Effects of twelve weeks of aerobic training, resistance training or combination of both trainings on the levels of blood sugar, HbA1c and cardiovascular risk factors in women with type 2 diabetes

1-Eskandar Rahimi 2- Zeinab osadat Mousavi nejad 3- Alireza Rahimi
1- Department of Physical Education, science and research branch, Islamic Azad University, Fars, Iran

Article history: Received 02 December 2013; accepted 26 March 2014

ABSTRACT

Introduction and purpose: Diabetes mellitus is a metabolic disease that is brought about by either insufficient production of insulin or the inability of the body to respond to the insulin formed within the system. The aim of this study was to exam the influence of 12 weeks of aerobic training, resistance training, or a combination of both on the level of blood sugar,
hemoglobin A1C (HbA1c)) and cardiovascular risk factors in women diagnosed with type 2 diabetes.

**Materials and Methods:** In this semi experimental survey, 45 women diagnosed with type 2 diabetes at Nader Kazemi Clinic who had the required qualifications were chosen for the survey and were divided into four groups including aerobic training group (11), resistance training group (11) combination exercise group (12) and control group (11). Aerobic, resistance and combination groups performed the exercises for 12 weeks under the supervision of skillful trainers. Fasting blood samples were obtained from the subjects prior to breakfast at the beginning and the end of the study to measure blood sugar, hemoglobin A1c, total cholesterol, triglyceride HDL and LDL. To display central inclination index and distribution indices, descriptive statistics and Wilcoxon non parametric tests were used to examine the data distribution type and to compare the averages of the data prior to & after the test in each group. Two-way ANOVA test (P<0.05) was used for statistical analyses.

**Results:** In the combined training group, there was a significant decrease (p<0.1) in the level of HbA1c at the end of the study, while the resistant training group demonstrated a significant decrease in total cholesterol (p<0.05) and LDL (p<0.01) and an increase in HDL (p<0.05) at the end of the training period. The control group showed an increase in fasting blood glucose level compared with the other three groups (p<0.01). In all of the training groups, BMI decreased significantly (p<0.05) and the triglyceride level did not change (p>0.05).

**CONCLUSIONS:** Based on the results obtained, combination exercises decreased blood HbA1c level, and resistance training diminished serum total cholesterol, and LDL levels and elevated the HDL level. Therefore, it appears that different types of exercise may be effective in controlling type 2 diabetes.

**Key words:** aerobic training, resistance training, combination training, hemoglobin A1C.

**INTRODUCTION**

The prevalence of type 2 diabetes is increasing worldwide in the 21st century. The main reason for the increase is the changes in lifestyle, specifically doing less exercise and consuming excessive calories. According to World health Organization (WHO), the number of people diagnosed with diabetes in the year 2000, was 171,000,000. This number may rise up to 366,000,000 in the year 2030 if appropriate measures are not taken to prevent and cure this
Disease (Aghamollaie T, et al 2004). Diabetes is diagnosed with metabolic disorders such as blood sugar build-up and is followed by some complications such as eye, neural and renal problems and also cardiovascular failures (Bee Hoon Heng, et al 2010). Just as the main reason for the increased prevalence of type 2 diabetes is lifestyle changes, the cornerstones of treatment must also incorporate lifestyle changes to control and reduce the complications of type 2 diabetes. Physical activity has been recommended as one of the alternatives (Carey RM, et al 2003).

Investigators show that trainings such as walking, bicycling, jogging and running and resistance training like weight lifting result in reduction of HbA1c. Hb A1C is an indication of the amount of blood sugar within the past 2 to 3 months and helps physicians to diagnose and treat the illness more effectively. A decrease in the amount of HbA1C up to 1% diminishes the danger of cardiovascular disease up to 15 to 20 percent and eventually results in a reduction of the complications of micro vasculature up to 37 percent (American Diabetes Association, 1999 & Selvin E, et al 2004).

Most of the researches done so far have displayed the effects of aerobic and resistance trainings on the level of HbA1c (Bruce CR, et al 2004 & - Massi-Benedetti M, et al 1996). Little research has been carried out on the effects of combination training (aerobic and resistance) on the level of HbA1C. The results of a clinical investigation on 251 adult patients during 26 weeks of training showed that in comparison with aerobic and resistance trainings alone, combination (aerobic and resistance) training decreased HbA1c more prominently. However, there were no statistically significant changes in the level of blood lipids (Eriksson J, et al 2002). Baldoucci et al monitored effects of combination training on the level of HbA1c and certain other metabolic factors in type 2 diabetic patients for one year. Change in the amount of HbA1c revealed that the combination training and the resistance one had produced a more significant decrease in blood sugar compared with the control. In addition, LDL and total cholesterol also decreased significantly in combination training, while HDL level increased (Balducci S, et al 2004).

Timothy et al studied the effects of aerobic, resistance and combination trainings on the level of HbA1c in type 2 diabetic patients. Their results showed a significant decrease in HbA1c level in the combination group, while the resistance and aerobic groups had no significant effect (Timothy S, et al 2010).

Some researchers have demonstrated the effects of either aerobic training or resistance training alone on the level of HbA1c. Bruce et al launched a survey on the sensitivity level of insulin in
The results of their survey demonstrated that training causes a drop in HbA1c level from 7.9% to 7% and the fasting plasma, blood glucose dropped from 8.3 m mol to 7.9 m mol, although this change was not significant. Plasma insulin level was also decreased significantly and some factors such as total cholesterol, HDL and LDL did not show any changes (Bruce CR, et al 2004). Eriksson et al showed that 8 type 2 diabetic patients who had participated in progressive power trainings for 3 month, demonstrated considerable improvement in the amount of HbA1c but did not show any significant change in serum lipid levels (Eriksson J, et al 2002).

As therefore mentioned literature indicates, the effects of physical activity and its type in improving type 2 diabetic patients is still unknown. Therefore, the objective of this investigation was to find out if three sixty sessions of either aerobic, resistance or a combination of both trainings for a period of 3 months reduces HbA1c and the lipid profile of women with type 2 diabetes.

METHODS
Subjects and experimental design
This study is semi-experimental. Sixty type 2 diabetic women attending Nader Kazemi Clinic in Shiraz, Iran for clinical diagnosis and treatment and were treated with standard doses of metformine or glibenclamide daily comprised our experimental group. The mean of their age, weight, and height were (55.14±6.46) years, (69.80±5.8) kg, and (154±6.46) cm, respectively. They had a history of type 2 diabetes for (4.72±1.06) yrs. Our inclusion criteria were being females, having type 2 diabetes according to an endocrinologist report, age over 35 years, fasting blood sugar between 140-200 mg/dl, and doing no physical exercise in the past 3 months. The exclusion criteria comprised of chronic illnesses, psychological disorders, type 1 diabetes and diabetic complications such as diabetic wounds, diabetic nephropathy or retinopathy. All the participations filled out a questionnaire on preparation for participating in physical activity (PAR-Q)1 (Canadian Society for EPH 2002.). Informed consent was obtained from every person participating in the study. Subjects were divided into 4 groups of control, aerobic training, resistance training and combination training base on their HbA1c at the beginning of study.

1 - Physical Activity Readiness Questionnaire
Because 15 patients did not participate in the experimental protocol, therefore the final number of participate were: control group, 11; aerobic training, 11; resistance training, 11; and the combination training, 12. Blood samples were obtained from 8-12- hour fasting subjects prior to the study and later after 12 weeks at the end of the physical exercise periods.

The different exercise groups performed their exercises for 30-60 min, 3 days per week for a period of 12 weeks under the supervision of a skillful trainer. Every session started with stretching exercise and jogging for 5-10 min and for a period of 5-10 min of cooling down at the end of the period. Exercises were done on even days at 5:00 pm. The exercise protocols of the 3 groups are summarized below:

1- The aerobic training group did their exercise by walking on treadmill equipped with heart beat pacer and with a maximum of 60-65 % of their maximal heart rate using targets heart rate method. The physical activity of their groups lasted for 30 min per day during the first two weeks and increased to 45 min per day in the 3rd and 4th weeks and reached 60 min per day during the final weeks.

2- The resistance training group stated their first two weeks with a minimum weight of 2 sets and a repetition of 8-10 times to get accustomed to weight lifting. From 3rd weeks onward, 3 sets were used for each muscle groups and each set was repeated 10-12 times and with 60-75 % of one repetition maximum (1 RM). Evaluation of the called weight was done by one repetition maximum through Berzike's formula (- Gill, T, et al 2005).

Resistance training included the bench press, shoulder press, curl triceps, dumbbell curls, and lateral pull down, leg press, leg extension, twists, decline press and sit-ups.

3- The combination training groups started their first two weeks with 20 min of aerobic training and performing resistance training with minimum weight and 8-10 repetition to learn the exercise correctly. From the 3rd week on, they performed 30 min of aerobic training and 30 min of resistance training or more if needed.10 to 12 repetitions for each set with 3 sets for each muscle with 60-75% of one maximum repetition were performed by this group.

**Anthropometric measurements**

All Anthropometric measurements were done on the subjects wearing light underwear and without shoes. Body weight was measured to the nearest 0.5 kg using a digital scale (Germany) that was calibrated with a 50 Kg weight when weights were determined. Height was measured to
the nearest 0.5 cm against a wall – mounted tape (China). BMI was calculated by dividing the weight in kg by height in meters squared and was classified into four categories according to WHO protocol. Thus, underweight was defined as a BMI of under 18.5, normal weight as BMI of 18.5 - 24.9, overweight as BMI of 25-29.9 and obesity as a BMI ≥ of 30.00 kg/m². (WHO 2002).

**Blood samples**

Blood samples were obtained in the morning after an 8-12 hr fast prior to the start of the study and again 12 weeks after at the end of the study under the same conditions. Serum total cholesterol and triglyceride levels were measured by enzymatic kits (Mann Chemical Company) using an auto analyzer.

LDL-Cholesterol and HDL-Cholesterol were measured by an Auto analyzer using commercial kits (Pars Azema Company, Teheran, Iran). Serum fasting blood sugar levels were measured by Selectra-E autoanalyzer using an enzymatic kit (Mann Chemical Company). Hb A₁c was determined by an Affinity HPLC method (Younglee 9100 made in South Korea).

**Statistical analyses**

To show the central tendency and variability, descriptive statistics was applied. The sample Kolmogorov - Smirnov test for normal distribution of data was used. Wilcoxon nonparametric test was used to determine the type of data distribution, and to compare the means of the data pre-test and post-test of any group, Two-way ANOVA was used. Statistical significance was set at (p < 0.05). All data were analyzed by SPSS, software, version 16.

**Results**

Table 1 shows the serum levels of various analytes and risk factors in the four groups before and after 12 weeks of exercise.
Table 1. Effects of different training protocols on BMI and certain blood analytes of Women with types 2 diabetes.

<table>
<thead>
<tr>
<th>Experimental groups</th>
<th>BMI (kg/m²)</th>
<th>FBS (mg/dl)</th>
<th>TG (mg/dl)</th>
<th>LDL-C (mg/dl)</th>
<th>HDL-C (mg/dl)</th>
<th>Total Cholesterol (mg/dl)</th>
<th>HbA1c (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>28.1 ± 3</td>
<td>172.4 ± 60</td>
<td>158 ± 85</td>
<td>101.7 ± 27</td>
<td>47.8 ± 17.7</td>
<td>185.2 ± 26</td>
<td>10.2 ± 2.3</td>
</tr>
<tr>
<td>P Value</td>
<td>0.003</td>
<td>*0.01</td>
<td>0.929</td>
<td>0.04</td>
<td>0.006</td>
<td>0.04</td>
<td>0.477</td>
</tr>
<tr>
<td>Aerobic Group</td>
<td>31 ± 3</td>
<td>161.5 ± 43</td>
<td>166.3 ± 63</td>
<td>101 ± 27</td>
<td>37.8 ± 8.4</td>
<td>168.2 ± 33</td>
<td>9.8 ± 2.6</td>
</tr>
<tr>
<td>P Value</td>
<td>*0.003</td>
<td>0.213</td>
<td>0.79</td>
<td>0.182</td>
<td>0.789</td>
<td>0.091</td>
<td>0.061</td>
</tr>
<tr>
<td>Resistance Group</td>
<td>28.7 ± 3</td>
<td>142 ± 46</td>
<td>159.9 ± 76</td>
<td>102 ± 28</td>
<td>37.3 ± 3.3</td>
<td>171.3 ± 32</td>
<td>9.6 ± 2.1</td>
</tr>
<tr>
<td>P Value</td>
<td>*0.003</td>
<td>0.35</td>
<td>0.328</td>
<td>*0.013</td>
<td>*0.003</td>
<td>*0.037</td>
<td>*0.201</td>
</tr>
<tr>
<td>Combination Group</td>
<td>29.3 ± 7</td>
<td>172 ± 57</td>
<td>118.8 ± 48</td>
<td>88.2 ± 34</td>
<td>44.2 ± 10.5</td>
<td>157.3 ± 35</td>
<td>10.2 ± 2.25</td>
</tr>
<tr>
<td>P Value</td>
<td>*0.002</td>
<td>0.666</td>
<td>0.505</td>
<td>0.158</td>
<td>0.314</td>
<td>0.666</td>
<td>*0.002</td>
</tr>
</tbody>
</table>

BTP = Before test period; ATP = After test period.

Although after aerobic exercise, the levels of total cholesterol, HbA1c, LDL-C, TG, FBS and BMI decreased to some extent, but only BMI was diminished significantly (p < 0.003).

After resistance exercise, total cholesterol (p = 0.037), LDL-C (p = 0.013) and BMI (p = 0.003) decreased significantly. In this group, FBS and HDL-C showed some increase but only the increase in HDL-C was significant (p = 0.003).

After the combination exercise, all the factors except TG demonstrated reductions, however the reductions in the level of HbA1c and BMI were significant (from 10.22 ± 2.25 to 8.52 ± 2.27; p = 0.01) and (from 29.3 ± 7 to 28.6 ± 6; p = 0.002), respectively. In this group HDL-C was unchanged.

Factors such as HbA1c, FBS and BMI showed some increase in the control group and only FBS elevation was significant (p < 0.002). There were no significant reductions in total cholesterol, LDL-C and HDL-C in this group.

**DISCUSSION**
The aim of this study was to evaluate the effects of 12 weeks of aerobic, resistance and combination of the two physical trainings on the level of blood sugar, HbA1c and cardiovascular risk factors in women with type2 diabetes.

The main finding of this study involving individuals with type2 diabetes is that any kind of physical training can provide benefits for type2 diabetics. Furthermore, although all the 3 kinds of training improve metabolic parameters and risk factors, but the effect of resistance training was more prominent.

Although both aerobic and resistance training decreased HbA1c (from 9.8 to 8.6 and from 9.6 to 9.2 respectively), only the combination of both trainings diminished HbA1c significantly (p=0.002, from 10.2 to 8.5). Our results agree with those of (Selvin et al 2004 & Shenoy, et al 2009, but do not confirm the studies of (Shahla et al 1995, Bruce, et al 2004 & Eriksson, et al 2002).

Blood sugar in the aerobic and the combination groups demonstrated 10.9 Mg/dl and 2 Mg/dl reductions, respectively; however these reductions were not statistically significant. Blood sugar showed an increase in both the resistance and the control groups and was significant only in the control group (P= 0.001). Our results agree with the work of (Ronald, et al 2007 & Shenoy et al 2009), but not with those of (Bruce et al 2004 & Balducci et al 2004). Elevation of blood sugar following resistance training is unexpected, however lowering of blood sugar in the other two training groups and the reduction of HbA1c in all three training groups are conceivable, because following physical activity, muscle contractions, like insulin, transfer a great deal of glucose into muscle cells (Gaeini A.A, et al 2009). It is also expected that physical activity will result in an increase in the level of GLUT4, improving insulin function in glucose metabolism (Heng been H 2010), although it is possible that resistance training in a beginner may cause muscular damage such as soreness and temporarily reduce the sensitivity to insulin and consequently result in an increase in blood sugar (Gu K, et al 1998).

Nevertheless the duration and intensity of the trainings, the primary level of subjects’ readiness, the individual differences and the basal level of blood sugar are all among reasons for inconsistencies.

Total cholesterol level shows some reduction in all the three training groups and the reduction is only significant in the resistance group; agreeing with the results obtained by ( Mohebi et al 2006).
The levels of TG in the aerobic and resistance groups dropped by 5 and 11%, respectively, but such reductions were not statistically significant. Serum TG level increased by 10.5 Mg/dl in the combination group. LDL-C dropped in all four groups and its drop was significant in resistance group (P< 0.013) (aerobic 11Mg/dl, combinationation6.2 Mg/dl and control 12.7 Mg/dl). The results obtained on TG and LDL-C levels are consistent with those of (Mohebi et al 2006 & Sabine et al 2008), and inconsistent with those of (Ronald et al 2007 & Balducci et al 2004). It seems that the existing differences between the results of different studies lie in differences between the intensity and duration of each training session (Castaneda C, 2002). BMI has dropped significantly in all three training groups, thus it proves that all kinds of physical activity could offer a sufficient stimulus for body weight control, consistent with the study of (Mohebi et al 2006).

**Conclusion**

The results showed that 12 weeks of aerobic, resistance and combination physical activities will reduce metabolic indicators and risk factors such as Hb A1C, total Cholesterol, LDL -C, triglyceride and BMI, and increase HDL -C in women diagnosed with type 2 diabetes. However the levels of such reductions are different among different training group. Finally one may imply that resistance training is more effective than the aerobic or the combination training in improving metabolic factors in patients with type 2 diabetes.

**REFERENCES**


10-Timothy S, Church, & et al (2010). Effects of Aerobic and Resistance Training on Hemoglobin A1c Levels in Patients With Type 2 Diabetes. JAMA, 304 (20), 2253-2262.


