The Effect of Multimodal Exercise Training Program in Subject with Type 2 Diabetes Mellitus

Tip 2 Diabetes Mellituslu Olgularda Multimodal Egzersiz Eğitim Programının Etkinliği

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Abstract

Purpose: The aim of our research was to investigate the effect of multimodal aerobic, resistance and flexibility exercise training program on cardiovascular disease risk factor related with exercise capacity, lipid profile, flexibility, body composition, and glycemic control in newly diagnosed type 2 diabetic patients.

Material and Method: Sixteen newly diagnosed type 2 diabetes patients including 6 study subjects and 10 controls were enrolled in the study. Study group attended to exercise program for a period of 12 weeks. Body composition, flexibility, aerobic capacity, lipid profile, fasting blood glucose (FBG), postprandial glucose (PPG), and hemoglobin A1c (HbA1c) levels were assessed in all participants.

Results: Body fat decreased, flexibility, which was assessed using the sit and reach test, and aerobic capacity increased after the exercise program, these variables showed statistically significant difference within the groups (p<0.05). Triglyceride cholesterol and postprandial glucose levels showed statistically significantly decrease after the exercise program in all participants (p<0.05). Only post exercise FBG and hemoglobin A1c levels showed statistically significant difference between exercise and control groups (p<0.05). Additionally, the Borg Scale significantly positively correlated with FBG (r=0.63, p=0.09), PPG (r=0.51, p=0.039), and HbA1c (r=0.59, p=0.014).

Discussion: Twelve-week multimodal exercise training program improved the aerobic capacity and flexibility and decreased the cardiovascular disease risk related glycemic control by controlling body fat and triglycerides and by maintaining FBG and HbA1c below certain values. Turk Jem 2014; 18: 67-74

Key words: Diabetes mellitus, glycemic control, exercise training

Özet

Amaç: Bu çalışmanın amacı yeni tip 2 diabetes mellitus tanısı alan hastalarda aerobik, dirençli ve fleksibilite egzersizlerinden oluşan multimodal egzersiz eğitim programının kardiyovasküler hastalık risk faktörü ile ilişkili olan egzersiz kapasitesi ve lipid profilinin esneklik, vücut kompozisyonu ve glisemik kontrol ile olan ilişkisini belirlemektir.


Bulgular: Egzersiz programı sonrasında vücut yağını azaldı, otur ve uzan testi ile aerobik kapasite arttı, bu sonuçlar gruplar arasında istatistiksel olarak anlamlı fark gösterdi (p<0,05). Trigliseride kolesterol ve tokluk kan glukozu gruplar arasında egzersiz eğitimi sonrası istatistiksel olarak anlamlı azalma gösterdi (p<0,05). Sadece egzersiz eğitimi sonrası açlık kan glukozu ve hemoglobin A1c değerleri egzersiz ve kontrol grubu arasında değerlendirildiğinde istatistiksel olarak anlamlı fark gösterdi (p<0,05). Ek olarak, yorgunluk skalası olan Borg Skalası ile sırasıyla açıklık kan glukozu, (r=0,63, p=0,09), tokluk kan glukozu (r=0,51, p=0,039) ve HbA1c (r=0,59, p=0,014) de orta derecede korelasyon bulundu.


Anahtar Kelimeler: Diabetes mellitus, glisemik kontrol, egzersiz eğitimi

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Introduction

Diabetes mellitus (DM) is a group of metabolic diseases characterised by hyperglycemia and defects in insulin secretion and/or insulin activity. Chronic hyperglycemia caused by DM results in long-term damage, dysfunction, failure in several organs such as the eyes, kidneys, nerves, and the heart as well as vessel damage and general dysfunction [1,2]. Epidemiological studies indicate that DM incidence have increased in developing countries as well as across the world in recent years [3]. DM has high morbidity and earlier mortality, with a risk of cardiovascular disease followed by acute and chronic complications. It has caused an important public health problem and it is estimated that 246 million persons have had to face with this disease [3,4].

Lifestyle changes involving healthy diet, moderate weight loss, and increased physical activity reduce the risk of DM. In this framework, the Diabetes Prevention Program (DPP) and the Finnish Diabetes Prevention Study (DPS) are important studies showing lifestyle intervention to be as a cornerstone of therapy to prevent DM [5,6].

Pharmacological treatment improved the prevention of hyperglycemia and its related cardiovascular risk factors, however, for long-term achievement, the new healthy life approaches, such as exercise training, should be considered to overcome obesity and sedentary lifestyle causing metabolic abnormalities [7,8]. Clinical cohort studies shows that lifestyle modification delayed the onset of type 2 DM. In these lifestyle approaches, independently from oral antidiabetic agents and insulin usage, physical activity and appropriate diet play a key role in glycemic control [9,10].

From the physical activity aspect, it has been indicated in cohort studies that, since the number of diabetic subjects with cardiovascular disease risk have been increasing day by day, an average 150 minutes of mild-intensity aerobic activity a week has been offered to provide weight control with a decrease in cardiovascular risk. Additionally, 90-minute activities with 60% maximum volume of oxygen (VO2) max added to the program in a week have been accepted as A level evidence in exercise programs to reduce the cardiovascular risk [11].

In their study, Timothy et al. investigated the effect of both aerobic and resistance exercises on HbA1c parameters in subjects with type 2 DM and they found improvements in HbA1c levels in aerobic and resistance exercise group compared to non-exercising subjects [12]. In another study, Arora et al. compared the effects of 8-week progressive resistance exercise and aerobic exercise on glycemic control, metabolic profile, cardiovascular fitness and general well-being parameters. They demonstrated a significant decrease in HbA1c levels in both groups. Total cholesterol levels significantly decreased in both groups. Both exercise groups showed significant reduction in systolic blood pressure and general well-being increased much more in the progressive resistance exercise group compared to the aerobic group [13].

The literature is still in need of combined aerobic and resistance exercise protocols for evidence-based studies. On the other hand, it has still not been clarified how flexibility exercises, which are used especially in the beginning and at the last section of the exercise programme as warm-up and cool down protocols, affect the metabolic control in type 2 DM [12,14]. Body elasticity decreases in type 2 DM; however, there is no evidence how flexibility exercises affect the glycemic control and cardiovascular parameters in patients with type 2 DM [15]. Additionally as indicated before in American Diabetes Association (ADA) consensus report; non-harmful exercise program such as flexibility training should be part of the multimodal exercise programs [11].

Furthermore, early detection and diagnosis are very important to prevent insulin resistance in patients with DM. They play a crucial role in rapidly attaining good metabolic control [16]. Thus, in our study, we aimed to investigate the effects of a supervised multimodal exercise program consisting of aerobic, resistance and flexibility exercises on glycemic control and cardiovascular parameters, lipid profiles, flexibility and body composition in patients with newly diagnosed type 2 DM.

Materials and Methods

Study Population and Intervention
This was a prospective, randomised controlled clinical trial. The details of the study and interventions are described in Figure 1. Briefly, we recruited the subjects by visiting Dokuz Eylül University Endocrinology Department between December 2008 and June 2010. First of all, the patients had face-to-face interviews with the physician (endocrinologist) about their metabolic complaints and then the patients with clinical diagnosis of type 2 DM for at least six months and on oral antidiabetic medication and diet therapy were randomised. All subjects gave their written informed consent and the local ethics committee of the Dokuz Eylül University approved the study. Subjects aged 40-70 years, having a diagnosis of type 2 DM according to the ADA criteria [11] and those willing to participate were considered to be eligible to be included in the study. Those with body mass index (BMI)>35 kg/m², uncontrolled hypertension (systolic≥160, diastolic≤90 mmHg), severe peripheral and/or autonomic neuropathy, proliferative or
severe nonproliferative retinopathy, microalbuminuria (>30 mg/ 
min) and nephropathia (serum creatinin level <1.3 for female, <1.4 
for male), glomerular filtration rate of <60 ml/min, congestive 
heart failure, ischemic heart disease, coronary heart disease, 
cerebral, vascular, pulmonary disease, psychological and other 
neurological problems with communication difficulties, and those 
having contra-indications to participate in an exercise program 
were excluded. Patients' age, gender, body weight, height, DM 
duration, treatment modality of DM and biochemical analysis 
were recorded. After body composition tests, exercise tests and 
flexibility measurements, the patients were enrolled in the study.

### Anthropometric Measurements and Laboratory Tests

Height measurements were done (G-Tech International). Body 
weight and body fat ratio were measured using the bioimpedance 
spectroscopy (BIS) technique. Inbody 720 Biospace, Seoul, Korea. 
This technique uses a spectrum of electrical frequencies given to 
the body. Thus, the body fat percentage is calculated according 
to the differences among the densities in tissues. The BMI was 
calculated by dividing the patients' weight in kilograms by the 
square of their height in meters (BMI=kg/m²). Fasting blood 
glucose (FBG), postprandial glucose (PPG), total cholesterol, 
triglycerides, low-density lipoprotein (LDL) cholesterol, and high-
density lipoprotein (HDL) cholesterol were measured by standard 
(enzymatic) protocol. HgA1c was measured using ADAMS-A1c 
HA-8160. Its reference range was between 4% and 6%. The test 
method was HPLC, analytical measurement range was 2%-20% 
and analytic sensitivity was 0.1% g/dl. Inter-assay CV was 0.24% 
and intra-assay CV was 2.12%.

### Exercise Capacity

The Astrand Test was performed to assess the individuals' 
maximal oxygen consumption at steady state heart rate with 
sub maximal workload. Workload determines the maximal 
Oxygen consumption depending on the relationship between 
heart rate and VO2, between VO2 and workload and, between 
workload and heart rate as well as a predicted maximal heart rate 
based on age. Before the test, subjects were given the necessary 
information. To assess the heart rate, a heart rate monitor and 
chest strap (Polar Fitwatch, Finland) were used. Saddle height 
was arranged for each subject. Additionally, the subjects were 
asked to pedal 3-4 minutes without load to accommodate to the 
bicycle and warming-up section. The start workload was 300 
kpm/min for each subject. The workload was increased by 50% 
for the subjects who were not able to reach 120 beats/min for the 
first 2 minutes of the test. The workload was decreased by 50% 
for the subjects who reached over 170 beats/min for the first 3 
minutes. Additionally, heart rate was recorded at the end of 10 
seconds of each minute. The test was terminated if there was 
no difference in 5 beats/min between the 5th and 6th seconds. 
If this difference was more than 5 beats/min, then the test was 
extended for another one minute. After that, aerobic capacity was 
calculated by using the completing heart rate and the workload 
from the Astrand nomogram (17).

### Flexibility Measurement

#### Sit and Reach Test

The subject was sited with extension of the knee leaning to a 
wooden test table on the floor. Then, the subject pushed the ruler 
without knee flexion to the end point as much as she/he can. 
After that, the furthest point of the subject's reach was recorded 
in cm (18).

#### Trunk Lateral Flexion Test

The subject stayed with minimal shoulder abduction with parallel 
to each other in the standing position. First, we measured the 
distance between the third finger and the floor, then asked the 
subject to bend laterally to the right side. We then recorded the 
distance between standing position and bending position. The 
test was repeated for the left side as well (19).

### Multimodal Intervention Program

30 subjects were included in the study according to the inclusion 
and exclusion criteria. The subjects were randomly divided into 
two groups, 15 in the control and 15 in the exercise group after 
the whole evaluation program. The control group had only 
medical therapy and were offered walking, while the exercise 
group had a supervised exercise program. Five subjects from 
the control group did not want to join the program after the 
measurements. Additionally, 5 subjects did not want to attend 
the exercise program since the program lasts a long period. The 
study started with 10 subjects from control and 10 subjects from 
the exercise group. In exercise group, 2 subjects discontinued 
the program after the first two weeks and 2 subjects ended after 
a 6-week program. By the end of the program, only 10 subjects 
had completed the study from the control group and 6 subjects 
from the exercise group. In total, 16 patients participated the study 
(Figure 1).

The exercise program lasted 12 weeks, 3-4 days in a week. Before 
the program, the patients were educated about type 2 DM, the 
related symptoms and complications; other necessary knowledge 
explaining why they were participating in such a program, the 
importance and the effects of the exercise program and other 
points to consider were provided. Additionally, the patients were 
warned not to change their medication regimen. The exercise 
group were evaluated with the same program before and after 
the study. Exercise intensity was 60%-75% of maximum heart rate 
and, exercise duration was 20-75 minutes progress in this 12-
week exercise program. The subjects started with low intensity 
and duration for the first 2 weeks, then, the program duration and 
intensity were increased gradually.

The multimodal exercise program included stretching and 
flexibility exercises for a 20-minute period with warm-up and 
cool-down exercises and, aerobic exercise with 60%-90%. Max 
heart rate intensity for 20-60 minutes on a treadmill, and resistive 
exercises given on a stationary device and exercises for 15-25 
minutes were applied on a mat.

### Table 1. The demographics of the subjects

<table>
<thead>
<tr>
<th>Variables</th>
<th>EG* (n=6)</th>
<th>CG* (n=10)</th>
<th>p** values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>55.16±8.10</td>
<td>57.80±10.06</td>
<td>0.713</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>165.90±6.63</td>
<td>162.82±8.64</td>
<td>0.428</td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>71.00±16.29</td>
<td>83.63±16.47</td>
<td>0.492</td>
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</tbody>
</table>

**Mann-Whitney U Test, All values are means and standard deviations, p<0.05**

*EG: Exercise Group, CG: Control Group
The exercise program started with 20-30 min/day. The repetition of exercises was between 8-12 repeats for the 3 sets. When patients reached 12 repetitions, the exercise duration was 55-60 minutes. During the exercises, the modified Borg scale was used to assess fatigue and heart rate, blood pressure and breath frequency were measured before and after each section.

Table 3. Changes in PPG, FG, HDL-LDL-total cholesterol, triglycerid and HgA1c levels in exercise and control groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>EG</th>
<th>CG</th>
<th>p**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preexercise Test HR (beat/min)</td>
<td>79.83±1.72</td>
<td>76.00±1.78</td>
<td>0.267</td>
</tr>
<tr>
<td>Postexercise Test HR (beat/min)</td>
<td>20.89±1.69</td>
<td>20.90±1.9</td>
<td>0.913</td>
</tr>
<tr>
<td>VO2max (ml/kg/dl)</td>
<td>67.68±1.69</td>
<td>67.68±1.69</td>
<td>0.857</td>
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<tr>
<td>Total Cholesterol (mg/dl)</td>
<td>154.50±1.69</td>
<td>154.50±1.69</td>
<td>0.913</td>
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<tr>
<td>HDL-Cholesterol (mg/dl)</td>
<td>110.50±1.69</td>
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<td>0.913</td>
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<td>LDL-Cholesterol (mg/dl)</td>
<td>128.50±1.69</td>
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<tr>
<td>Triglycerid (mg/dl)</td>
<td>45.60±1.69</td>
<td>45.60±1.69</td>
<td>0.913</td>
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<tr>
<td>Postparandial Blood Glucose (mg/dl)</td>
<td>328.60±1.69</td>
<td>328.60±1.69</td>
<td>0.913</td>
</tr>
<tr>
<td>Postparandial Blood Glucose (mmol/L)</td>
<td>18.80±1.69</td>
<td>18.80±1.69</td>
<td>0.913</td>
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</tbody>
</table>

Table 2. Changes in body composition, flexibility, exercise test HR and VO2max in exercise and control groups

<table>
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<tr>
<th>Variable</th>
<th>EG</th>
<th>CG</th>
<th>p**</th>
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<tbody>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>33.2±5.44</td>
<td>33.2±5.44</td>
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<tr>
<td>Body Fat Percentage (%)</td>
<td>31.7±5.1</td>
<td>31.7±5.1</td>
<td>0.827</td>
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<tr>
<td>VO2max (ml/kg/dk)</td>
<td>31.7±5.1</td>
<td>31.7±5.1</td>
<td>0.827</td>
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<td>0.913</td>
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Statistical Analysis
All analyses were performed using the ‘Statistical Package for Social Science version 15.0 for Windows. Data were expressed as means ± SD and a p value of less than 0.05 was considered statistically significant. The Mann-Whitney U Test was used for the comparison of the two groups for pre- and post-training results. The Wilcoxon signed-rank test was used for the comparison of the pre- and post-training values in the groups. Additionally, the Spearman correlation analysis was used to assess the association of the Borg Scale results with gender, age, BMI, fat percentage, VO2max, flexibility, FBG, PPG, and HbA1c (20).

Results
The data were obtained from a total of 16 participants (6 patients from exercise group and 10 age-, weight- and height-matched subjects from control group). The age range of the exercise group and the controls was between 46 and 70 years. There were no significant difference in demographic variables between exercise and control groups (p=0.05). Table 1 illustrates the comparison of demographic data between the groups.

There were no significant differences between the exercise and the control groups in pre-exercise and post-exercise BMI, body fat percentage, flexibility, VO2peak, and heart rate. However, after the 12-week exercise program, it was found that body fat percentage significantly decreased in the exercise group (p=0.028), whereas BMI did not change (p=0.173). Flexibility was statistically significantly increased in the sit and reach test, whereas it did not change in the lateral flexion test (p=0.026 sit and reach test, p=0.916 lateral flexion test right, p=0.581 lateral flexion test left). The pre-exercise heart rate did not show any change in the exercise group, whereas the post-exercise heart rate showed statistically significant difference in the exercise test (p=0.046) after the 12 week period. The participants completed the exercise test with higher heart rate values. Additionally, VO2peak statistically significantly increased after 12 weeks (p=0.027) (Table 2). There were statistically significantly difference in both training group pre-exercise measurement and control group measurement (p=0.031) and training group post-exercise measurement and control group measurement (p=0.05) for FBG. Additionally, statistically significantly difference was observed in training group post-exercise and control group measurement for HbA1c values. Whereas there was no statistically significant difference in PPG, HDL-cholesterol, LDL-cholesterol, total cholesterol, and triglyceride values between the groups. After 12 weeks of the exercise program, PPG (p=0.02) and triglyceride (p=0.043) levels were significantly decreased in the exercise group, whereas the changes in other parameters were not significantly significant (Table 3).

We investigated the association between gender and fat percentage, gender and flexiblity, BMI and fat percentage, as well as the association of the Borg scale results with FBG, PPG and HbA1c using a correlation analysis. We found a significant positive correlation between gender and fat percentage (r=0.72, p<0.01), gender and flexibility (r=0.68, p=0.003) (p=0.003), and BMI and fat percentage (r=0.72, p=0.02). In addition, Borg scale results significantly positively correlated with FBG (r=0.63, p=0.09), PPG (r=0.51, p=0.039), and HbA1c (r=0.59, p=0.014) (Table 4).

Discussion
In the present study, we investigated the effects of a supervised multimodal exercise program, consisting of aerobic, resistance and flexibility exercises, on glycemic control and cardiovascular

Table 4. The correlation among gender, age BMI, fat %, VO2max, sit and reach test, FBG, PPG, HbA1c, and borg scale

<table>
<thead>
<tr>
<th></th>
<th>Gender</th>
<th>Age</th>
<th>BMI</th>
<th>%Fat</th>
<th>VO2max</th>
<th>Sit&amp;Reach</th>
<th>FBG</th>
<th>PPG</th>
<th>HbA1c</th>
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*Spearman correlation analysis
parameters, lipid profiles, flexibility, body composition and exercise capacity in patients with type 2 DM. The most important findings of our study were a decrease in body fat percentage, PPG and triglyceride levels; increase in flexibility and VO₂max, as well as changes in post-exercise fasting blood glucose and HbA1C percentage between the exercise and control groups. The benefits of the exercise training in type 2 DM treatment have been proved. It has been accepted that this comprehensive approach reduces the risk of cardiovascular disease by regulating lipid profile and glycemic control with HgA1C, FBG, and PPG levels (12,13,14,21).

Although studies have proved that resistance training alone, aerobic training alone or combined aerobic and resistance training improves cardiovascular outcomes in type 2 diabetic adults, our study indicated that aerobic capacity significantly improved after the multimodal exercise training intervention only in the exercise group. The pre-training results in the control group were higher than in the exercise group, however, there was no statistically significant difference between the groups after the training. It has been shown that aerobic capacity decreases in type 2 DM which is a chronic disease (22). On the other hand improvement in exercise capacity can be maintain by long-term exercise training programs which consist of aerobic, resistance and flexibility training components. Thus our results do not support a negative effect of impaired glucose metabolism on training efficacy by means of improvement in exercise capacity without impaired glucose metabolism in diabetic adults.

Sigal et al. declared that a minimum of 150 minutes regular exercise in a week is effective in glycemic control (11). In the same report (ADA Consensus Report, 2006) it was indicated that aerobic exercises with moderate intensity, i.e. VO₂max 40%-60%, max HR 50%-70%, and/or with high intensity for 90 minutes, i.e. VO₂max >60% or max HR >70%, provides glycemic control by lowering body weight and cardiovascular disease risk, and additionally, resistance exercise with 60%-70% of 1 Repetitive Maximum (RM) for 3 days in a week and with 8-10 repetitions, maintains the glycemic control. These exercise applications were reported as A level evidence for the exercises which are applied in diabetic subjects (11). Therefore, we are able to say that our diabetes exercise program was developed within the scope of current literature. The present study can be applied as a standardised program in terms of the quality assessment of current applications. It is common to face with changes in body composition and exercise capacity in type 2 diabetes because of impaired glucose tolerance and insulin resistance (22). It has been shown that aerobic capacity decreases in diabetic subjects (22). However, Mariorona et al. found that combined aerobic and resistance exercise training with an 8-week training program improves the aerobic capacity in diabetic subjects (23). Similarly, in the present study, the exercise capacity of the subjects significantly improved after the exercise intervention. Even the expectation to aerobic and resistance training improvement of VO₂peak, with advanced cardiovascular fitness levels in healthy subjects, this improvement for diabetic subjects was almost over than the expected results with 140% improvement.

It is known that higher levels of serum triglyceride, LDL cholesterol, glycosylated haemoglobin, microalbuminuria, hypertension, lower levels of HDL cholesterol and increased BMI are significantly related to coronary heart disease (5,6). According to the Finnish Diabetes Prevention Program, these variables - fasting blood glucose, HgA1C and lipid profile - are the variables that have to be checked regularly (6).

In the present study, there were some significant changes in blood variables after the 12-week intervention, i.e. fasting blood glucose (training group pre-exercise versus control group and training group post-exercise versus control group), PPG (pre-exercise-post-exercise) and triglycerides (pre-exercise-post-exercise). No significant changes were seen in HDL, LDL and total cholesterol levels in the exercise group. Maintaining fasting blood glucose below certain values helps decreasing the complications. Likewise, controlling triglycerides, LDL, and HDL cholesterol within acceptable ranges decreases morbidity and mortality (6). A significant decrease was observed in HgA1C levels in only post-exercise measurements. Similarly, Tokmakidis et al. found a significant reduction in blood glucose and HbA1C parameters in type 2 diabetic subjects after 16 weeks of a combined strength and aerobic exercise program (12). Additionally, Marcus et al. and Bweir et al. found that 16 weeks and 10 weeks of combined aerobic and resistance exercises associated with better glycemic control compared to aerobic alone and 10 weeks of resistance and treadmill exercises (21,24). Christos et al. and Yavari et al. found that 16 weeks of a supervised exercise program was effective in improving PPG and HgA1C levels (25,26). Similarly to our results, according to Cauze et al., changes in triglyceride levels were significantly different in combined endurance and strength exercise groups (27). However, a meta-analysis by Kelley et al. declared no changes in triglyceride levels with aerobic exercise treatment in type 2 diabetic subjects (28). In our study, the decrease in triglyceride cholesterol was similar to the literature and results with decreases in the cardiovascular risk profile in diabetic subjects. Additionally, in large population-based studies, 1% decrease in HgA1C has been observed. Several studies have shown a decline in HgA1C in patients with type 2 DM after aerobic or resistance training spanning from several weeks to several months (21,25). Our data showed a 1% change from baseline after the intervention program, which is an important improvement in glycemic control.

We showed that the Borg Scale, which was used to assess fatigue after submaximal exercise testing, was positively correlated with physiological parameters such as FBG, PPG and HbA1C. In diabetic patients, fatigue is widespread clinical complaint and may be the result of simply elevated blood glucose levels. In general, a few data support the relationship between chronic hyperglycemia and fatigue (29). From another point of view, fluctuations in PPG levels result in cytokine activity and oxidative stress which may cause severe fatigue in diabetic subjects (30). Several studies have shown the relationship between fatigue and HbA1C levels (31,32). We also found a strong correlation between HbA1C levels and fatigue. It may be explained by the fact that higher levels of blood glucose lead to fatigue because of chronic inflammation caused
by cytokine activity (30). The relationship of fatigue with FBG and PPG may also be explained by chronic hyperglycemia mechanism in diabetic subjects. Because, in chronic hyperglycemia, the other symptoms of DM, such as psychological symptoms, disease-specific symptoms can be observed (29).

Regarding the relationship between gender and body fat percentage, Wang W found that female diabetics had higher levels of body fat percentage than did male diabetic subjects (33). Our results supported this data. Besides, flexibility and gender showed a positive correlation in the present study. Sephard et al. similarly found positive correlation between gender and flexibility in favour of female subject by using sit and reach test (34).

Shah NR and Braverman ER showed that BMI can be used to estimate body fat percentage. Additionally, the United States Centers for Disease Control and Prevention explained that BMI correlates with body fat percentage. Both these parameters are used to define the adipose tissue of the people (35). Similarly, BMI and body fat percentage were positively correlated in the present study.

A limitation of our study is the small sample size. Although the study started with thirty subjects before randomization, we had large numbers of drop outs. Thus, a statistically significantly difference was not found between several pre- and post-exercise training variables despite the fact that mean ± SD values were different after the training program.

In summary, the data of the present study showed that multimodal exercise intervention is effective in providing glycemic control with improvements in flexibility, exercise capacity and a decrease in body fat percentage in newly diagnosed type 2 diabetic patients.

**Conclusion**

We conclude that a multimodal exercise program provides good glycemic control in diabetic individuals by maintaining fasting blood glucose and HbA1c below certain values and controlling the triglycerides. Thus, a decrease in the cardiovascular risk profile was seen in diabetic patients with a decrease in complications.

**Conflicts of Interest**

There are no conflicts of interest.

**References**

10. The IDF Global Guideline for Type 2 Diabetes. Diabetes S152-S158.