbow depression at the lateral end of the transverse cubital crease and the lateral epicondyle of the humerus and LV3 (Tai chong, located on the top of

the foot, in the depression where the first and second metatarsal bones meet) while the patient in long sitting position with back supported and forearms and legs bared.

**Statistical Analysis:** The data obtained were analyzed using descriptive statistics of mean and standard deviation for all the variables. Inferential statistics of dependent and independent t-tests were used to explore differences in mean values of HbA1c and total cholesterol between the two groups and within each group. The SPSS for windows was used for the analysis and the level of significance was set at  $p \leq 0.05$ .

## RESULTS

Comparison of the effects of aerobic exercise in the form of cycling and electrical stimulation of acupoints of diabetes mellitus on the glycemic control and the level of total cholesterol in T2DM women was studied on 40 diabetic women who were divided randomly into two groups of equal number. Comparison of the demographic and clinical characteristics (age, weight, height and BMI) of the patients in both groups revealed no significant differences at the entry of the study as represented in Table (1).

Results concerning HbA1c as represented in Table (2) showed: for group A, the mean value of pre treatment was  $(8.71 \pm 1.09)$  & post treatment was  $(7.96 \pm 1.12)$  with a significant difference between pre and post treatment mean values ( $P = 0.001$ ). For group B the mean value of pre treatment was  $(8.15 \pm 0.42)$  & post

Table 1: Demographic data of patients of both groups in the study (A and B)

Variable	Group (A)	Group (B)	t-value	p-value	Significance
	Mean± SD	Mean± SD			
Age (year)	47.20 ±2.1	47.93±1.7	-1.01	0.32	NS
Weight (kg)	85.13±11.5	82.33±5.11	0.86	0.40	NS
Height (cm)	160.53±6.8	159.93±4.2	0.29	0.78	NS
BMI(kg/cm <sup>2</sup> )	33.02±1.8	31.99±1.4	0.98	0.34	NS

SD: Standard Deviation, Kg: kilogram, Cm: Centimeter, P- value: Probability Level, NS : Non-Significant

Table 2: Analytic statistics for HbA1c and blood cholesterol of both groups

	Groups	Pre- treatment Mean± SD	Post-treatment Mean± SD	p-value	t-value
HbA1c (%)	A	8.71±1.09	7.96±1.12	0.001*	4.55
	B	8.15±0.42	8.06±0.41	0.004*	3.39
Between groups	p-value	0.08	0.74		
	t-value	1.80	-0.32		
Blood cholesterol (mg%)	A	226.27±10.76	211.27±9.68	0.001*	15.93
	B	222.40±11.83	208.27±13.51	0.001*	6.03
Between groups	p-value	0.35	0.49		
	t-value	0.93	0.69		

SD: Standard Deviation, P- value: Probability Level, \*: significant

treatment was  $(8.06 \pm 0.41)$ , with a significant difference between pre and post treatment mean values ( $P=0.004$ ). While comparison between both groups revealed no significant differences either in the pre or post treatment values with P value (0.08 and 0.74 respectively).

Regarding the results of the blood cholesterol level as represented in table (2): for group A the mean value of pre treatment was  $(226.27 \pm 10.76)$  & post treatment was  $(211.27 \pm 9.68)$ , paired t-test results showed significant difference with  $P=0.001$ . For group B the mean value of pre treatment was  $(222.40 \pm 11.83)$  & post treatment was  $(208.27 \pm 13.51)$  and paired t-test results showed significant difference with  $P=0.001$ . While comparison between both groups revealed no significant differences either in the pre or post treatment values with P value (0.35 and 0.49 respectively).

## DISCUSSION

Diabetes mellitus is an increasingly prevalent and costly disease that can cause damage to many structures in the body. Many of these adverse effects are caused by hyperglycemia and hyperlipidemia. Without proper treatment, diabetes can cause many serious long-term complications such as cardiovascular disease, chronic renal failure, and retinal damage, but people with diabetes can take steps to control the disease and lower the risk of complications [12, 13].

This study was conducted to compare the effects of aerobic exercise in the form of cycling and electrical stimulation of acupoints of diabetes on the glycemic control and total cholesterol in T2DM women. The findings of this study revealed improvement (decrease) in the HbA1c and blood cholesterol level in response to both aerobic exercise and electrical stimulation of acupoints, with non significant differences when comparing the effects of both modalities.

The reason for choosing HbA1c as a method for assessment of glycemic control in this study is based on the recommendation made by the International Expert Committee [14]. Also, HbA1c is used in the diagnosis as well as in monitoring the effects of treatment of diabetes because HbA1c reflects the average plasma glucose levels over the recent 8 to 12 weeks and it is not affected by short-time lifestyle changes [1, 15].

Patients with T2DM are often presented with low physical fitness because they are not capable of overcoming the numerous barriers of physical activity [16]. However, exercise has been considered the cornerstone of diabetes management, along with diet and

medication [17]. Numerous studies strengthen the importance of long-term physical activity programs for the treatment and prevention of diabetes and its complications [4].

Low insulin sensitivity as well as low glucose effectiveness are often shown in T2DM patients. Enhancement of insulin sensitivity in T2DM patients has been shown after moderate aerobic exercise training for 3 months as exercise increases glycogen synthase activity so the glucose uptake in skeletal muscles is increased. As skeletal muscle is a major site of insulin resistance; exercise training has proved to be useful in the management of insulin resistance state in T2DM [18-20].

In this study, all patients were exercised at moderate intensity. Hansen *et al.* [21] stated that moderate intensity is the best choice for exercising this group of patients and they revealed in their study that prolonged continuous low-to-moderate-intensity exercise training is equally effective when compared with more intense exercise training to lower blood HbA1c level. This is of important clinical relevance, as patients with long-standing T2DM generally suffer from muscle weakness, cardiovascular co-morbidities and reduced exercise tolerance. Concerning the number of exercise sessions per week, Sigal *et al.* [22] recommended that the interval between sessions should not exceed 72 hours.

The results of the current study showed improvement due to decreased level of the HbA1c and blood cholesterol level in group (A) with 8.50 % and 6.62% respectively.

The results of Okada *et al.* [23] agree with the result of the current study as they revealed reduction of HbA1c by 7.4% after aerobic exercise training in the form of cycling for patients with T2DM.

In the current study, cycling exercise induced reduction in the total cholesterol. Exercise lowers the elevated blood cholesterol by increasing the amount of high-density lipoproteins, which are mainly responsible for removing cholesterol from the blood stream. By lowering the cholesterol level in diabetics, the risk for cardiac disease or stroke is also reduced [24].

The results of the current study agree with Lazarevic *et al.* [25] who demonstrated beneficial effects of regular cycling exercises on cholesterol control, glycemic control and insulin resistance as regular cycling exercises increased the insulin receptors sensitivity and break down of lipid molecules.

The results of the present study also revealed an improvement (decreased) of the HbA1c and blood cholesterol level by 1.1 % and 6.35% respectively in group (B).

These results were consistent with the findings of Arsalan [26], who found that treatment of diabetes with TENS stimulation at a frequency of 25 Hz and intensity of 9 mA on acupoint was effective in reducing blood glucose level.

In the current study the acupoints of ST36 and LI11 were used which agrees with Yan-Fen and Zhuangl, [27] who proved precise therapeutic effects in reducing lipids when using acupoints of the Spleen and Stomach Meridians which are most commonly selected in the treatment of hyperlipidemia.

The effect of acupuncture treatment on reducing the level of triglyceride and total cholesterol suggested that these changes in lipid metabolism may be caused by increase in the serum beta-endorphin levels [28].

Zhiyuan *et al.* [11] revealed improvement in the state of patients with T2DM with Acu-TENS and they recommended the use of Acu-TENS as a therapy in clinical application due to its beneficial effects on the biochemical and physical indices of patients with T2DM.

It was reported by Chen *et al.* [29] that acupuncture prevents and reverses dangerous cellular accumulations of fatty materials in cases of high cholesterol by prevention and reversal of the formation of foam cells which form at the site of fatty streaks and considered as the beginning of atherosclerotic plaque formation in blood vessels. The presence of foam cells is indicative of an increased risk of heart attacks and strokes. Based on the research, the investigators note that acupuncture could play an essential role in treating hyperlipidemia and stopping it from developing into a further level and increases the rate of cholesterol efflux from macrophages.

## CONCLUSION

Based upon the results of the current study it can be concluded that aerobic exercises in the form of cycling at moderate intensity and Acu-TENS on acupoints of diabetes three times weekly for 12 weeks are equally effective in controlling the hyperglycemia and hypercholesterolemia in T2DM adult women.

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