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 belirlemekti.

Gereç ve Yöntem: Çalışmamıza 16 yeni tip 2 diabetes mellitus tanısı alan olgu dahil edildi. Egzersiz grubu 12 hafta süreyle egzersiz programına devam etti. Hastaların vücut kompozisyonu, esnekliği, aerobik kapasitesi, lipid profili, açlık ve tokluk glukoz değerleri ile hemoglobin A1c değerleri ölçüldü.

Bulgular: Egzersiz programı sonrasında vücut yağı azaldı, otur ve uzan testi ile aerobik kapasite arttı, bu sonuçlar gruplar arasında istatistiksel olarak anlamlı fark gösterdi ($p<0,05$). Trigliserid kolesterol ve tokluk kan glukozu gruplar arasında egzersiz eğitimi sonrasında 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 açlık 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.

Tartışma: On iki hafta multimodal egzersiz programı aerobik kapasiteyi ve esnekliği arttırdı, vücut yağını kontrol ederek açlık kan glukozu ve Hb A1c düzeylerini belli değerlerde tutarak ve trigliseridleri kontrol ederek kardiyovasküler hastalık risk faktörü ile ilişkili glisemik kontrolü geliştirdi. *Turk Jem 2014; 18: 67-74*

Anahtar Kelimeler: Diabetes mellitus, glisemik kontrol, egzersiz eğitimi

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 Eylul 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 kgm^2, uncontrolled hypertension (systolic≥160, diastolic≤90 mmHg), severe peripheral and/or autonomic neuropathy, proliferative or
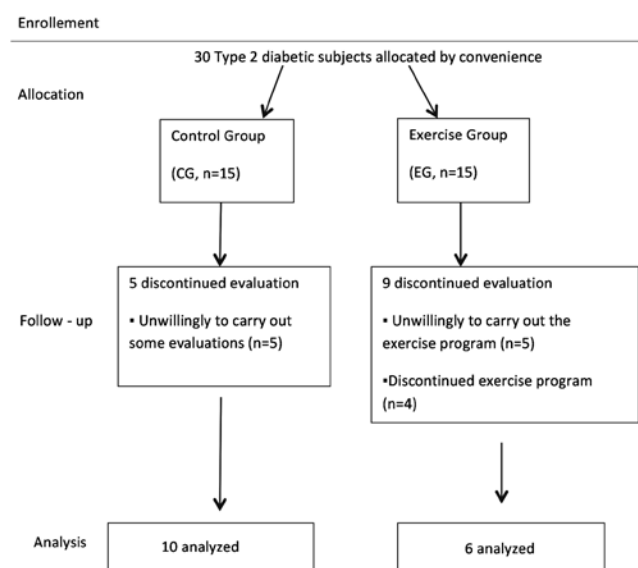

Figure 1. Randomization table

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/m^2). 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 submaximal 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			
Variables	**EG* (n=6)** X±SD	**CG* (n=10)** X±SD	**p** values**
Age (years)	55.16±8.10	57.80±10.06	0.713
Height (cm)	165.90±6.63	162.82±8.64	0.428
Body Mass (kg)	71.00±16.29	83.63±16.47	0.492
**Mann-Whitney U Test, All values are means and standart deviations, p<0.05 *EG: Exercise Group, CG: Control Group			

Table 2. Changes in body composition, flexibility, exercise test HR and VO$_{2peak}$ in exercise and control groups

Variable	EG	CG	p**
Body Mass Index (kg/m^2)			
Pre	33.32±5.84		0.562
		31.42±4.95	
Post	32.78±5.78		0.827
p*	0.173		
Body Fat Percentage (%)			
Pre	35.30±9.20		0.958
		35.84±7.97	
Post	32.75±7.89		0.377
p*	0.028		
Sit and Reach Test (cm)			
Pre	3.50±4.32		0.562
		5.00±5.09	
Post	10.16±3.86		0.052
p*	0.026		
Lateral Flexion Test R (cm)			
Pre	16.16±4.66		0.313
		13.50±3.53	
Post	15.33±4.13		0.221
p*	0.916		
Lateral Flexion Test L (cm)			
Pre	14.83±4.44		0.428
		12.70±3.19	
Post	14.16±5.07		1.000
p*	0.581		
VO$_{2max}$ (ml/kg/dk)			
Pre	20.90±27.88		0.073
		27.88±7.82	
Post	28.16±4.59		0.913
p*	0.027		
Preexercise Test HR (beat/min)			
Pre	79.83±1.72		0.428
		76.80±11.78	
Post	82.50±10.19		0.267
p*	0.686		
Postexercise Test HR (beat/min)			
Pre	128.00±7.77		0.792
		128.70±7.71	
Post	132.00±9.12		0.743
p*	0.042		

*Wilcoxon Signed Rank Test **Mann-Whitney U Test

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, trigliserid and HgA1C levels in exercise and control groups

Variables	EG	CG	p**
Fasting Blood Glucose (mg/dl)			
Pre	141.33±71.47		0.031
		182.10±53.72	
Post	107.50±13.21		0.05
p*	0.249		
Postparandial Blood Glucose (mg/dl)			
Pre	208.83±130.05		0.368
		252.80±112.63	
Post	137.66±39.58		0.052
p*	0.028		
LDL-Cholesterol (mg/dl)			
Pre	123.16±47.02		0.792
		121.88±46.00	
Post	97.40±25.69		0.267
p*	0.249		
HDL-Cholesterol (mg/dl)			
Pre	44.83±10.87		0.857
		45.80±12.57	
Post	42.50±11.81		0.913
p*	0.276		
Total Cholesterol (mg/dl)			
Pre	201.50±45.47		0.958
		212.20±32.14	
Post	165.83±33.36		0.180
p*	0.173		
Trigliserid (mg/dl)			
Pre	167.16±82.51		0.875
		173.60±69.22	
Post	132.50±75.83		0.510
p*	0.043		
HbA1c (%)-(mmol/mol)			
Pre	7.49±2.27-58		0.073
		8.47±2.02-69	
Post	6.46±0.80-47		0.038
p*	0.173		

*Wilcoxon Signed Rank Test **Mann-Whitney U Test

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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, VO_{2max}, 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, VO_{2peak}, 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 sitand 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 %, VO_{2max}, sit and reach test, FBG, PPG, HbA1c, and borg scale										
	Gender	**Age**	**BMI**	**%Fat**	**VO$_{2max}$**	**Sit&Reach**	**FBG**	**PPG**	**HgA1c**	**Borg Scale**
Gender	NS	NS	r=0.72 p<0.01	NS	NS	r=0.68 p<0.01	NS	NS	NS	NS
Age		NS	NS	NS	NS	NS	NS	NS	NS	NS
BMI			NS	r=0.72 p<0.01	NS	NS	NS	NS	NS	NS
Fat%				NS	NS	NS	NS	NS	NS	NS
VO$_{2max}$					NS	NS	NS	NS	NS	NS
Sitand Reach						NS	NS	NS	NS	NS
FBG							NS	NS	NS	r=0.63 p<0.01
PPG								NS	NS	r=0.51 p<0.01
HgA1c									NS	r=0.59 p<0.01
Borg Scale										NS
*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 VO_{2max} 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. VO_{2max} 40%-60%, max HR 50%-70%), and/or with high intensity for 90 minutes, (i.e. VO_{2max} >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 Maximumum (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 VO_{2peak} 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, glycolised heamoglobin, 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-exericse 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, fluctations in PPG levels result in cytokine activity and oxidative stress which may cause severe fatigue in diabetic subjects (30). Several studies have showed 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 pshcological 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.

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