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Changes in adipose tissue and biochemical parameters after aerobic exercise in overweight and obese women

Meltem Sertbaş [1], Serkan Elarslan [2], Emre Şenocak [3]

[1] Department of Internal Medicine, Fatih Sultan Mehmet Education and Research Hospital, Istanbul, Turkey
[2] Department of Chief Physician, Fatih Sultan Mehmet Education and Research Hospital, Istanbul, Turkey
[3] Marmara University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Istanbul, Turkey

ORCID ID of the author(s)
MS: 0000-0001-8987-7199
SE: 0000-0001-6386-4525
EŞ: 0000-0003-3677-9813

Corresponding Author
Meltem Sertbaş
Fatih Sultan Mehmet Eğitim ve Araştırma Hastanesi, Dahili Bilimler Polikliniği, İstanbul, Turkey
E-mail: msertbas68@gmail.com

Ethics Committee Approval
This study was approved on 01.02.2021 with the decision number 1591 by the Clinical Research Ethics Committee of Fatih Sultan Mehmet Training and Research Hospital.
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

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No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Obesity is a global epidemic, and it is more common in women due to physiological differences. Exercise programs are the cornerstones of obesity treatment. This retrospective study aimed to examine the effect of moderate-intensity continuous aerobic exercise (MICT) program on body composition, biochemical parameters, and cardiovascular risk in overweight and obese female.

Methods: This retrospective cohort study analyzed the data of overweight and obese women who exercised for 12 weeks. The exercise program was maintained under the supervision of a physiotherapist three non-consecutive days a week. Each session was performed for 60 minutes at an intensity of 50% to 65% of maximum heart rate (HRmax). Body composition was evaluated by TANITA bioelectrical impedance analysis system, and aerobic capacity was assessed with 6-minute Walking Test (6-MWT). Biochemical parameters were analyzed in the laboratory. All results of the participants were obtained from the patient files.

Results: Body Mass Index (BMI), Fat Mass (FM-kg), Fat-free Mass (FFM-kg), Total Body Water (TBW-kg), and aerobic capacity improved after the implementation of the exercise program ($P<0.05$ for all). There was no significant change in blood parameters except HDL ($P=0.002$). An 11% reduction was observed in cardiometabolic risk factors due to the increased HDL.

Conclusion: The MICT program appears suitable for improving body composition and aerobic capacity with 50-65% intensity for 12 weeks. However, we think that exercise intensity should be increased for more biochemical benefits.

Keywords: Overweight, Moderate-intensity continuous aerobic training, Body composition, Aerobic capacity, Cardiovascular risk

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Introduction

Obesity is the most common health problem in many countries, and its worldwide prevalence is rising every day [1]. A society comprising over 30% overweight individuals is referred to as "obese." Turkey has become one of the obese countries with 32.1% gender-neutral obesity, and this rate is higher than 40% among females [2]. Accordingly, weight-related systemic illnesses have also increased among women [3-5]. Physical activity is frequently used as a method of treatment or prevention of these secondary health problems. The American College of Sports Medicine (ACSM) guideline recommends a minimum of 150 minutes of moderate-intensity continuous aerobic exercise (MICT) in a week to improve weight-related health outcomes [6].

Prolonged inactivity leads to a decrease in the enzymatic activity of lipoprotein lipase (LPL), which burns fat cells, and impaired carbohydrate metabolism because of reduced muscle contractions [7]. The increase of muscle mass and strength caused by aerobic exercises accelerate fat utilization by increasing energy consumption and basal metabolic rate. Furthermore, LPL is activated, cardiorespiratory capacity is increased, carbohydrate metabolism is regulated, and the risk of cardiovascular events is reduced by controlling the blood lipid profile through exercise [8–10].

Different studies exploring the relationship between obesity and exercise can be found in the literature [10-18]. Most of these studies do not have consistent findings because they include both genders. Our paper aimed to analyze the effects of routine exercise programs in the sports center for females. Because females and males have different metabolic and physical features, their responses to the exercises also differ. We think that the results may be affected due to the gender disproportion and gender-based characteristics. For this reason, we only investigated women in this study to eliminate gender-related variations. We obtained the results of female patients who exercised more than 12 weeks to determine the effectiveness of long-term exercise on body composition, aerobic capacity, biochemical parameters, and cardiovascular risk factors.

Materials and methods

Subjects

Sixty-eight overweight and inactive obese women were recruited in this study. The inclusion criteria were (1) having a sedentary lifestyle (not performing strenuous physical activity once a week or walking more than 20 min/day less than three times in a week), (2) being aged 18-65 years, (3) BMI > 25 kg/m^2. Exclusion criteria were (1) participating in moderate or high-intensity physical activities within the last three months (2) over 2 kg weight loss or unstable gain weight in the previous three months, (3) using medications which induce weight loss or decrease appetite, (4) taking lipid-lowering medications, (5) a history of angina pectoris or myocardial infarction within the last 12 months, (6) having uncontrolled hypertension. This study was approved by the Clinical Research Ethics Committee of Fatih Sultan Mehmet Education and Research Hospital on 01.02.2021 with the decision number 1591, and conformed to the principles of the Declaration of Helsinki.

Study design

The aerobic exercise program was designed as moderate-intensity continuous training. Routine nutrition habits of all subjects were encouraged to continue throughout the study. The exercise program consisted of 10 minutes of warm-up, 30-45 minutes of aerobic exercise, and 10 minutes of cool-down. The subjects were recruited non-consecutively and attended three supervised exercise sessions per week for 12 weeks in the sports center. All assessments were obtained before and after the 12-week exercise program.

Moderate Intensity Continuous Aerobic Training

The Karvonen formula was used to calculate the patient's HRmax. This formula is frequently used to calculate relative heart rate reserve using resting pulse and age during training sessions [19]. Blood pressure and heart rate were measured after the 10 minutes resting period at sitting position before the sessions. Exercise intensities were checked regularly with pulse oximetry during exercise.

The MICT program consisted of three parts: (1) 10-minute warm-up, (2) walking continuously for 30-45 min at 50–65% of HRmax on the treadmill, and (3) 10 min cool-down period. The exercise protocol progressed from 30 minutes and 50% HRmax to 45 minutes and 65% HRmax by the fifth week of this program. The program maintained 65% HRmax and sessions lasted 45 minutes between the fifth-twelfth weeks.

Body composition

Total body fat distributions were measured by bioimpedance analysis system (TANITA). The system has three main parts for assessment: (1) Stainless foot-pad electrodes, (2) hand electrodes, and (3) computer analysis. Demographic values were entered into the software interface. Every subject took off jewelry, shoes, and socks before the test, and they stood in erect position on the platform barefoot and held the hand probes [20].

Biochemistry parameters

Values of total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein cholesterol (LDL), and triglyceride were obtained from the clinical records.

Aerobic Capacity

The 6-minute walk test (6-MWT) shows the effectiveness of interventions and aerobic capacities. This test was performed according to the American Thoracic Society guidelines in an enclosed corridor [21]. Two cones were placed at the terminals of the 20-meter-long corridor. Assessor notified to patients walk as much as possible for six minutes, not run or jog. At the end of every minute, the assessor informed the patient about how much time was left. The distance was noted in meters. Heart rate, blood pressure, and perceived exertion were recorded before and after the test [22].

Statistical analysis

All analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 22.0 for Windows. Data are expressed as mean and standard deviation. The one-sample Kolmogorov-Smirnov test was performed to assess the distribution of data. Comparison of variables before and after the exercise program were compared by the paired sample t-test. *P*-value of less than 0.05 was considered significant.

Results

Subject characteristics

The data of sixty-eight women who had 100% participation in the exercise program between 2019-2020 were included in the study. During this time, no adverse events were reported. The age mean was 48.19 (9.30) years. BMI scores of obese and overweight subjects were 34.97 (3.26) kg/m^2 and 27.25 (1.37) kg/m^2, respectively.

Body Composition and Aerobic Capacity

There was a significant improvement in body composition parameters between baseline and the post-intervention period. Weight, BMI, fat mass FM (kg), fat-free mass FFM (kg), and total body water TBW (kg) significantly differed baseline and post-intervention. In addition to improving these parameters, aerobic capacity also increased considerably from 442 (33) m to 478 (34) m (P=0.001). Results are shown in Table 1.

Table 1: Body composition and aerobic capacity values

Parameter	Baseline	Post Intervention	P-value
Weight	80.08 (13.20)	77.90 (12.12)	0.001
BMI	31.45 (5.16)	30.56 (4.50)	0.001
FM (%)	37.26 (7.18)	37.18 (5.92)	0.116
FM (kg)	30.70 (8.91)	29.40 (8.20)	0.001
FFM (%)	16.71 (1.72)	16.83 (1.59)	0.056
FFM (kg)	13.22 (1.73)	12.99 (1.58)	0.003
TBW (%)	45.03 (7.15)	44.29 (7.32)	0.001
TBW (kg)	36.16 (4.60)	35.51 (4.31)	0.001
6-MWT	442 (33)	478 (34)	0.001

Data are presented as mean (standard deviation), BMI: body mass index, FM: fat mass, FFM: fat-free mass, TBW: total body water, 6-MWT: 6-minute walking test

Blood profile

The LDL, total cholesterol and triglycerides values insignificantly decreased at the end of the exercise program (P=0.470, P=0.484, and P=0.695, respectively). Only the HDL value and total Cholesterol/HDL ratio (cardio-metabolic risk factor) showed a statistically significant improvement at the end of the program (P=0.002, P= 0.001). All biochemical results are shown in Table 2.

Table 2: Biochemical parameters and cardiometabolic risk factors

Parameter	Baseline	Post Intervention	P-value
Fasting Blood Glucose (mg/dL)	95.16 (9.96)	95.93 (9.72)	0.517
Postprandial Blood Glucose (mg/dL)	95.78 (19.23)	92.02 (20.22)	0.294
HbA1c (mg/dL)	5.71 (0.77)	5.77 (0.36)	0.580
LDL (mg/dL)	140.07 (31.00)	138.49 (30.80)	0.470
Triglyceride (mg/dL)	136.50 (72.29)	131.98 (78.12)	0.484
HDL (mg/dL)	50.82 (10.97)	54.06 (11.39)	0.002
Total Cholesterol (mg/dL)	218.84 (37.32)	219.85 (3.41)	0.695
Total Cholesterol / HDL	4.43 (1.05)	4.17 (0.93)	0.001

Data are presented as mean (standard deviation).

Discussion

Regular physical activity programs play a crucial role in the improvement of health-related gains. Obese people should perform 150 minutes of moderate-intensity or 75 minutes of a vigorous-intensity exercise program per week to gain benefit [23]. This paper's main findings are that the 12-week MICT program has successfully improved body composition, aerobic capacity, and cardiovascular risk factors in overweight and obese women.

Exercise, the main component of obesity treatment, is part of a lifestyle change. Some studies show that the aerobic exercise program reduces visceral adipose tissue independently [24], and we found similar results in the literature. According to our results, weight, BMI, fat mass, free fat mass, and total body water parameters statistically improved after the exercise. Two exercise protocols with different intensities were compared for body composition gains in the literature. Kong et al. performed the study with two different aerobic exercise types, such as high-intensity interval training (HIIT) and the MICT protocol. The MICT groups completed all sessions with 65% VO2max for 40 minutes and had statistically significant improvement in total lean mass compared to the HIIT [25]. When the MICT program with 55-65% VO2max was compared with the high-intensity interval program, the fat percentile improved in the MICT group [26]. In another study, Martins et al. evaluated MICT and the HIIT programs for 12 weeks, and neither was superior to each other in terms of body composition change [27]. A meta-analysis reported that body fat decreased in 11 studies, and BMI decreased in 9 studies with the MICT protocol [28]. Our results of body composition were similar to those mentioned above. People use large muscle groups during gait-based physical activity. Therefore, energy needs and consumption increase [29,30]. We know that the energy obtained from the glucose is spent in the first minutes of the exercise. For this reason, the fat-burning mechanism is activated to supply the increasing energy need. As a result of this mechanism, the body increases its basal metabolism to adapt to this condition and weight loss process accelerates [31].

The reduction of VO2max is more related to mortality than excessive fat mass [32]. Besides, mortality risk increases further with a decrease in VO2max and excessive fat in obese people. The MICT program can be used to avoid most adversities by using the known general benefits of exercise. One of these benefits is an improvement in aerobic capacity, and the reduction of aerobic capacity correlates with the risk of death. In our results, aerobic capacity showed improvement after the exercise program. Our findings are consistent with other studies mentioned below. The short-term MICT program has been found useful in increasing aerobic capacity [33]. Further research was performed by Cocks et al., who investigated the effect of the MICT program on the aerobic capacity in obese men. This program maintained 20 sessions with 65% for 40-60 minutes, and the MICT protocol lead to an improvement in aerobic capacity [16]. The studies had different intensities between 60-85% HRmax, and the minimum duration was 30 minutes [34-37]. We used a protocol compatible with the literature at our sports center. Our patients completed the aerobic exercise program with 65% HRmax for 45 minutes except for warm-up and cooling-down periods.

Exercise is described as a non-drug treatment method for different diseases, and it is known that regular exercise causes an increase in mitophagy capacity and mitochondria life, as well as regulating mitochondrial functions [38]. A study reported a positive correlation between mitochondrial function and aerobic capacity [39]. Exercise capacity is regulated by increased mitochondrial electron flow, decreased oxidative damage, improved mitochondrial respiratory chain, regulated enzymatic activity in mitochondria, and increased mitochondria in skeletal muscle mechanisms with aerobic exercise programs [40]. This is one of the possible mechanisms of the effect of exercise on increased aerobic capacity in our study. Also, regular aerobic exercises cause increases in oxygen consumption. The stroke volume, heart rate, and cardiac output increase the blood need of tissues. As a result of this accommodation, cardiac hypertrophy and bradycardia occur, and heart contractility increases. After increased contractility, heart rate volume and aerobic capacity increase. However, exercise must be continued for at least six weeks for the cardiorespiratory adaption [41].

Aerobic exercise regulates the hormonal system, the parasympathetic system, and vagus nerve activities. It also provides autonomic control for body systems, improvement in the blood parameters, and a reduction in cardiovascular diseases risk such as hypertension, myocardial infarcts, and atherosclerosis [12, 26]. In our study, the 12-week moderate-intensity exercise program resulted in no significant changes in LDL, triglyceride, HbA1c, and total cholesterol values. Improvement was seen in HDL and Total Cholesterol/HDL ratio as a cardiovascular risk factor and risk was reduced by 11% due to increased HDL. According to the Canadian working group, the “Total Cholesterol/HDL” ratio formula is more sensitive and specific for cardiovascular risk assessment than individual blood parameters [42]. Mathunjwa et al. [43] showed that while HDL cholesterol increases with the MICT program, the LDL, triglyceride, and total cholesterol decrease, and 2% improvement occurs in cardiovascular risk. In another study, obese individuals exhibited a significant reduction in total cholesterol, HDL, and Framingham risk score after the MICT program that was performed 150 min/week for eight weeks [13]. A study consisted of aerobic exercise (30 minutes, 3 days in a week for 8 weeks) and showed decreased triglyceride and increased HDL levels [44]. According to our results, the improvement in biochemical parameters except HDL was not statistically significant, and these results were not compatible with the literature. We progressed the exercise intensity when patients' heart rate did not increase during exercise. Patients who reached 45 minutes of exercise at 65% HRmax were included in the study. We think that this exercise intensity might be insufficient to improve these biochemical parameters, which may be positively affected by increasing exercise intensity or duration. This exercise program was initiated as a public service for three months to help gain exercise habits in addition to traditional treatment. At the end of three months, assuming that the patients gained exercise habits, the exercise programs were terminated, and other patients were recruited in the sports center's exercise program. Based our results, aerobic exercise programs with higher intensity can be applied to the participants in our center.

Limitations

Our study was conducted retrospectively and did not include a control group. Conducting the study prospectively and including a control group may affect the quality of the study. In addition, the study did not include follow-up, which could be useful to examine the long-term effects of exercise.

Due to the retrospective nature of the study, the medical files of the participants were examined. The files of the patients who did not meet the study criteria and had a missing data were excluded. This may have changed the characteristics of the study universe. Also, the evaluator was not blind because he followed the pre-determined protocol used in the clinic. However, all evaluation and treatment processes were conducted by the same physiotherapist. In this way, inter-rater bias was prevented.

Conclusions

Moderate intensity exercise programs help reduce adipose tissue, increase cardiorespiratory capacity, improve lipid profile, and reduce cardiovascular disease risk by increasing metabolic and hormonal activities. These effects are reversible, and physical activity needs to be transformed into a lifestyle for ongoing gains. The addition of regular and supervised nutrition programs to the exercise will increase the profits.

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