Efficacy of Whole Body Vibration Exercises Versus Aerobic Training On Glycemic Control in Overweight Women with Type II Diabetes

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Abstract

Background: Diabetes is a global health problem affecting all ages and uncontrolled diabetes has a negative impact on people's lives and is one of the most important causes of cardiovascular disease and hypertension and is a cause of death globally.

Aim of Study: The aim of the current study was to compare the effect of whole body vibration exercises versus aerobic exercises on glycemic control in overweight women with type II diabetes.

Material and Methods: Sixty overweight women type II diabetes with aging ranged from 40 to 50 years and BMI ranged from 25-29.9Kg/m², divided randomly into two groups equal in number (A) and (B). Each of them consisted of thirty participants; Group (A) enrolled into whole body vibration exercise program, and Group (B) enrolled into aerobic (cycling) training program. They were randomly selected from the women that frequently visit National Diabetes Institute in Cairo. The study conducted through January 2017 to August 2018. The study lasted for twelve weeks at a frequency of three sessions per week. Evaluation included, body mass index, glycated hemoglobin and blood glucose level. Glycated hemoglobin was measured at the start and after the exercise program.

Results: Results of the current study showed a statistically significance reduction in blood glycated hemoglobin in both groups. But when comparing the two groups with each other there is no statistically significance value. Results the current study approved that both vibration exercise and aerobic training have similar effect on long term glycemic control in overweight women with type II diabetes.

Conclusion: The findings of the current study suggest that whole body vibration exercises may be beneficial tool and needs less time to enhance glycemic control in overweight

women with type II diabetes when compared with aerobic exercise especially in women with decreased fitness.

Key Words: Type II diabetes – Whole body vibration exercise – Aerobic training – Glycemic control.

Introduction

DIABETES Mellitus (DM) usually referred to heterogeneous group of metabolic diseases in which blood sugar levels are increased over a long period of time with clinical manifestations such as frequent urination, increased thirst, and more hunger [1]. neglected cases of diabetes suffers from many complications as diabetic ketoacidosis, cardiovascular disorders, cerebrovascular stroke, renal failure, diabetic foot ulcers, and eye diseases [2]. There are many types of diabetes such as Type I DM insulin-Dependent Diabetes Mellitus (IDDM) and

Abbreviations

DM	: Diabetes Mellitus.
IDDM	Insulin Dependent Diabetes Mellitus.
NIDDM	: Non-Insulin Dependent Diabetes Mellitus
WBV	: Whole Body Vibration.
KG	: Kilogram.
NS	Non Significant.
Μ	: Meter.
p	: Probability.
S	Significant.
SD	Standard Deviation.
SPSS	Statistical Packaged for Social Science.
BMI	Body Mass Index.
CNS	Central Nervous System.
HbA1c	: Glycated Hemoglobin.
RPE	Rating of Perceived Exertion Scale.
MANOVA	Multivariate Analysis of Variance.
MMOL/L	Millimoles per Litre.
FPG	: Fasting Plasma Glucose.
GLUT-4	: Glucose Transporter Type 4.

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type II DM Non-Insulin Dependent Diabetes Mellitus (NIDDM) [3,4]. Diabetes mellitus is a serious, chronic and global health problem, globally; among adults population; there were about 422 million complain from diabetes in 2014 when compared to about 108 million complain from diabetes in 1980. That indicates there were increases in the etiological risk factors of diabetes like obesity and hypertension. Over the past decade, the incidence of diabetes has been increased at a faster rate in low and middle income societies than in high income societies; the people who died from Diabetes in 2012 were estimated by 1.5 million. The percent of deaths due to high blood sugar level or diabetes that happen before the age of 70 years old is higher in low and middle income societies than in high income societies, the higher percentage of people who suffered from diabetes are affected by type II diabetes and most commonly between adults, although recently it also occurs in children [5]. The Whole Body Vibration (WBV) is a therapeutic modality that utilizes electric motors to provide vibration movement to an individual standing on a platform. It induces muscular contraction by stimulating the muscle spindles that leads to enhancing stretch reflex activation, increases peripheral blood flow and energy consumption [6]. But it is not clear if it is as beneficial as regular physical exercise [7]. Aerobic training considered as a type of physical exercises with different intensity ranged from a low to high rate through using the oxygen to efficiently meet the metabolic demands of the body during exercise through aerobic metabolism that can be lasted for long periods of time [8].

Perfect glycemic control indicates that the blood glucose levels were always normal ranged from 3.9 to 7.2mmol/l, as the blood glucose levels changed throughout the day and the glucose records are not precise for the changes occurred, the percentage of hemoglobin which is glycosylated is an indicator for the long term glycemic control in people with diabetes that shows the average glucose level for 2-3 months ago, while poor glycemic control shows that the blood glucose level is continuously elevated and the glycosylated hemoglobin levels ranged from 11 to 28mmol/l or higher over months and years [9,10]. The management strategies of diabetes consisted of a healthy diet, physical training program, decreasing body weight, avoidance of tobacco and control of blood pressure, type I DM mainly managed with insulin injections, but physical exercises is the ideal modality in prevention and control of type II diabetes mellitus. Aerobic exercises improve insulin sensitivity and helping in the management of blood glucose levels, fats, blood pressure, cholesterol, cardiovascular risk, mortality and quality of life [11]. As aerobic exercise considered the effective treatment modality for type II diabetic patients, the whole body vibration exercises has recently been introduced as a passive intervention [12]. Because of the higher prevalence and the serious complications of diabetes, the current study was prepared to explore the impact of the whole body vibration exercise versus aerobic training in form of cycling exercise on glycemic control in overweight women type II diabetes.

Subjects and Methods

Sixty three over-weight women referred with type II diabetes with age ranging from 40 to 50 years and Body Mass Index (BMI) that ranged from 25-29.9Kg/m². They were randomly selected from the women that frequently visit National Diabetes Institute in Cairo through January 2017 to August 2018. Three overweight women type II diabetes were excluded from the study due to lack of interest, lack of time and perceived discomfort when exercising. Full history taking and physical examination were done for all women as body mass index, blood glucose levels and glycated hemoglobin (HbA $_{1c}$) level were measured before treatment, The remaining sixty overweight women were divided randomly into two groups equal in number, Group (A) that performed whole body vibration exercise while Group (B) that performed aerobic (cycling) exercises and the program lasted twelve weeks, three times/week, all women continue in their prescribed medications with the physician, prior to the commencement of the study; all women signed a consent sheet, the nature and the procedure of the study, also all the rights of the study participants were explained for them, all women were diagnosed as non-insulin dependent diabetics for more than four years and the same Inclusion criteria as follow: Women age ranged from 40 to 50 years, BMI ranged from 25-29.9 Kg/m⁻, women had sufficient cognition and educated enough to understand the requirement of this study, women have normal blood pressure (90-120 mmhg systolic, 60-90mmhg diastolic) according to [13]. All women with diabetic neuropathy, autonomic neuropathy, nephropathy, fractures of lower limbs, severe arthritis in the lower limbs joints, Central Nervous System (CNS) dysfunction, women had any surgical problems of the feet, who did not fit the age range and body mass index range were excluded from the current study. Glycated hemoglobin (HbA_{1_c}) was measured before and after training program.



Evaluation instruments:

Glycosylated hemoglobin testing device: Is a device used to measure the amount of blood sugar attached to the hemoglobin in erythrocytes with the results given as a percent, Mercury Sphygmomanometer: A stethoscope and Mercury Sphygmomanometer were used to measure the blood pressure and calculate its mean value, weight and height scale: The body weight of each woman was measured in light indoor clothes and the patient height was measured without their shoes using calibrated healthy scale 160kg, and then BMI for each woman calculated through the formula: BMI=

body weight (kg)/height (m²), Borg rating of perceived exertion scale (RPE scale): This scale was used to set the exercise intensity to be at moderate intensity, represented from 12-14 on the scale. RPE scale is generally believed to be valid and precise method and recommended to monitor the exercise intensity, also all questions concerning the RPE from the participant were answered [14].

Sample collection and measurement of glycosylated hemoglobin:

A 2ml of venous blood sample was drawn from antecubital vein for all women for measuring the

glycosylated hemoglobin (HbA $_{1C}$) before starting the training program and at the end of the study, in the morning after 8 to 12 hours of overnight fasting. Blood sample of HbA1C levels were measured within 2 hours by a high quality, calibrated, valid liquid chromatography variant II hemoglobin measuring system. Analysis was performed closely according to the manufacturer's guidance by using the original kit, and good quality control. All steps were executed by highly qualified doctors [15].

Treatment intervention:

Group (A): (The whole body vibration group):

After the first evaluation of all parameters, all volunteers have performed a unique WBV session, while standing barefoot, with their heels of the ground; they were oriented to direct their heads and their eyes ahead and distributed their body weight equally on both feet with the distance between both feet were 20 centimeters [16]. The WBV group performed the exercise program on a perpendicular vibrating machine (Fit vibe Excel; Belkin, Belgium) for two sets of six, one minute vibration squatting with twenty second rest periods in between, three times/week for twelve weeks (total exercise duration was thirty six minutes/ week). The six positions that were static consisted of a deep squatting position in which the knee joint angle was 90, high squatting position in which the knee joint angle was 125, high squatting position with the heels raised, slight knee flexion by holding the hand straps with flexion shoulder, slight knee flexion by holding the straps of the hand with shoulder abduction and slight knee flexion by holding the straps of the hand with elbow flexion. The training intensity was increased gradually from a vibration at frequency of 30Hz and a platform amplitude shift of 2mm from the start in the first week to a vibration at frequency of 40Hz, and a platform at amplitude shift of 4mm in the fifth week, which lasted till the end of the study in the twelve week [17].

Group (B): (The aerobic (cycling) exercise group):

The bicycle is connected to a digital screen to display the resistance level, the heart rate and the pedaling rate. The cycle apparatus model no: Matrix Fit Taiwan. With magnetic resistance, All Women performed aerobic exercise on a stationary bicycle for 30-40 minutes. There were 5 till 10 minutes warm up in the form of light aerobic training. Also there were 5 till 10 minutes cool down in the form of light aerobic training and in between 20-30 minutes of cycling exercises that performed at

moderate intensity represented by 12-14 on the Borg scale, Before any exercise session, the women were familiarized with the RPE scale (Borg scale) and asked to observe the rating scale while exercising on cycling; RPE ranges from 6-20, where the number 6 referred to "no exertion at all" and the number 20 referred to "maximal exertion.", then she can determine the number from the Borg scale that well described her intensity level of activity. The aerobic exercise program performed at a frequency of three days per week throughout the training period [18].

Statistical analysis:

Descriptive statistics and *t*-test were conducted for comparison of characteristics of the subjects between both groups. Normal distribution of the data was checked using the Shapiro-Wilk test for all variables. Levine's test for homogeneity of variances was conducted to test the homogeneity between groups. Mixed MANOVA was conducted to compare the mean values $_{HbA_{1C}}$ between Group A and B as between group comparison and between pre and post-treatment in each group as within group comparison. Partial squared eta was considered as the effect size. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparison. The significant level for all statistical tests was set at p < 0.05. All statistical analysis was conducted through using the Statistical Package for Social Studies (SPSS) Version 19 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics:

Table (1) showed the mean \pm SD age, weight, height and BMI of Group A and B. There was no significant difference between both groups in the subject characteristics (p > 0.05).

Table (1): Comparison of subject characteristics between Group (A) and (B).

	X ±	SD	MD	<i>t</i> - value	<i>p</i> - value
	Group A	Group B			
Age (years)	45.26±3.03	45.66±3.15	-0.4	-0.5	0.61 *
Weight (kg)	82.33±5.01	81.93±9.27	0.4	0.2	0.83*
Height (cm)	172.16±5.76	171.83±9.69	0.33	0.16	0.87*
BMI (kg/m ²)	27.76±1.22	27.67±1.05	0.09	0.29	0.77*

: Mean.

p-value : Probability value. SD : Standard Deviation : Non-significant.

MD : Mean Difference.

Effect of treatment on HbA $_{1c}$:

Mixed MANOVA revealed that there was no significant interaction of treatment and time (F= 0.46, p=0.49, $\eta^2=0.008$). There was a significant main effect of time (F=504.48, p>0.001, $\eta^2=0.89$). There was no significant main effect of treatment (F=0.2, p=0.65, $\eta^2=0.004$).

Within group comparison:

There was a significant decrease in $_{HbA_{1c}}$ posttreatment in both groups compared with that pretreatment (p>0.001). The percent of decrease in HbA1c of Group (A) 8.98% and that of Group (B) was 9.42% (Table 2).

Between groups comparison:

There was no significant difference in HbA $_{1c}$ pre-treatment between both groups (p=0.59). Also, there was no significant difference in HbA $_{1c}$ post-treatment between both groups (p=0.72) (Table 2).

Table (2): Mean HbA1c pre and post-treatment in Group (A) and (B).

	Group A			Group B			Between groups	
	- Pre X ± SD	- Post X ± SD	<i>p</i> -value	- Pre X ± SD	– Post X ± SD	<i>p</i> -value	Pre <i>p</i> -value	Post <i>p</i> -value
HbA _{1c}	8.9±0.83	8.1±0.75	0.001 * *	9.02±0.88	8.17±0.79	0.001 * *	0.59*	0.72*

: Non significant.

**: Significant.

X : Mean

SD

Standard Deviation.



Fig. (1): Mean _{HbA1c} pre and post-treatment in Group A and B.

Discussion

The current study was prepared to determine the health effects of the whole body vibration exercises against aerobic exercise on HBA $_{1C}$. In over-women type II diabetes with the same age, as both of these modalities are commonly used in physical therapy practices, so it was very beneficial to determine which one of them is better in glycemic control and more efficacy on HBA $_{1C}$. Sixty over-weight women with type II diabetes were included and divided at random into two groups equal in number, the first group (Group A) received whole body vibration exercises, while the second group (Group B) received aerobic exercises on stationary bicycle. Both groups performed the

training program three sessions/week for twelve weeks. Various articles have examined the effect of aerobic exercise on glycemic control. But, the health effects of different types of exercise training on glycemic control have not been well determined. Healthy diet, a program of exercises and decrease the body weight are the keystone in the management of diabetes that improve the insulin sensitivity, glycemic control, decrease muscle wasting and mortality. The targeted interventions are necessary to improve long term control of diabetes [19,20]. Vibration exercise program is a recent and more effective modality to improve insulin sensitivity and prevent muscular weakness and decrease bone density when compared to the traditional exercise training program, vibration needs a significant minimal time, therefore, can be predictable to reach a high compliance level in the sedentary women [21]. Glycosylated hemoglobin was assessed as an indicator of the progression of $_{HBA}_{1C}$ in type II diabetic over-weight women. The cause for choosing $_{HbA_{1C}}$ as a sole method for assessment was based on the fact that Glycosylated hemoglobin is not affected by lifestyle changes for short time, although, few days or weeks of healthy dieting or exercising can significantly affecting the Fasting Plasma Glucose (FPG) test. Unlike glucose, HbA_{1c} is stable at room temperature; blood samples were collected and were subjected to laboratory investigations for glycosylated hemoglobin analysis before intervention, and were repeated after eight weeks of treatment [22]. Results of the current study has shown that there is significance improvement in $_{HbA_{1C}}$ in each group by either mode of exercise

training while there was non-significant difference

when comparing the results of both groups. In the current study, all women were performed an exercise program at moderate intensity [23]. Suggested that a continuous exercise training program at low to moderate intensity has the same effect when compared with exercise training program at severe intensity as a modality to reduced blood HbA_{1C} level by 0.2% with cycling aerobic exercises while treadmill exercise reduced HDA1C with 0.1% which is very important especially for diabetic women, because the women in long standing type II diabetes generally complain from muscle weakness, cardiovascular diseases and decrease exercise tolerance. Hence, moderate intensity is the best intensity for exercising this group of women. According to [24] concerning the number of exercise sessions per week, he approved that the rest period between the sessions should not more than 72 hours. Also According to [25] several articles in medical field have been performed about the effect of aerobic exercise on $_{HbA_{1C}}$ and recorded heterogeneous results. Meta-analysis concerning the data from 14 studies, recorded significant reduction in HbA $_{1C}$ concentrations approximately by 10% with aerobic exercise, another study showed that aerobic exercise in the form of cycling exercises lowering the glycated hemoglobin (HbA_{1C}) by 8%. The result of the current study came in agreement with results of [26] who studied the impact of the aerobic exercise as combined with healthy diet and medical drug in management of diabetes mellitus. This study approved that following six weeks of cycling exercises the percent of insulin binding to the monocyte receptor sites was increased and this increase resulting in higher insulin mediated glucose uptake with increasing the oxidation of glucose and its glycolytic products. The glycogen utilization and storage during and after physical training can affect the glucose metabolism, so there was an improvement in glucose uptake following treadmill exercise. The results of [27] also agree with the result of the present study as it showed that a program of progressive aerobic exercises improves glucose tolerance and enhances insulin sensitivity in older subjects [28]. Explained that mild exercise training by using bicycle ergometer for one hour/ day, five days/week, for twelve weeks improves glucose effectiveness and insulin sensitivity in healthy men with no change in body composition. Because many reports have shown that type II diabetic women have low insulin sensitivity beside low glucose effectiveness, so exercises is considered to be effective method to prevent glucose intolerance. The results of [29] came in agree with the results of the present study as they explained

that aerobic training in the form of cycling exercise for women with NIDDM decreased the HbA1C by 7.4% which considered a non-significant reduction in HbA1C when compared to the effect of whole body vibration exercises on HbA 1C. Also a program of physical exercises can leads to an increase in the basal and insulin stimulated AMP kinase pathway activity that decreases the levels of HBA 1C Although, there were many studies which explained the relationship between insulin resistance in type II diabetic women and VO2 max, the present study was the first one to explore the effect of whole body vibration and cycling on glycemic control for overweight women type II diabetes [30]. Mentioned that according to the collected data from several prospective studies there was an association between cardiopulmonary fitness represented by VO2 max and insulin resistance after performing an exercise training program on a bicycle and on a treadmill on separate days for eight women, after that he measured oxygen consumption (VO2) and showed no differences at peak exercise between the two forms of exercise for VO 2 [31]. Mentioned that low cardiopulmonary fitness is closely associated with fasting glucose impairment. A study performed by [32] emphasized that decreased VO2max is considered as an early sign of impaired glucose regulation. So we can be concluded that change in VO2 max is considered an indicator for the change in insulin resistance and consequently, an indicator for the change in HbA 1C. Study done by [33] who observed that there was a muscle activation and significant reduction in HbA1C in the whole body vibration group by a percentage of change was (8.1 ± 0.75) while in the cycling group was (8.17 ± 0.97) . The statistically significant difference was not approved between the two values. p-value is 0.001, which means there is no superiority between both modes of exercise on glycemic control in overweight women with type II diabetes. So according to the previous facts, it clearly noticed that both whole body vibration and cycling exercises have beneficial influence in reducing HDA 1C and it was suggested that the exercise session should be performed for 30-40 min per session, three sessions per week for successive twelve weeks. The results of the current study was contradicted by [34] which reported that WBV at 12.6Hz has a positive effect and highly significance effect of on blood glucose when compared to aerobic group. Also the study conducted by [35] on 65 diabetic women with type II he mentioned that aerobic exercise in the form of walking on treadmill at mild to moderate intensity has a highly significant effect on blood glucose and $_{Hba_{1C}}$ levels and the whole body vibration

has no significant effect on the $_{HBA_{1C}}$ level. The mechanism through which aerobic Exercise training lowering glycated hemoglobin as follow, Aerobic exercise increased the muscle GLUT4 and the increasing in GLUT4 resulting in increased the capacity for insulin induced glucose transport in the trained women which considered important therapeutic strategy for people with metabolic syndrome and hence reduce the levels of HBA 1C [36]. Concerning the whole body vibration exercises, the mechanical vibrations cause activation of the alpha-motor neurons and muscle spindles that initiate muscle contractions comparable with tonic vibration reflexes that are transmitted to the body which considered direct response obtained from body vibration exercises when applied directly to a muscle belly or tendon and reinforce the muscles to consume a large amount of GLUT4 and increase the level of uptake of GLUT4 through its receptors and therefore decrease the levels of glycated hemoglobin in diabetic and obese patients [37] this vibration training utilizes a mechanical stimulus characterized by an oscillatory motion in all three planes.

Conclusion:

We concluded that whole body vibration as a new effective method that needs less time and fitness and aerobic (cycling) exercises have significantly beneficial effect in reducing glycosylated hemoglobin in overweight women with type II diabetes, but until now it is not well defined which modality has the superior benefit on $_{\rm HbA\,1C}$ than the other.

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Conflict of interest statement:

The authors report no conflicts of interest.

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تآثير الإهتزاز الكامل للجسم مقابل التمارين الهوائية على ضبط السكر في السيدات ذوات الوزن الزائد مرضى البوال السكرى (النوع الثاني)

يمثل البوال السكرى مشكلة صحية عالمية تؤثر على جميع الأعمار وعدم التحكم فى هذا المرض يؤثر تآثيرا سلبا على حياة الآشخاص ويعد من آهم العوامل المسببة لآمراض القلب والشرايين وضغط الدم كما يعد من مسببات الوفاة عالميا.

هدف البحث: دراسة تأثير الإهتزاز الكامل للجسم مقابل التمارين الهوائية على ضبط السكر في السيدات ذوات الوزن الزائد مرضى البوال السكري (النوع الثاني).

آساليب البحث: آجرى البحث على ستين سيدة تعانين من زيادة الوزن مع مرضى البوال السكرى (النوع الثانى)، تتراوح أعمارهن بين الآربعين والخمسين عاما، تم إختيارهن عشوائيا من المعهد القومى للسكر بالقاهرة، وبعد إجراء الفحص الطبى تم تحويلهن لقسم العلاج الطبيعى، ثم تقسيمهن عشوائيا إلى مجموعتين كل مجموعة تضمنت (٣٠) سيدة، المجموعة الآولى (آ) نفذت برنامج الإهتزاز الكامل للجسم والمجموعة الثانية (ب) نفذت برنامج التمارين الهوائية وقد إستمر البرنامج لمدة إثنى عشر إسبوعا بمعدل ثلاث جلسات إسبوعا، وقد تم سحب عينات الدم وتم قياس كتلة الجسم والهيموجلوبين السكرى ونسبة السكر بالدم قبل البرنامج العلاجى وقياس الهيموجلوبين السكرى قبل وبعد البرنامج العلاجى لجميع السيدات المشاركات.

نتائج البحث: أسفرت نتائج هذه الدراسة عن وجود نقص ذات دلالة إحصائية فى نسبة الهيموجلوبين السكرى فى كلا المجموعتين، ولكن عند المقارنة بين المجموعتين لا يوجد قيمة ذات دلالة إحصائية.

وخلصت نتائج هذه الدراسة إلى أن ممارسة تمارين الإهتزاز الكامل للجسم والتمارين الهوائية لهما تآثير مماثل فى ضبط نسبة الهيموجلوبين السكرى فى الدم فى السيدات ذوات الوزن الزائد مرضى البوال السكرى (النوع الثاني).