Influence of Exercise on Leptin, Adiponectin and Quality of Life in Type 2 Diabetics

Tip 2 Diyabetlilerde Egzersizin Leptin, Adiponektin ve Yaşam Kalitesi Üzerine Etkisi

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Abstract

Purpose: This study aimed to investigate the influence of aerobic exercise on the quality of life and leptin and adiponectin levels in patients with type 2 diabetes mellitus.

Material and Method: Patients were randomized into two groups: aerobic exercise-training and control group. Parameters were assessed at baseline and end of the twelve-week follow-up for 60 type 2 diabetic patients who completed the program. The 36-item Short Form Health Survey was administered to the patients.

Results: The exercise-training group results showed a decrease in adiponectin and leptin levels, a reduction of waist circumference and percentage of body fat (p=0.007, 0.023, 0.012 and 0.048, respectively). The leptin levels in the aerobic exercise group were positively correlated with body mass index (r=0.303, p=0.021) and percentage of body fat (r=0.371, p=0.005); they were negatively correlated with physical problems (r=-0.482; p=0.009) and pain (r=-0.540; p=0.003). Exercise led to statistically significant improvements in the SF-36 physical functioning and mental health subscales (p=0.020 and 0.023, respectively).

Discussion: The association of better HbA1c, waist circumference, and percentage of body fat with improved mental and physical scores may be related to a decrease in leptin levels, despite a significant reduction in serum adiponectin levels. *Turk Jem 2015; 19: 7-13*

Key words: Adiponectin, exercise, leptin, SF-36, type 2 diabetes mellitus

Conflicts of Interest: The authors reported no conflict of interest related to this article.

Özet

Amaç: Bu çalışmada tip 2 diyabetli hastalarda aerobik egzersizin serum leptin, adiponektin düzeylerine ve yaşam kalitesi üzerine etkisini değerlendirmeyi amaçladık.

Gereç ve Yöntem: Hastalar 2 gruba randomize edildi: aerobik egzersiz ve kontrol grubu. Altmış tip 2 diyabetli hastanın parametreleri başlangıçta ve 12 haftalık program sonunda değerlendirildi.

Bulgular: Egzersiz grubunda adiponektin, leptin düzeylerinde düşme, bel çevresinde ve vücut yağ oranında azalma gözlendi (sırasıyla p değerleri 0,007, 0,023, 0,012, 0,048). Egzersiz grubunda leptin düzeyleri, Beden kitle indeksi (r=0,303, p=0,021), vücut yağ oranı (r=0,371, p=0,005) ile pozitif korelasyon, fizik problemlerle (r=-0,482; p=0,009) ve ağrı (r=-0,540; p=0,003) ile negatif korelasyon gösteriyordu. Aynı zamanda egzersiz, bir yaşam kalitesi ölçeği olan SF-36 anketinde fiziksel fonksiyon ve mental sağlık skalasında da anlamlı iyileşmeyle sonuçlandı (sırasıyla, p değerleri 0,020, 0,023).

Tartışma: Serum adiponektin düzeylerinde önemli ölçüde azalmaya rağmen, mental ve fiziksel skorlardaki iyileşme, HbA1c, bel çevresi ve vücut yağ oranındaki iyileşme azalan leptin düzeyleri ile ilişkili olabilir. *Turk Jem 2015; 19: 7-13*

Anahtar kelimeler: Adiponektin, egzersiz, leptin, SF-36, tip 2 diyabet

Çıkar Çatışması: Yazarlar bu makale ile ilgili olarak herhangi bir çıkar çatışması bildirmemiştir.

Introduction

The incidence and prevalence of diabetes mellitus (DM) has been increasing in recent years (1). Type 2 DM (T2DM) is associated with insulin resistance and obesity resulting from genetic and environmental factors including the decrease of physical activity and the increase of calorie intake (2). Regular physical activity has a positive effect on insulin sensitivity, appetite, glycemic regulation, and control of body weight. Therefore, exercise is suggested as the primary first-line modality and is considered indispensable in the treatment of obesity and T2DM (3). However, the mechanisms underlying the beneficial effects of aerobic exercise that prevent cardiovascular disease and improve glycemic control are not entirely understood.

Adiponectin (4) and leptin (5), two proteins secreted by adipose tissue, are implicated in insulin resistance, and they may play a role in the etiology of T2DM. Adiponectin has anti-diabetic, insulin-sensitizing, anti-inflammatory, and anti-atherogenic effects (6,7) and it may be used as a treatment strategy in the management of obesity, diabetes, and metabolic syndrome (4). Adiponectin also has beneficial actions in the control of the inflammatory process and atherogenesis on vascular endothelial function (7). We have little knowledge about the relationship between the improvement in insulin resistance induced by short-term aerobic exercise and adiponectin levels in T2DM. In the literature, a few reports have investigated the acute or chronic effects of short- and long-term physical activity on plasma adiponectin levels (8,9,10,11).

Leptin is produced by adipocytes and acts on the satiety center on the hypothalamus to suppress appetite, limit food intake and increase energy expenditure. A leptin-resistant/hyperleptinemic state has been demonstrated in obesity and obesity related cardiovascular disease (12). Furthermore, there was a significant association between insulin resistance and serum leptin concentrations (13). High serum leptin levels and low serum adiponectin levels have been demonstrated to be related to T2DM (4,5). The effect of exercise on circulating adiponectin remains inconclusive, with increases (14,15), decreases (8), and "no change" (9) reported in different studies.

Several studies have shown that diabetic patients have a decreased quality of life (QOL) compared to healthy individuals (16). On the other hand, the relationship between glycemic control and QOL is unclear. A randomized controlled double-blind trial showed that improved HbA1c was associated with short-term improvement in QOL and economic benefits in T2DM (17). Another study showed no association (18) in these parameters.

In this study, the relationship between aerobic exercise and QOL as measured by the SF-36 was evaluated before and after 12 weeks of exercise. The major purpose of this study was to determine whether moderate-intensity exercise training would change leptin and adiponectin levels and whether leptin and adiponectin levels affect QOL. Another purpose was to determine if adults who regularly exercised had better QOL than those who did not perform these lifestyle behaviors.

Materials and Methods

Participants

Potential participants were excluded if they: 1- were receiving insulin therapy, 2- were participating in exercise ≥2 times per week for at least 20 min per session or had undertaken any resistance training during the previous six months, 3- reported changes in oral hypoglycemic medications during the previous two months, 4- reported changes in antihypertensive or lipid-lowering agents in the previous month, 5- reported a change of ≥5% in body weight during the previous two months, 6- had serum creatinine ≥1.5 mg/dL, 7- had proteinuria >1 g/24 h, 8- had blood pressure >160/95 mmHg, 9- had physical activity restrictions due to disease, 10- had other medical conditions making participation inadvisable, 11- had HbA1c >9.5%, 12- were smoking, 13- were receiving hormone replacement therapy, or 14- had any known microvascular or macrovascular diseases. Seventy-five T2DM patients aged between 35 and 70 years, with an HbA1c value of 6.5% or above, weight stability (±2 kg) 6 months before entry; without restraining orthopedic or neuromuscular diseases were assessed for eligibility. The study was approved by our institution's ethics committee and it was conducted in accordance with the Declaration of Helsinki.

All participants were asked to revert to their pre-study activity levels. They were inactive and none reported previous systematic (more than once a week) exercise activity.

Nine of 75 subjects were unwilling to participate following completion of the preparation phase of the study (such as filling out the questionnaire, dietary assessment, and advice). Sixty-six subjects (medical outpatients) were randomized into two groups: aerobic exercise training and no exercise (control). Of these, six patients dropped out (three from each group) during the experimental period due to non-compliance and loss to follow-up. Twenty-nine males and 31 females with T2DM completed this study. The aerobic exercise and control groups did not differ in clinical or demographic characteristics. Eligible patients were interviewed to measure utility values, and they were administered the 36-item Short Form Health Survey (SF-36) (19) which provides scores on eight areas of functioning and well-being (physical functioning, mental health, role physical, role emotional, bodily pain, general health, vitality, and social functioning) and all items are summed and transformed to form a scale from 0 to 100. We used the Turkish version of the SF-36 prepared by Kocyigit and colleagues (20). A dietitian evaluated the study participants, and she prescribed a diet program to all participants according to American Diabetes Association recommendations (21). Participants were asked to check compliance with the diet at the end of the study. A total of 60 subjects were receiving blood glucose-lowering medication as follows: metformin alone (6 in exercise group, 6 in control group); sulfonylurea (1 in the exercise group, 1 in the control group); pioglitazone + metformin (4 in the exercise group, 4 in the control group); sulfonylurea + metformin (12 in the exercise group, 11 in the control group); sulfonylurea + pioglitazone (2 in the exercise group, 1 in the control group); and pioglitazone + metformin + sulfonylurea (5 in the exercise group, 7 in the control group).

All patients completed the SF-36 using the pencil-and-paper method in a separate, quiet room while waiting for their turn to see the doctor. In order to avoid bias, relatives and friends were

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not allowed to be present. On average, each patient took about 10-15 minutes to complete the SF-36. During the administration of the questionnaire, a researcher was readily available for assisting the patients in understanding the SF-36 if required. The researchers were instructed to minimize their explanations, and the patients were asked to answer the questions according to their understanding. After completion of the questionnaire, the researcher determined the completeness of the returned SF-36s. The participants filled out the SF-36 questionnaire again at the end of 12 weeks.

The aerobic exercise group consisted of 30 subjects who took part in an exercise-training program. The participants exercised on a treadmill three times per week, with training gradually progressing in length and intensity. Heart rate monitors were used to adjust workloads to achieve target heart rates. The participants progressed from 15-20 minutes per session at 60% of maximum heart rate to 45 minutes per session at 75% of measured maximum heart rate. A personal trainer was present for a minimum of three scheduled sessions weekly at each exercise facility and supervised the exercise program. After randomization, the trainer met each participant individually at least once a week for four weeks, then, every two weeks for the subsequent eight weeks to ensure appropriate progression through the program. The personal trainer monitored attendance and contacted the participants if any sessions were missed. Patients, who completed fewer than ten of the 12 weeks exercise sessions during the study period, were excluded. The control participants were asked to revert to their pre-study activity levels, and they continued with their normal daily activities during the twelve weeks of research without additional guided physical activities. Efforts were made to minimize dietary and medication co-intervention.

Laboratory Tests

Blood samples were obtained from all subjects in the morning between 08:00 and 09:00 hours after an overnight fast. Measurements were taken on recruitment and repeated after twelve weeks. The samples were centrifuged, aliquoted, and immediately frozen at -80 °C for analysis of leptin, adiponectin, and lipoproteins.

Serum glucose, total cholesterol (TC), LDL-cholesterol (LDL-c), triglyceride (TG), and HDL-cholesterol (HDL-c) levels were measured using Randox enzymatic kits in the Roche-Hitachi Modular system. LDL-c was calculated by the Friedewald equation method. Leptin and adiponectin concentrations in serum were determined using a commercially available ELISA kit from RayBiotech (Norcross, GA, USA). The intra- and inter-assay coefficients of variation were less than 7-10% for all parameters.

Body weight (kg) and height (cm) of all subjects were measured; measurements were taken on recruitment and repeated after twelve weeks. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Waist circumference (WC) was measured as the minimum between the costal margin and the iliac crest.

A foot-to-foot body fat analyzer (Tanita TBF 300, Tanita, Tokyo, Japan) was used for bioelectrical impedance analysis. Fat percentage was recorded before and after twelve weeks. Physical examinations included systolic and diastolic blood pressure measurement using a mercury sphygmomanometer after a 10-minute rest.

Statistical Analysis

The Kolmogorov-Smirnov test was used to determine if continuous variables were normally distributed. For normally distributed data, results were presented as mean ± standard deviation (SD) and comparison between groups of continuous variables was performed by using the Student's t test. When the variables were found not to be normally distributed (SF-36, and TG), results were given as median ± interquartile range (IQR); comparisons between groups of data were made using the Mann-Whitney U test. Differences between categorical variables were analyzed by the chi-square test (gender and DM treatment). Changes in outcome measures were assessed using paired t-test or the Wilcoxon-signed ranks test (SF-36, and TG). Relationships between variables were analyzed using Pearson's or Spearman's rank correlation coefficients (SF-36, and TG). Statistical analysis was carried out by using Statistical Package of Social Science (SPSS), version 16.0 (SPSS Inc., Chicago, IL). A p value of <0.05 was considered statistically significant.

Results

A total of 60 patients, 31 females and 29 males, were included in the analysis. HbA1c values, lipid panel values, and baseline scores on the SF-36 sub-scales and summary measures are shown in Tables 1 and 2.

No exercise-related injuries were reported. Five hypoglycemic events were observed immediately post-exercise, which were resolved with administration of high-sugar snacks. Exercisers did not report hypoglycemia at home or on non-training days.

The aerobic exercise and control groups did not differ in baseline HbA1c, age, gender, percentage of body fat, duration of diabetes, BMI, WC, systolic (SAP) and diastolic arterial blood pressure (DAP), LDL-c, HDL-c, TG, TC, or leptin and adiponectin levels (Table 1). The SF-36 showed no statistically significant differences in baseline scores between the control and aerobic exercise groups except physical functioning (Table 2).

The exercise training group completed follow-up over twelve weeks, with a 2% weight loss. Lipid profile, BMI, and SAP and DAP decreased, but these changes were not statically significant (Table 3). HbA1c levels also decreased but were not statistically significant (7.0±0.8 vs. 6.7±1.0, p=0.079). The levels of WC, leptin, adiponectin and percentage of body fat decreased significantly after the 12-week period in the exercise training group (Table 3; p=0.012, 0.023, 0.007, 0.048, respectively). Changes in adiponectin levels were not associated with changes in any parameter.

Comparison of initial and terminal SF-36 scores revealed significant improvements in the physical functioning and mental health subscales in the aerobic exercise group (p=0.020, 0.023, respectively). No effects on the other SF-36 parameters were noted in that group (Table 4).

Spearman's correlation analysis revealed that baseline physical functioning scores were correlated with mental health (r=0.496, p<0.001), physical functioning (r=0.494, p<0.001), bodily pain (r=0.584, p<0.001), general health (r=0.512, p<0.001), vitality

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(r=0.544, p<0.001), social functioning (r=0.416, p=0.001), and role emotional (r=0.370, p=0.004) in both groups.

In both groups, baseline leptin levels were positively correlated with percentage of body fat (r=0.530, p<0.001), BMI (r=0.457, p<0.001), TC (r=0.301, p=0.021), and LDL-c (r=0.302, p=0.020). Baseline leptin levels were negatively correlated with physical functioning (r=-0.265, p=0.042), physical problems (r=-0.280, p=0.032), bodily pain (r=-0.360 p=0.005), general health (r=-0.334, p=0.010), vitality (r=-0.335, p=0.010), role emotional (r=-0.261, p=0.046) and mental health (r=-0.292, p=0.025). Baseline adiponectin levels were not correlated with any parameters.

After the 12-week period, Spearman's correlation analysis revealed that physical functioning scores in the aerobic exercise group were negatively correlated with HbA1c levels (Figure 1; r=-0.475, p=0.009);

mental health scores were negatively correlated with LDL-c levels (r=-0.391, p=0.044). After the 12-week period, mental health scores in the aerobic exercise group were positively correlated with physical functioning (r=0.478, p=0.009).

After the 12-week period, leptin levels in the aerobic exercise group were positively correlated with BMI (r=0.303, p=0.021) and percentage of body fat (Figure 2, r=0.371, p=0.005); they were negatively correlated with physical functioning (r=-0.482; p=0.009) and bodily pain (r=-0.540; p=0.003).

Discussion

Our data show that an aerobic exercise training program induced a significant decrease in adiponectin and leptin levels and WC, as

Table 1. Clinical and laboratory characteristics of aerobic exercise and control group at the baseline period

Variable	Aerobic Exercise Group (n=30)	Control Group (n=30)	p
Age, mean (yrs.)	52.5±7.5	55.5±8.4	0.175
Gender	15 M/15 F	14 M/16 F	0.606
Treatment DM	M/S/P+M/S+M/S+P/P+M+S	M/S/P+M/S+M/S+P/P+M+S	0.810
Fat percentage (%)	33.4±6.9	33.5±7.5	0.691
HbA1c (%)	7.0±0.8	6.8±1.0	0.181
BMI (kg/m^2)	30.8±4.6	30.2±4.5	0.566
WC (cm)	101.9±8.6	99.5±10.7	0.315
SAP (mmHg)	127.6±16.1	127.1±12	0.910
DAP (mmHg)	78.7±9.0	77.6±8.9	0.633
LDL-c (mg/dL)	109.4±36.5	115.0±35.9	0.552
HDL-c (mg/dL)	39.6±12.1	41.0±21.0	0.337
TG (mg/dL)*	143±112	128±97	0.716
TC (mg/dL)	181.5±46.2	186.7±45.3	0.661
Adiponectin (μg/mL)	6.6±0.8	6.5±1.1	0.786
Leptin (ng/mL)	27.1±19.8	26.6±17.5	0.925
Duration of DM (yrs)	6.1±5.2	6.7±4.5	0.634

Chi-square was used to detect differences between groups for gender and DM duration. Results were presented as mean ± SD, and *median ± IQR. P values <0.05 accepted as statistically significant

Table 2. The difference in the SF-36 between the two groups of patients at baseline

Scale in SF-36	Aerobic Exercise Group (n=30)	Control (n=30)	p
Physical health component			
Physical functioning	85.0±18	60.0±41	0.010*
Physical problems	75.0±50	50.0±75	0.102
Pain	80.0±39	61.5±46	0.074
General health perception	60.0±27	58.5±43	0.425
Mental health component			
Vitality	65.0±30	57.5±35	0.235
Social functioning	87.5±25	75.0±38	0.262
Emotional problems	66.6±67	100.0±75	0.402
Mental health	68.0±18	66.0±24	0.761

Data are median ± IQR. Mann-Whitney U test was applied to test for significant differences between groups. *p<0.05 by Mann-Whitney U test

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well as an improvement in physical functioning and mental health subscales in sedentary middle-aged type 2 diabetic subjects maintaining their usual dietary habits.

Adiponectin is secreted by visceral adipose tissue rather than subcutaneous adipose tissue, and recent studies have demonstrated that the visceral fat area is negatively correlated with plasma adiponectin levels in obese subjects (22). Furthermore, visceral adipose tissue, not total adipose tissue, plays an important role in pathogenesis of insulin resistance, T2DM, and cardiovascular disease (23,24). Circulating levels of adiponectin may be a link between visceral obesity and certain related metabolic abnormalities that contribute to the development of insulin resistance, T2DM, and atherosclerosis (25,26,27). Adiponectin levels have been reported to be inversely correlated with central adipose tissue stores. The marked reduction in WC induced by our training program was associated with a decrease in adiponectin

levels. These findings suggest that decreased adiponectin levels may be because of the increases in proinflammatory cytokines (28), such as inteleukin-6, tumor necrosis factor-α and adrenaline, or ethnicity discrepancy, in the post-exercise period (29). The reasons for these discordant findings are not clear.

In recent years, various authors have emphasized that increased adiponectin levels may not always be beneficial in terms of good health (30,31). Hadjadj et al. reported increased levels of adiponectin associated with diabetes-related microvascular complications (30). Dekker et al. found that high adiponectin serum levels predict all-cause and cardiovascular disease mortality (31). On the other hand, we found a relationship between leptin and the percentage of body fat and BMI in the exercise training group. This is in agreement with a number of studies that have shown decreases in leptin levels in response to weight loss, lower percentage of body fat, and decreased WC. In general, post-exercise decreases in leptin can

Table 3. Comparisons of clinical and laboratory characteristics baseline and after 12 weeks period in aerobic exercise and control group (mean ± SD or median (min-max))

Variable	Baseline Aerobic Exercise Group (n=30)	After 12 weeks Period in Aerobic Exercise Group (n=30)	Baseline Control Group (n=30)	After 12 weeks Period in Control Group (n=30)	p^	p*
HbA1c (%)	7.0±0.8	6.7±1.0	6.8±1.0	6.8±1.0	0.079	0.608
BMI (kg/m^2)	30.9±4.6	30.0±4.5	30.2±4.5	30.9±4.7	0.289	0.548
WC (cm)	101.9±8.6	100.0±8.2	100.7±10.2	101±9.9	0.012$^\beta$	0.631
Fat percentage%	32.5 ±7.7	31.6±8.0	34.2±6.9	34.5±6.6	0.048$^\beta$	0.267
SAP (mmHg)	127.6±16.1	122.0±12.2	127.2±12.1	124.5±15.6	0.112	0.331
DAP (mmHg)	78.7±9.0	76.5±8.2	77.7±9.0	76.7±8.1	0.240	0.536
LDL-c (mg/dL)	109.4 ± 36.5	102.9±25.2	114.1±36.2	115.3±34.0	0.299	0.877
HDL-c (mg/dL)	40.7±12.8	38.6±7.6	43.5±9.9	41.4±10.4	0.372	0.274
TG (mg/dL)†	143±112	124±96	128±97	138±128	0.182	0.473
TC (mg/dL)	181.5±46.2	172.8±32.6	185.5±45.6	186.6±48.6	0.120	0.880
Adiponectin (μg/mL)	6.6±0.8	6.0±0.8	6.6±1.2	6.4±1.0	0.007$^\beta$	0.275
Leptin (ng/mL)	26.6±20.5	23.8±19	26.6±17.6	27.9±16.7	0.023$^\beta$	0.491

Results were presented as mean ± SD, and †median ± IQR. p^ Before vs after 12 weeks period in aerobic exercise group. p* Before vs after 12 weeks period in control group. $^\beta$Statistical difference compared to pre-test values of dependent variables in aerobic exercise group of diabetic patients (paired t-test and Wilcoxon signed ranks test (TG); p<0.05)

Table 4. The difference in the SF-36 baseline and after 12 weeks period in aerobic exercise group (median ± IQR)

Scale in SF-36	Before Exercise (n=30)	After Exercise (n=30)	p
Physical Health Component			
Physical functioning	85.0±18	90.0±20	0.020$^\beta$
Physical problems	75.0±50	100.0±25	0.367
Pain	80.0±39	74.0±38	0.936
General health perception	60.0±27	62.0±34	0.267
Mental Health Component			
Vitality	65.0±30	70.0±28	0.216
Social functioning	87.5±25	87.5±25	0.776
Emotional problems	66.6±67	66.6±67	0.346
Mental health	68.0±18	72.0±20	0.023$^\beta$

$^\beta$Statistical difference compared to pre-test values of variables in aerobic exercise group of diabetic patients (Wilcoxon signed ranks test (SF-36); p<0.05)

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be observed if energy expenditure is high. In our study, BMI decreased after the 12 week-period in the exercise-training group, but these changes were not statically significant. The levels of WC and leptin decreased in spite of a significant decrease in serum adiponectin levels. Leptin levels were positively correlated with BMI and negatively with physical functioning and pain. As in our study, Gomez-Merino et al. reported a reduction in leptinemia after three weeks of military training, but body weight remained stable (32). Ishii et al. showed a reduction in leptinemia after six weeks of aerobic training in type 2 diabetic subjects (33). As with fat percentage, expected associations between physical activity and leptin were observed. Thus, our study supports a potential link between reduced leptin levels and elevated physical activity levels in patients with T2DM.

We found significantly lower leptin levels after exercise, and we concluded that regular exercise, by reducing WC and percentage of body fat, suppresses serum leptin levels. This decrease appeared despite the absence of significant changes in BMI. There is, however, a wide variation in serum leptin levels among
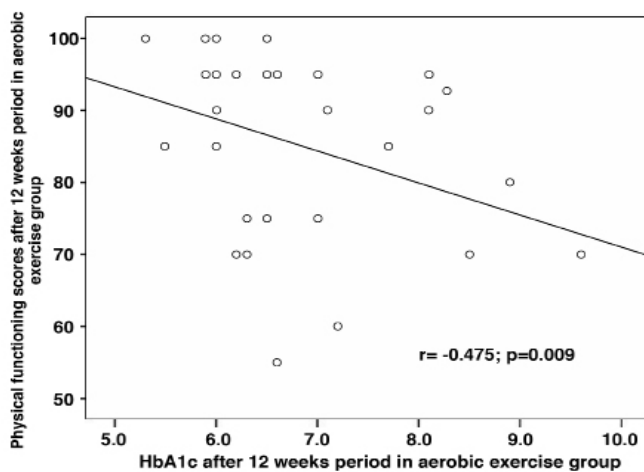

Figure 1. Physical functioning scores were negatively correlated with HbA1c levels after 12 weeks period in aerobic exercise group

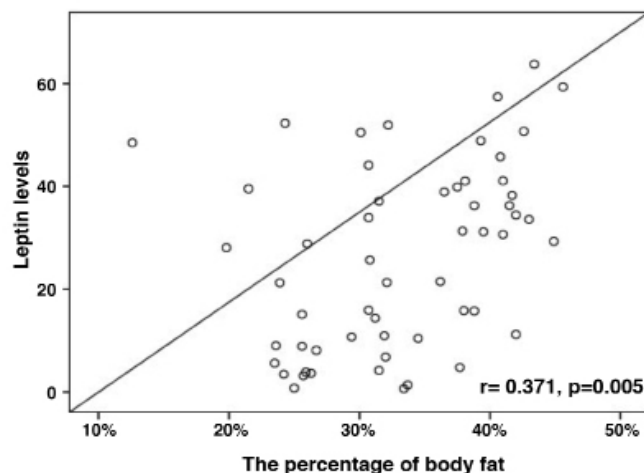**Figure 2.** After 12 weeks period in aerobic exercise group, leptin levels were correlated with the percentage of body fat

individuals with similar BMI or fat mass (34,35,36) indicating that there are also other modifiers of serum leptin levels.

Physical exercise affects hormonal concentrations (insulin, cortisol, growth hormone, catecholamines, testosterone, etc.) and metabolites (free fatty acids, lactic acid, triglycerides, etc.). For these reasons, we believe that physical exercise and training could modify leptin response, depending on several factors.

After the 12-week period, mental health scores in the aerobic exercise group were positively correlated with physical functioning. Thus, high physical activity is viewed as a consequence of cognitive processing. A number of studies have indicated that physical activity can prevent or reduce mental health problems (typically, anxiety and depression) and that physically active adolescents are less likely to suffer from these mental health problems (37,38,39). In our study, we found that mental health scores were negatively correlated with LDL-c levels in the exercise-training group after the 12-week period. However, whether low-serum cholesterol levels may cause adverse effects on mental health remains unclear (40). Strandberg et al. found, with 39 years of follow-up, that men with the lowest serum cholesterol levels have longer survival rates, better physical function, and QOL, along with no adverse effect on mental health (41).

It is generally known that the overall QOL in patients with diabetes mellitus is poorer than in the normal population, however, the extent of this decline related to the level of glycemic control remains debatable, as results from previous studies have been inconsistent (17,18). After 12 weeks, we found that patients in the exercise training group who reported better physical functioning and vitality were more likely to have decreased HbA1c levels. Higher glycemic levels were associated with lower well-being scores (42). Improved QOL was positively associated with a decrease in hyperglycemic incidences, which may be a reflection of better glycemic control (17,43). Whether measures to improve physical functioning and vitality would help to improve glycemic control may be an area for future studies.

Improved diabetic control through aerobic exercise training is associated with improved mental and physical functioning and is related to a decrease in adiponectin and leptin levels. Improvement in physical functioning and mental health and amelioration of glycemic status may result in an improvement of physical QOL.

A limitation of our study is that there was a lack of multi-isoforms and receptors of adiponectin. The high molecular weight isoform has been shown to be the active form and, therefore, may be determined to identify the beneficial health effects of endurance training in T2DM. Our results may be explained by different adiponectin isoforms or the expression of adiponectin receptors. Finally, aerobic exercise training may bring about significant beneficial effects including a decrease in serum adiponectin and leptin and an improvement in body fat, glycemic status, and physical and mental QOL in type 2 diabetic individuals.

Larger, longer-term cohort studies are needed to further evaluate the relationship between glycemic control and QOL. Physicians should be aware of physical and mental QOL in the management of T2DM.

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