The Assessment of Aerobic Capacity in Obese Women

Obez Kadınlarda Aerobik Kapasitenin Değerlendirilmesi

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ABSTRACT Objective: In obese persons the ability to deliver oxygen to working muscle and the rate of its use by these muscles (aerobic capacity) may be reduced. The aim of this study is to compare the aerobic capacity, pulmonary functions in obese and non-obese women, and to assess the associaton between obesity and aerobic capactiy. **Material and Methods:** Fourty six voluntary obese women who admitted to our department with a body mass index ≥ 30 kg/m^2 and 24 non-obese women volunteers were participated in the study. Body mass index (BMI), waist hip ratio (WHR) and fat percentage were measured in both groups. Pulmonary function tests, maximum oxygen consumption (VO_{2max}), maximum exercise ventilation (VE_{max}), anaerobic threshold (AT) and 6-minute walk test were evaluated. **Results:** The age of obese and control group were 36.6 and 33.3 years respectively. BMI, WHR and fat percentage were significantly lower in subjects with obesity ($p< 0.05$). Forced expiratory volume during the first second/forced vital capacity, peak expiratory flow rate and maximum voluntary ventilation were significantly different in two groups ($p< 0.000$). VO_{2max}, VE_{max}, AT and 6 minute walk test were significantly lower in subjects with obesity $p< 0.05$) and BMI, WHR and fat percentage correlated negatively with these parameters ($p< 0.01$). **Conclusion:** Aerobic capacity of obese subjects were found to be lower than control group and aerobic capacity significantly associated with BMI, WHR and fat percentage in our study. In conclusion aerobic exercise may be recommended to improve aerobic capacity and to increase caloric expenditure in subjects with obesity.

Key Words: Obesity; respiratory function tests; exercise

ÖZET Amaç: Obez kişilerde çalışan kaslara oksijen sağlama ve oksijenin bu kaslarda kullanım kapasitesi düşebilir (aerobik kapasite). Bu çalışmanın amacı; obez ve obez olmayan kadınlarda aerobik kapasite ve pulmoner fonksiyonları karşılaştırmak; obezite ve aerobik kapasite arasındaki ilişkiyi incelemektir. **Gereç ve Yöntemler:** Kliniğimize başvuran, beden kitle indeksi (BKİ) 30 kg/m^2'den yüksek olan 48 gönüllü obez ve BKİ normal sınırlarda olan 24 gönüllü kadın çalışmaya dahil edildi. Her iki grupta BKİ, bel kalça oranı (BKO), vücut yağ yüzdesi (VYY) ölçümleri yapıldı. Solunum fonksiyon testleri, maksimum O_2 tüketimi (VO_{2max}), maksimum ventilasyon hacmi (VE_{max}) anaerobik eşik (AT) ve 6 dakika yürüme testi ölçüldü. **Bulgular:** Obez ve kontrol grubunun ortalama yaşları sırasıyla 36.6 ve 33.3 yıl idi. Obez grupta BKİ, BKO ve VYY anlamlı olarak düşüktü ($p< 0.05$). İki grup arasında birinci saniyedeki zorlu ekspiratuar volüm/zorlu vital kapasite, tepe akım hızı ve maksimal istemli ventilasyonda anlamlı fark bulundu ($p< 0.000$). Obez bireylerde, VO_{2max}, VE_{max}, AT ve 6 dakika yürüme mesafesi kontrol grubuna göre anlamlı olarak düşüktü ($p< 0.05$), ve BKİ, BKO ve VYY değerleri bu parametrelerle anlamlı olarak korele idi ($p< 0.01$). **Sonuç:** Çalışmamızda obez bireylerin aerobik kapasitesi kontrol grubuna göre anlamlı olarak düşük bulunurken, aerobik kapasitenin BKİ, BKO ve VYY ile anlamlı olarak ilişkisi saptanmıştır. Sonuç olarak aerobik egzersizler obez bireylerde enerji tüketimi ve aerobik kapasiteyi arttırmak için önerilebilir.

Anahtar Kelimeler: Obezite; solunum fonksiyon testleri; egzersiz

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Being overweight and obese result from a positive energy balance created by excess energy intake, insufficient energy expenditure, or both.[1]

Obesity is a chronic disease that is associated with hypertension, cancer, diabetes, and cardiovascular disease. The causes of obesity include genetic influences, the environment, neurological, physiologic, biochemical, cultural, and psychical factors.[2,3] The cause of the rising prevalence of obesity in the general population is unclear, although there is increasing evidence that reduced physical activity may play a major role.[4] The modern lifestyle with high-calorie diets and reduced exercise is closely associated to the increase in percentage of obese subjects.[5] Obese persons tend to be chronically hypoventilated and have reduced aerobic capacity, because of sedentary life, a heavy thoracic wall and abdominal mass.[6,7]

The mechanical work of breathing, reflected by a higher oxygen cost of breathing, is increased in obesity.[8] The intercostal muscles are forced to move the large adipose tissue mass overlying the thorax and the contracting diaphragm work against an enlarged and distended abdomen. As the increased work of breathing occurs at reduced lung volume, a feeling of respiratory distress occurs that reduces the desire and ability to exercise.[8]

In obese persons the ability to deliver oxygen to working muscles and the rate of its use by these muscles [aerobic capacity, maximum exercise ventilaton (VO_{2max})] may be reduced, depending on age, sex, and history.[1] Thus, their relative endurance to perform hard work is reduced, causing them to limit activity to relatively low exercise intensity and for shorter periods.[1]

A study has indicated that obese patients had significantly lower anaerobic threshold and peak oxygen consumption at baseline than the lean patients.[9]

In an other study designed to compare differences in pulmonary gas exchange at rest and at peak exercise in two groups of women found that, morbidly obese women have poorer exercise capacity, cardiac efficiency, and compensatory hyperventilation at peak exercise, and poorer gas exchange at rest compared to physically active, non-obese women.[10]

The aim of this study was to compare the aerobic capacity, pulmonary functions of obese and non-obese subjects and to evaluate the relationship of obesity with aerobic capacity and pulmonary functions.

MATERIAL AND METHODS

Fourty eight obese women who admitted to our department with a body mass index (BMI) ≥ 30 kg/m^2 and 24 non-obese women volunteers from the hospital personnel who served as a control group were participated in the study. It was carried out between October 2003 and April 2004 and the study group was selected among voluntary obese women.

Informed consent was obtained from all participants and the protocol and procedures employed were reviewed and approved by the Hospital Ethical Committee.

All obese and non-obese subjects were evaluated by a detailed clinical, cardiovascular and respiratory examination by the same physician. Hepatic and renal function tests, serum glucose levels, total blood counts, electrocardiography (ECG), chest radiographs, erythrocyte sedimantation rates (ESR), C-reactive protein (CRP), and rheumatoid factor latex were measured in order to exclude contraindications as a protocol of this study. Patients suffering from severe disc herniation, acute sprain or strain, or symptomatic cardiopulmonary disease were excluded from the study.

Body composition was evaluated by representative parameters such as body mass index (BMI), percent fat, waist hip ratio (WHR). WHR measured as the ratio of the minimal abdominal circumference to the maximal gluteal protuberance, was used as an index of body fat distribution.[11]

The percentage of body fat was determined by the sum of the skinfold method performed by a single observer and Skyndex Skinfold Caliper (Skyndex electronic body fat calculator system; Caldwell Justiss) was used for measurements.[12] Skinfolds were measured from the dominant side and from the biceps, triceps, subscapuar and suprailiac sites.

Pulmonary function tests (PFT) were assessed by a computerised spirometer (Sensor Medics, Vmax 29, Yorba Linda, CA). Vital capacity (VC), forced expiratory volume during the first second (FEV_1), forced vital capacity (FVC), FEV1/FVC, maximal midexpiratory flow rate (FEF_{25-75}), peak expiratory flow rate (PEF) and maximum voluntary ventilation (MVV) were recorded in the sitting position. The values were expressed as percentage of the predicted normal values according to Kory/Polgar. The acceptable three recordings were obtained from manoeuvre and the best values were chosen for further analysis.

The hallmark of the obstructive pattern is a reduction in the FEV_1/FVC (in percent; > 69 normal, 61-69 mild obstruction, 45-60 moderate obstruction, and < 45 severe obstruction). In addition, the FEV_1 is consistently reduced and usually accompanied by a reduction in FVC. The hallmark of the restrictive pattern is a reduction in the forced vital capacity accompanied by a proportional drop in the FEV_1.[13]

The maximum respiratory pressures (MIP: maximum inspiratory pressure, MEP: maximum expiratory pressure) were carried out using a digital mouth pressuremeter (MPM, Sensor Medics, Yorba Linda, CA). MIP was measured with the subject sitting in a chair and breathing in through a mouthpiece connected to the digital MPM, just after clamping the nose. MEP was measured following end-inspiration by the same procedure. Both of the measurements were carried out three times and mean values were calculated as MIP and MEP in cmH_20.

Exercise capacity was assessed on a treadmill using the Bruce protocol (Burdick T600 treadmill).[14] Maximal aerobic capacity defined as the maximum oxygen consumption (VO_{2max}) and maximum exercise ventilation (VE_{max}; defined as the highest exercise ventilation) were achieved during the exercise test. Anaerobic threshold (AT) was measured by the V-slope method and was expressed as a percentage of the predicted $V0_{2max}$. Heart rate and time elapsed (min) were computed, ECG tracing and blood pressure were continuously monitored. Oxygen saturation was measured by an oxygen photometer attached to the index finger (Sensor Medics, Pulse Oximeter, YorbaLinda CA, USA).

Subjects were instructed to refrain from eating for at least 3 hours and from drinking for 2 hour prior to testing. They were given instructions on how to inform the investigators when they reached fatigue. All subjects were given information about the test before beginning.

Blood pressure was measured before starting and at the end of each stage of exercise. The test was discontinued when subjects had angina pectoris or other cardiac symptoms, severe dyspnea, ECG changes or fatigue.

Six minutes walk test (6MWT), used as a clinical indicator of the functional capacity was performed in the hospital corridor.[15] Subjects were asked to walk at their own pace, and each subject was instructed to walk as much distance as possible, in 6 minutes.[16]

Statistical evaluations were assessed by SPSS for Windows 11.5 analytical methods included descriptive statistics and Student t-test for comparison of differences between groups and Pearson's correlation coefficient. Differences of $p< 0.05$ were taken as significant.

RESULTS

All enrolled patients successfully performed the tests and there were no exclusions or complications during the study. Table 1 shows the physical characteristics of the patients and control group.

There was a significant difference between two groups for BMI, WHR and fat percentage ($p< 0.05$) (Table 1).

An obstructive pattern defined by a low FVC, FEV_1 and FEV_1/FVC ratio were low in 16.6% (8 subject) of study group. None of them had restrictive ventilatory impairment.

TABLE 1: Physical characteristics of the obese and control subjects.

	Obese subjects (n= 48)	Control subjects (n= 24	p*
Age (year)	36.6 ± 3.5	33.3 ± 5.9	0.060
BMI (kg/m²)	35.3 ± 5.3	22.3 ± 3.4	0.000
WHR	0.84 ± 0.1	0.72 ± 0.0	0.000
Fat percentage	34.8 ± 4.2	22.5 ± 1.2	0.000

BMI: Body mass index, WHR: Waist hip ratio, *p< 0.05 Significant.

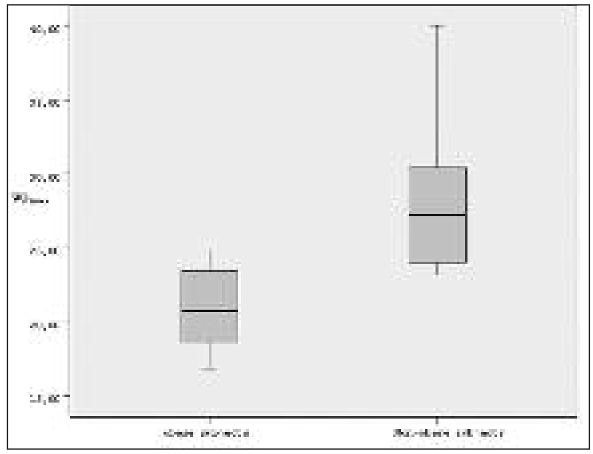

FIGURE 1: Maxsimum VO_2 consumption in obese and non-obese subjects

TABLE 2: Pulmonary functions of obese and control subjects.

	Obese subjects (n= 48)	Control subjects (n= 24	p*
FVC (%)	105.4 ± 11.1	103.8 ± 15.2	0.344
FEV_1 (%)	96.0 ± 16.4	104.0 ± 14.2	0.313
FEV_1 /FVC (%)	76.1 ± 5.6	95.4 ± 10.2	0.000
FEF_{25-75} (%)	63.3 ± 20.7	101.1 ± 15.5	0.000
PEF (%)	76.0 ± 11.2	106.4 ± 10.6	0.000
VC (%)	80.6 ± 22.8	103.7 ± 14.5	0.378
MVV (%)	80.6 ± 22.8	147.5 ± 42.8	0.000
MIP (cmH_20)	53.0 ± 9.4	69.3 ± 11.0	0.002
MEP (cmH_20)	66.3 ± 13.3	78.3 ± 3.8	0.017
Chest expansion (cm)	2.7 ± 1.1	4.9 ± 0.7	0.000

MIP:Maximum inspiratory pressure, MEP: Maximum expiratory pressure, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in 1 second, FEF_{25-75} : Maximal midexpiratory flow rate 25% and 75%, PEF: Peak expiratory flow, VC: Vital capacity, MVV: Maximum voluntary ventilation, *p<0.05 significant

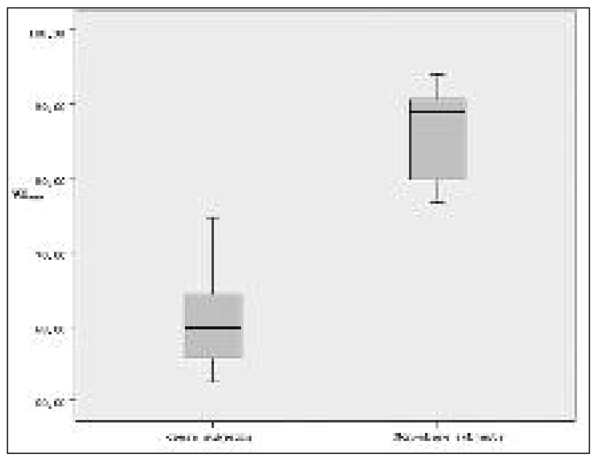

FIGURE 2: Maximum exercise ventilation in obese and non-obese subjects.

When pulmonary functions of obese subjects to non-obese subjects were compared, the values of FEV_1/FVC, FEF_{25-75}, PEF, MVV, MIP, MEP and chest expansion were significantly lower than control group ($p< 0.05$) (Table 2).

Figure 1, 2, 3 and 4 shows the distribution of VO_{2max}, VE $_{max}$, AT and 6 minute walk test of the obese and non-obese subjects.

VO_{2max}, VE_{max}, AT and 6 minute walk test were significantly lower in subjects with obesity $p< 0.05$) and BMI, WHR and fat percentage correlated negatively with these parameters ($p< 0.01$) (Table 3).

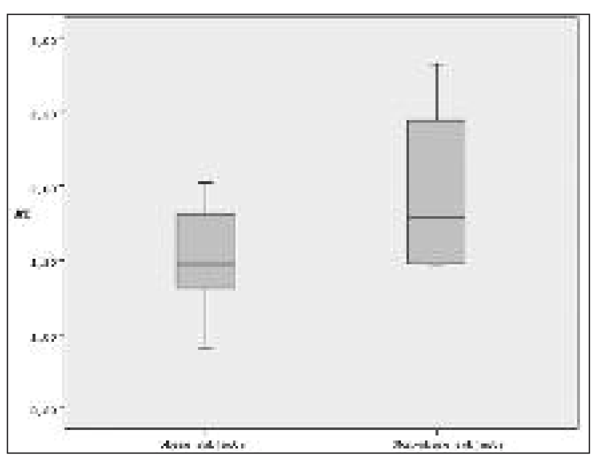

FIGURE 3: Anaerobic threshold in obese and non-obese subjects..

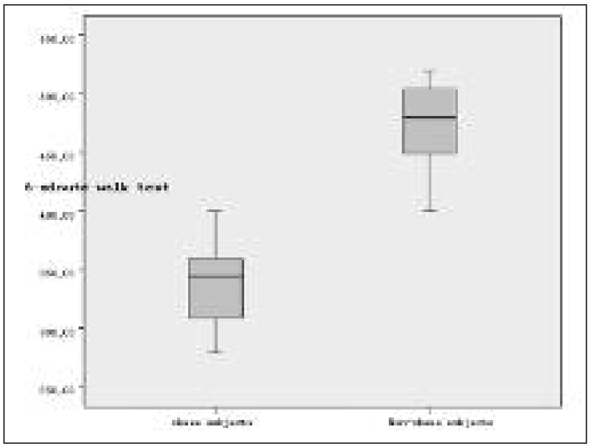

FIGURE 4: Six minute walk test in obese and non-obese subjects.

TABLE 3: VO_{2max}, VE_{max}, AT and 6 minute walk test of obese and control subjects.

	Obese subjects (n= 48)	Control subjects (n= 24)	p*
VO_2 (ml/kg/min)	21 ± 2.6	28.7 ± 1.8	0.000
VE_{max} (l/min)	60.6 ± 6.3	86.3 ± 6.1	0.000
AT (mL)	1.5 ± 0.3	2.0 ± 0.5	0.024
6 minute walk test (m)	337.9 ± 33.5	471.7 ± 43.0	0.000

MIP: Maximum inspiratory pressure, MEP: Maximum expiratory pressure, FVC: Forced vital capacity, FEV_1: Forced expiratory volume in 1 second, FEF_{25-75}: Maximal midexpiratory flow rate 25% and 75%, PEF: Peak expiratory flow, VC: Vital capacity, MVV: Maximum voluntary ventilation, *p< 0.05 significant

BMI, WHR and fat percentage negatively correlated with VO_2, V_{Emax}, AT and 6 minute walk test ($p< 0.01$) (Table 4).

DISCUSSION

We investigated the differences in aerobic capacity between obese and non-obese women. Obese subjects had lower aerobic capacity as compared with that of normal subjects. Our study showed that obese subjects have high WHR in addition to excess body fat percentage and have lower aerobic capacity compared to non-obese subjects. In addition, the relationship between body composition and aerobic capacity was evaluated. BMI, WHR and fat percentage inversely correlated with VO_2, $V_E$max, AT and and 6-minute walk test. Obese persons tend to be chronically hypoventilated and have reduced aerobic capacity, because of sedentary life, a heavy thoracic wall and abdominal mass.[6]

Several respiratory factors have been identified that limit exercise tolerance in obese persons, these can be listed as increased metabolic and associated ventilatory requirements to perform exercise, increased cost of breathing because of the high breathing frequency and the interfering chest wall and abdominal fat, and pulmonary insufficiency related to the heavy work of breathing and lung atelectasis[1]. These changes in pulmonary function exacerbate the ventilatory strain associated with exercise, and the high metabolic cost of breathing reduces exercise tolerance and the amount of work accomplished in a given time, thus increasing the imbalance between energy intake and expenditure.[1]

TABLE 4: The relationship between obesity parameters and VO_{2max}, VE_{max}, AT and 6 minute walk test*

	VO_{2max} (ml/kg/min)	VE_{max} (l/min)	AT(mL)	6 minute walk test (m)
BMI (kg/m²)	r= -0.612	r= -0.577	r= -0.381	r= -0.698
	p= 0.000	p= 0.000	p= 0.001	p= 0.000
WHR	r= -0.416	r= -0.857	r= -0.354	r= -0.579
	p= 0.000	p= 0.000	p= 0.002	p= 0.000
Fat percentage	r= -0.575	r= -0.780	r= -0.476	r= -0.820
	p= 0.000	p= 0.000	p= 0.000	p= 0.000

BMI: Body mass index, WHR: Waist hip ratio, VO_{2max}: Maximum O2 uptake, VE_{max}: Maximum exercise ventilation, AT: Anaerobic threshold, *p< 0.05 significant.

Body weight adjusted for stature is universally used as an alternative to the measurement of adipose tissue mass in the evaluation of individuals or population for obesity. Many studies have shown that BMI is a reasonable measure of adiposity[1]. Our study indicates that BMI has an effect on the VE_{max}.

Excessive body fat content extremely affects aerobic capacity. Adiposity diminishes weight-relative maximal aerobic capacity (VO_{2max} mL/kg/min).[17] Our study showed that obese subjects have high WHR in addition to excess body fat percentage and have lower exercise tolerance compared with normal subjects.

Increase in body fat produce more direct effect on components of the oxygen delivery chain, particularly those factors that affect cardiovascular function.[17,18]

We showed a statistically significant negative correlation between obesity and 6 minutes walk test. In the 6 minutes walk test, obesity women walked, on average 56.3 m/minute while normal subjects walked 78.7 m/min. Slowness of obese might be due to the heavier weight, musculoskeletal pain in the lower limbs, and lower cardiovascular fitness.[19,20]

The Bruce test revealed more serious shortcomings. Patients ran modest distances and became tired shortly after the start of the treadmill procedure, and yet they paid a steep metabolic price in the form of O_2 consumption.[21] For many years, it has been noticed that endurance is restricted in the presence of excessive body weight, subjects become quickly exhausted, and energy cost is excessive, reflecting poor cardiopulmonary performance along with the effects of a chronically sedentary lifestyle.[21]

Physical inactivity may be a significant effect on aerobic capacity in obesity. Although there are many social and behavioral factors that determine physical activity habits, obesity can be the determinant of exercise patterns, and therefore obese subjects can be less active than lean subjects.[22] It seems more likely that VO_2 max is affected by sedentary behaviours as well as the effect of the obesity.[22]

Population surveys using BMI have generally reported lower levels of pulmonary function among subcets with high BMI and longitudinal analyses have found that BMI gain is associated with accelerated loss of pulmonary fuction.[23,24]

Obesity has been associated with respiratory complications such as obstructive sleep apne, obesity hypoventilation syndrome and it is believed to reduce lung volumes.[25]

In adults, pulmonary function abnormalities are well reported complications of obesity; the most frequently reported abnormalities are reductions in lung volumes and expiratory flow rates.[26-28] Costa et al showed that obesity causes significant changes in respiratory function considerable changes in the components of pulmonary function tests similarly to our study but none of their patients showed obstructive or restrictive pattern.[29] An obstructive pattern defined by a low FEV_1, FVC, FEV_1/FVC ratio was observed in 16.6% of our patients.

Exercise has been recommended by most major health organization in conjunction with obesity treatment; however, the amount of weight loss due to exercise has been modest.[27]

It is difficult for obese people to develop the exercise habit and even if they join a supervised exercise program they generally do not continue to exercise when they leave the program.[30] Several reasons for lessening activity were cited, but unavailable time, poor motivation, and loss of social support predominanted.[1]

To reduce body weight and fat, exercise must involve reasonably high energy expenditure. This can be accomplished by activities as walking, hiking, stair climbing, lawn moving, dancing, jogging, or cross-country skiing.[1]

Given that physical activity increases energy expenditure, it is important to consider a physically active lifestyle for both prevention and treatment of obesity. A physically active lifestyle can help to improve cardiorespiratory fitness; promote flexibility, mobility, and physical self-confidence; modify risk factors associated with the development of cardiovascular disease and maturity-onset diabetes; allow weight loss with larger food intake that stil is nutritionall adequate.[1]

Lower aerobic capacity is considered to be a general characteristic of female obese subjects. The primary goal of a weight loss program is to reduce fat volume, rather than total weight. Exercise has been considered to be the cornerstone in treatment regimens for obese indivuals, and aerobic exercise has traditionally been advocated as the most suitable exercise type.[31]

Ballor and Keesey showed that weight loss after aerobic exercise training was modest in both sexes and associated with reductions in fat mass.[31]

CONCLUSION

This study demonstrates that aerobic capacity is impaired in obese subjects, indicating that their depressed levels of aerobic capacity (low peak VO_2) is related to BMI, WHR and percentage fat. This implies that therapeutic (aerobic exercise) exercise programs for obese subjects may be appropriately designed to increase caloric expenditure and improve aerobic capacity.

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