

Effect of Aerobic Exercises on Blood Glucose Level and Placental Blood Flow in Type II Diabetic Pregnant Women

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ABSTRACT

This study was conducted to determine the effects of moderate aerobic exercise on the maternal blood glucose level as well as umbilical blood flow in Type II diabetic pregnant women. Twenty multiparous pregnant women with Type II diabetes at 24 weeks' gestation from Department of Obstetrics and Gynecology, at Bab El-Sheria University Hospital were participated in this study. Their age ranged from 25-32 years old (28.57 ± 2.18 yrs.), their body mass index $>30 \text{Kg/m}^2$ (31.96 ± 1.84) and all of them were under insulin therapy. Each patient underwent moderate intensity aerobic exercise training (60% of maximum heart rate) for 30 minutes, 3 times /week for 4 weeks (12 sessions). Fasting blood glucose level and umbilical artery blood flow for each patient were evaluated before starting and after the end of the training program. Results of this study revealed that moderate intensity aerobic exercise training caused a statistically highly significant ($P < 0.001$) decrease in blood glucose level as well as statistically highly significant ($P < 0.001$) improve in the placental blood flow through decreasing umbilical artery pulsatility index (PI), resistance index (RI), systolic/diastolic (S/D) ratio and maximum systolic velocity as well as increasing its end diastolic velocity. Thus it could be concluded that aerobic exercises are effective in reducing blood glucose level and improving placental blood flow offering more nutrients to the fetus in Type II diabetic pregnant women.

Key words: Type II diabetes - Moderate intensity aerobic exercise - Blood glucose level - Umbilical artery blood flow.

INTRODUCTION

Diabetes is one of the most common chronic diseases encountered in the health care setting. It places a substantial burden on the individual, society and the economy¹. It has been known that diabetes antedating pregnancy can have severe adverse effects on fetal and neonatal outcomes¹⁰.

Several researches have indicated that type II diabetes is becoming an increasingly prevalent disorder in young people all over the world^{2,6}. It may range from predominant insulin resistance with relative insulin deficiency to predominant secretory defect with insulin resistance. This form of diabetes, which accounts for ~90-95% of those with

diabetes, previously referred to as non-insulin-dependent diabetes²².

It is a general clinical observation that the number of pregnant women with pre-gestational type II diabetes has become more frequent in the recent years; however, little knowledge exists concerning the prevalence and outcome of these pregnancies⁴.

Women with type II diabetes are of greater risk of prenatal mortality, congenital malformation, preterm delivery, large-sized infants, and fetal loss before 24 weeks' gestation when compared to those of normal population¹¹. Also, women who have diabetes before pregnancy have birth defect four times greater than women who got diabetes during pregnancy⁴.

There are at least two pathological defects in diabetic pregnant women, one is a decreased ability of insulin to act on peripheral tissue to stimulate glucose metabolism or inhibit hepatic glucose output i.e. insulin resistance. The other is inability of pancreas to fully compensate this insulin resistance²⁰.

Many clinical complications of type II diabetes may be ascribed to attention in vascular structure and function as non occlusive microvascular impairment and macroangiopathy characterized by atherosclerosis²³. Maternal diabetes also produces alterations in red blood cells, oxygen release and reduced placental as well as uterine blood flow which contribute to the increased incidence of intrauterine growth retardation due to a reduction in the transferred nutrients to the fetus¹³.

Umbilical artery (UA) Doppler blood flow velocity waveforms can be used to identify fetuses that might benefit from increased surveillance or planned delivery. Owing to difficulties encountered with volumetric blood flow assessment in small, pulsatile, convoluted UA, qualitative analysis of blood flow velocity waveforms, or semi-quantitative indexes, such as pulsatility index (PI), resistance index (RI), and the systolic-to-diastolic ratio (S/D) are often used¹⁴.

Regular exercise training is regarded as a cornerstone in the management of diabetic patients⁵. It should be explored as an additional mean to maintain normoglycemia preconceptually as well as throughout pregnancy⁴.

Studies concerning the effect of exercise on diabetes are available but the effect of exercise on maternal blood glucose level during pregnancy still not documented¹¹. Also, exercise have proved by many authors to improve uterine blood flow¹⁷ as well as placental blood flow^{9,16} in normal pregnant and

pre-eclamptic women. Whereas, none of the previous studies showed the exact role of exercise on blood flow in diabetic pregnant women^{7,8}.

As the data available seems incomplete for physicians and physical therapists to prescribe safe and effective antenatal exercise for diabetic pregnant women. So, this study is an attempt to provide such information by examining the effects of moderate aerobic exercise on the maternal blood glucose level as well as umbilical blood flow in Type II diabetic pregnant women.

SUBJECTS, MATERIALS AND METHODS

Subjects

Twenty multiparous pregnant women with type II diabetes at 24 weeks' gestation were recruited from Department of Obstetrics and Gynecology at Bab El-Sheria University Hospital. Their age ranged from 25-32 years old (28.57 ± 2.18 yrs.), their body mass index $> 30 \text{Kg/m}^2$ (31.96 ± 1.84) and all of them were under insulin therapy.

All patients were normotensive with no contraindication for performing exercise during pregnancy as multiple gestation, placenta previa, intra uterine growth retardation, fetal anomalies, previous history of pre term labor, abortion or bleeding. Also patients with renal or cardio-respiratory diseases, anemia, and uncontrolled diabetes were excluded from this study. Each patient underwent moderate intensity aerobic exercise training (60% of maximum heart rate) for 30 minutes, 3 times/week for 4 weeks (12 sessions). Fasting blood glucose level and umbilical artery blood flow for each patient were evaluated before starting and after the end of the training program.

Instruments

- 1- Electronic bicycle ergometer (E405) was used for performing exercise training program.
- 2- Doppler ultrasound machine (Sony ESAOTE EIOMCIA) with a linear 5MHz probe was used for measuring the umbilical artery blood flow before starting and after the end of the exercise training program (12 sessions).

Procedures

I- Evaluative procedures

- a- Initially each patient was subjected to a careful history taking as well as ultrasonographic examination to confirm the gestational age and to exclude cases of twins, placenta praevia or fetal anomalies. Weight and height were measured and BMI was calculated [$BMI = \text{weight}/\text{height}^2$ (Kg/m^2)] for each patient before starting the study.
- b- Umbilical artery Doppler measurement: Patient was asked to lie in half lying position for five minutes before starting Doppler assessment in which the Doppler transducer placed on the lower abdominal wall until the characteristic waveforms were seen with a clearly defined outline. The waveforms were only accepted when a clear continuous signals corresponding to the umbilical vein were visible in the reverse channel. The maximum systolic and end diastolic velocities of the umbilical artery were recorded, after that, the systolic per diastolic ratio (S/D ratio), resistance index (RI) and pulsatility index (PI) were calculated. The umbilical artery Doppler measurement was done before starting the study and after one month of aerobic exercise training.

- c- Blood samples, each patient was asked to fast for 12 hours before taking a blood sample from the antecubital vein to measure her fasting blood glucose level before starting the study and after one month of aerobic exercise training.

II- Aerobic exercise training program

After taking her diet and insulin dose, the pregnant woman was seated on the bicycle ergometer grasping the handle bar. The ear sensor was connected to her ear lobe to measure the pulse rate. Every session of the exercise training program (30 minutes) were consisted of three stages: First stage (warming up), consisted of 5 minutes warming up in the form of pedaling at a speed of 60 revolutions per minutes without load. Second stage (Active stage), consisted of 20 minutes pedaling at the same speed of the first stage with adjusted load to achieve 60% of her maximal heart rate (maximal heart rate = $220 - \text{age of the woman}$)¹⁸. Third stage (Cooling down), which is the same as first stage. Aerobic exercise training was performed 3 sessions per week for one month.

III- Statistical analysis

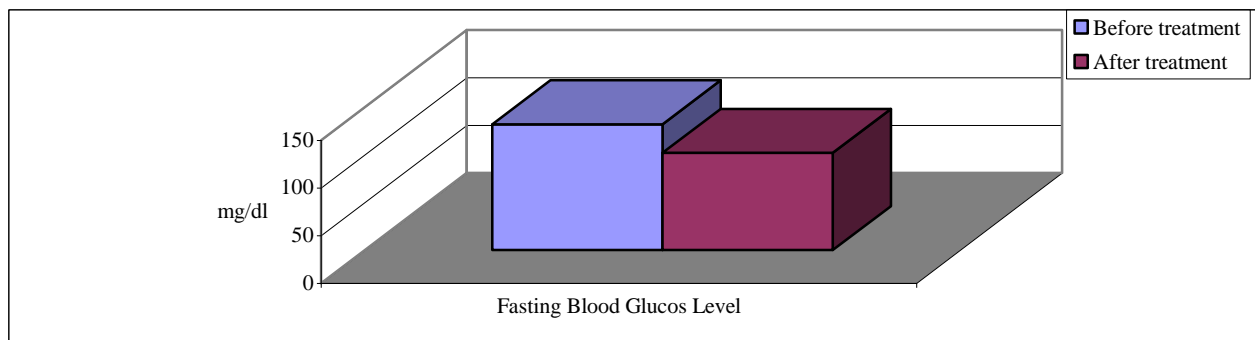
The data was collected and fed into computer for analysis. Paired t-test was carried to compare between before and after the end of the exercise training program (12 sessions), at a level of significance $P < 0.05$.

RESULTS

The mean value of fasting blood glucose level of patients before exercise training was 132.50 ± 57.40 mg/dl, while the mean value of fasting blood glucose level after exercise training was 102.25 ± 30.23 mg/dl. The statistical differences revealed that there was a highly significant ($P < 0.001$) decrease after training program with a percentage of decrease equal 22.7% as shown in table (1) and Fig.(1).

Table (1): Mean values of fasting blood glucose level before and after the training program.

	Fasting Blood Sugar	
	Before training	After training
Mean	132	102
S.D	± 57.40	± 30.23
Mean difference	30 ± 27.17	
Percentage	22.7 % ↓	
P- value	< 0.001	

**Fig. (1): Mean values of fasting blood glucose level before and after the training program.**

The maximum systolic velocity and end diastolic velocity as well as systolic/diastolic ratio in the umbilical artery was presented in table (2). Maximum systolic velocity was 0.47 ± 0.08 m/h before training and 0.41 ± 0.08 m/h after training which revealed a statistically highly significant ($P < 0.001$) decrease. Also the systolic/diastolic ratio was decreased from

3.45 ± 0.53 before training to 2.74 ± 0.34 after training with a percentage of decrease equal 20.6%. While, the end diastolic velocity was 0.13 ± 0.02 m/h before training and 0.15 ± 0.02 m/h after training which revealed a statistically highly significant ($P < 0.001$) increase as illustrated in Fig. (2).

Table (2): Maximum systolic, end diastolic velocities and systolic/diastolic ratio of umbilical artery before and after training program.

Variables	Before training	After training	% of change	t value	Level of significance
Maximum systolic velocity	0.47 ± 0.08	0.41 ± 0.08	↓ 12.8 %	4.1	$P < 0.001$
End diastolic velocity	0.13 ± 0.02	0.15 ± 0.02	↑ 15.4 %	-4.3	$P < 0.001$
Systolic/ Diastolic (S/D) ratio	3.45 ± 0.53	2.74 ± 0.34	↓ 20.6 %	4.84	$P < 0.001$

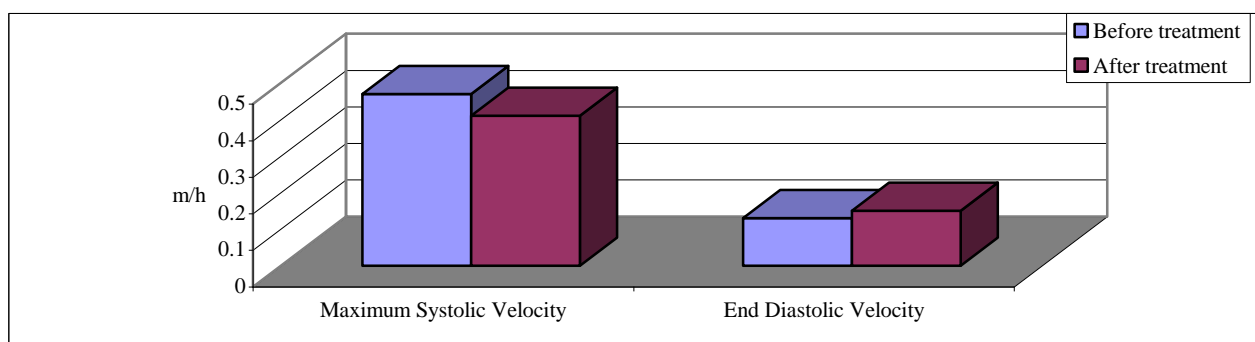


Fig. (2): Maximum systolic and end diastolic velocities of umbilical artery before and after training program.

The umbilical artery RI and PI were presented in table (3) and figure (3). Before training, the mean value of the umbilical artery RI was 0.70 ± 0.04 while after 4 weeks of exercise training it was 0.63 ± 0.04 . The mean reduction with respect to pre training values was 10% after 4 weeks of exercise training

program. Where, before training, the mean value of the umbilical artery PI was 1.09 ± 0.01 , it decreased after 4 weeks of exercise to 0.87 ± 0.09 . The mean reduction with respect to pre training values was 19.3% after 4 weeks of exercise training program.

Table (3): Mean values of umbilical artery RI and PI before and after training program.

	Umbilical artery RI		Umbilical artery PI	
	Pre training	After training	Pre training	After training
Mean \pm SD	0.70 ± 0.04	0.63 ± 0.04	1.09 ± 0.01	0.87 ± 0.09
Mean difference	0.07 ± 0.00		0.21 ± 0.02	
% of change	↓ 10%		↓ 19.3%	
P- value	P<0.001		P<0.001	

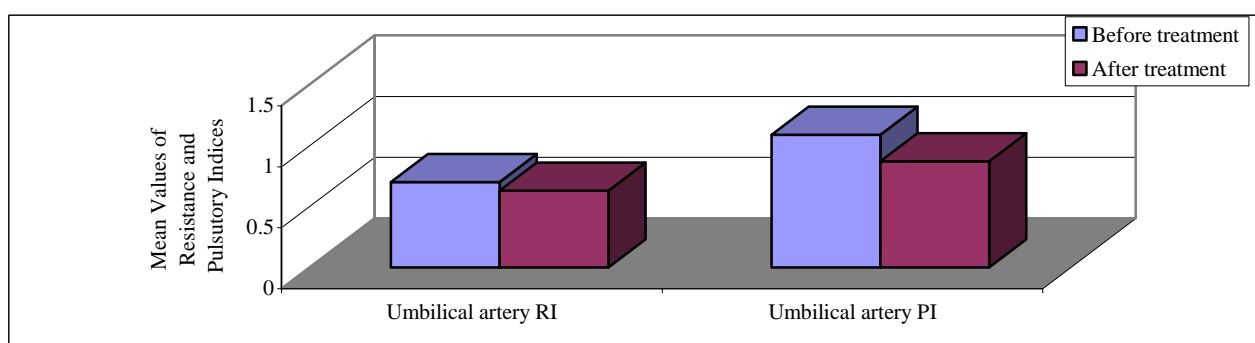


Fig. (3): Mean values of umbilical artery RI and PI before and after training program.

DISCUSSION

Many of clinical complications of diabetes may be ascribed to attention in vascular structure and function²³. Compared to non diabetic subjects, diabetic individuals are at increased risk for coronary artery diseases, increased proliferation and migration of vascular smooth muscle cells which contribute importantly to the formation of both atherosclerosis and restenotic lesion causing decrease in microvascular and macrovascular blood flow³.

Diabetic pregnant women with vascular complication may develop fetal growth retardation and intrauterine demise as early as the second trimester however, stillbirth have been observed most often after 36th weeks of pregnancy¹³.

This study was conducted to determine the effects of moderate aerobic exercise on reducing maternal blood glucose level as well as improving umbilical blood flow in type II diabetic pregnant women.

The results of this study revealed a significant ($P < 0.001$) reduction in blood glucose level after the exercise training program, these results come in agreement with Ross et al.,²¹ who had established that both acute and chronic exercise is associated with improvements in glucose tolerance in individuals with type II diabetes.

These results are also in agreement with Giacca et al.,¹⁵ who conducted a study on obese subjects with type II diabetes, and reported that plasma glucose levels decreased after engagement in moderate aerobic exercise program.

The improvement in umbilical artery blood flow obtained in the current study could be explained by the results obtained by Rafla and Beazely¹⁹, who related the decrease in the umbilical artery S/D ratio following exercise at

the 2nd trimester of pregnancy to the decrease in umbilical blood flow resistance and the increase in placental circulation.

These could be also explained by the results of Eriksson et al.,¹² who reported that in diabetic individuals, exercise may cause a decrease of triglycerides and low density level cholesterol, as well as increase of high density level cholesterol thus, decreasing the incidence of atherosclerosis or vasoconstriction which cause deficiency of placental blood flow.

These results are supported by James¹⁷ who concluded that, when moderate exercises continued during mid pregnancy, the placenta grow faster and had 15% more vessels and surface area at term. Thus, reducing the risk of intrauterine growth retardation and intrauterine fetal death.

The results are also in agreement with Clapp and his colleagues⁸, who studied the effect of exercise on normal pregnant women and found that moderate exercises lead to faster placental growth as well as increased morphometric indices of placental function leading to decrease the risk of fetal anomalies.

Thus it could be concluded that aerobic exercises seem to be effective in reducing blood glucose level and improving placental blood flow offering more nutrients to the fetus in Type II diabetic pregnant women.

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المخلص العربي

تأثير التمرينات الهوائية على مستوى السكر في الدم و سريان الدم المشيمي في مريضات النوع الثاني من الداء السكري أثناء الحمل

أجريت هذه الدراسة لاختبار مدى تأثير التمرينات الهوائية على مستوى السكر في الدم و سريان الدم المشيمي في مريضات النوع الثاني من الداء السكري أثناء الحمل . وقد تمت الدراسة على عشرين مريضة في الأسبوع الرابع والعشرين من الحمل تم اختيارهن من قسم أمراض النساء والتوليد بمستشفى باب الشعرية ، جامعة الأزهر . وقد قامت المريضات بإجراء برنامج تمرينات هوائية على العجلة الثابتة لمدة 30 دقيقة ، ثلاث مرات أسبوعيا لمدة شهر (12 جلسة) . وتم تقييم جميع الحالات بقياس نسبة السكر في الدم وكذلك أقصى سرعة انقباض وأدنى سرعة انبساط مع حساب معدل سريان الدم ونسبة المقاومة ونسبة النبض في الشريان السري للجنين قبل وبعد برنامج التمرينات الهوائية . وقد أثبتت النتائج أن التمرينات الهوائية لها تأثير ايجابي على تخفيض نسبة السكر في الدم وكذلك زيادة سريان الدم في الشريان السري وذلك عن طريق تأثيرها بالزيادة على أدنى سرعة انبساط للشريان وبالنقص على أقصى سرعة انقباض ونسبتا المقاومة والنبض في الشريان السري مما يؤدي إلى تحسين معدل سريان الدم في الشريان السري للجنين في مريضات النوع الثاني من الداء السكري .