Cardiopulmonary Adaptation Response to Aerobic and Anaerobic Exercise Training among Obese adults

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Background: Obesity is a global heath problem with a multitude of complications. Over the last few decades, it has become an increasingly significant public health concern in both developed and developing countries. **Objective:** This study was designed to determine changes in cardiopulmonary functions after aerobic and anaerobic exercise training in obese subjects. **Material and Methods:** Forty obese subjects, whose ages ranged between 18 to 25 years old, were divided into 2 equal groups: group (A) received aerobic exercise training in addition to dietary measures, and group (B) received anaerobic exercise training for 3 months in addition to dietary measures. Measurements of systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), maximum voluntary ventilation (MVV), maximal oxygen consumption (VO_2 max.) and body mass index (BMI) were obtained for both groups before and after the exercise program**. Results:** The mean BMI, SBP, DBP, HR and VO_2 max. values had significantly decreased, whereas the mean MVV values had significantly increased in group (A) after treatment. The mean MVV values had significantly increased also in group (B) after treatment. There were significant differences between the mean levels of the investigated parameters in group (A) and group (B) after treatment ($P < 0.05$). **Conclusion:** Aerobic exercise reduces weight and improves cardiopulmonary fitness in obese subjects better than anaerobic exercise does.

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Introduction

Obesity is a leading threat to the health of children and adolescents. Genetic factors, medical conditions, medications, and environmental factors are the common causes of childhood obesity, which is usually managed by diet regimen, exercise and surgical treatment [1-3].

The prevalence of overweight and obese individuals is increasing at an alarming rate, and obesity has become one of the most important avoidable and independent risk factors for morbidity and mortality [4].

A weight management program must include dietary adjustment, increased physical activity and behavior modifications. Nutrition modification should take into account the diet's energy content, composition and suitability for individual patients [5].

European standards for energy restricted diets have been established, leaving little flexibility for change. Three categories exist (i.e., very low-calorie diets [450 to 800 kcalorie], low-calorie diets [800 to 1200 kcalorie] and meal replacements [200 to 400 kcalorie] [6].

Obesity in children has been associated with lower levels of physical activity and fitness. Research examining maximal oxygen consumption (VO_2 max) in obese and nonobese children indicates a significant difference in exercise tolerance [7]. Physical activity and exercise are essential elements in obesity treatment. Regular physical activity has also been shown to lessen the burden of obesity-related comorbidities [8].

Physical activity without a reduction in calorie intake usually has no relevant effects on weight. Although it is possible to lose weight with physical activity alone, the amount of physical activity required for substantial weight loss is well beyond what is feasible for most people in today's world. For instance, it would take more than one or two hours of very vigorous activity per day for children [9].

The purpose of this study was to determine changes in cardiopulmonary functions after aerobic and anaerobic exercise training in obese DS subjects to detect the most appropriate type of exercise training program for them.

Materials and Methods

Subjects

Forty obese subjects, whose ages ranged from 18 to 25 years old. Subjects suffering from any cardiovascular, pulmonary, orthopedic or neurological disorders were excluded from the study. Patients were divided into 2 equal groups: group (A) received aerobic treadmill walking exercise training for 3 months, at a frequency of 3 sessions per week, in addition to dietary measures. The second group (B) received anaerobic exercise training for 3 months, at a frequency of 3 sessions per week, in addition to dietary measures. All participants were free to withdraw from the study at any time. If any adverse effects had occurred, the experiment would have been stopped, with this being announced to the Human Subjects Review Board. However, no adverse effects occurred, and so the data of all the participants were available for analysis. The authors confirm that the study was approved by the ethics committee and that the patients gave their informed consent. This study was applied in King Abdulaziz University Hospitals, Saudi Arabia.

Methods

1. Equipment

A. Cardiopulmonary exercise test unit (CPET): (Zan 800, made in Germany). It consisted of a breath gas (O2 and CO2) analyzer, an electronic treadmill, a 12-channel electrocardiogram, (ECG) monitor, a gas bottle, and a mask with a diaphragm to analyze gas, which was used to measure VO_2 max. and in exercise training. The speed and the inclination of the treadmill were controlled by pre-selected software (standard Bruce protocol).The final test results were printed out by the printer. This unit was calibrated daily, as its speed, inclination and timer are adjustable, and it was also provided with a control panel to display the exercise parameters.

B. Pulsometer (Tunturt TPM-400, made in Japan): this was used to detect pulse rate before, during, and after exercise. A spirometer (Schiller-Spirovit Sp-10, Swizerland) was used to measure maximum voluntary ventilation (MVV). A mercury sphygmomanometer (Diplomat, Presameter made in Germany) and stethoscope (Riester, duplex, made in Germany) were used to measure blood pressure before and after exercise training sessions.

2. Evaluation procedures

Before starting the study, a consent form was taken from each participant as an agreement to be included in the present study; also, before initiation of the exercise training program, each subject was examined medically by a physician in order to exclude subjects with any abnormal medical problems, as previously mentioned. A brief description has been given of the tasks expected during the test.

Cardiopulmonary exercise test procedure

Before conducting the exercise tolerance test, all subjects had to visit the laboratory to be made familiar with the equipment in order that they could cooperate during the test. The treadmill had front and side rails to aid subject stability. Each subject underwent a continuous progressive exercise tolerance test to measure VO_2 max., in accordance with the standard Bruce protocol, which consisted of a warming up phase, five active phases, and a recovery phase.

Measurements of systolic blood pressure, diastolic blood pressure, heart rate, maximum voluntary ventilation (MVV), maximal oxygen consumption (VO_2 max.) and body mass index (BMI) were obtained for both groups before and after the exercise program.

3. The aerobic exercise training program

The aerobic treadmill-based training program (Zan 800, made in Germany) was started with a 5-minute warm-up phase performed on the treadmill at a low load. The active phase of the training session was gradually increased from 20 to 30 minutes in the form of walking/running on the electronic treadmill with zero inclination three times per week for twelve weeks, its intensity being increased gradually from 60% to 70% of the maximum heart rate (HRmax) achieved in a reference ST which was performed in accordance with a modified Bruce protocol. This rate was defined as the training heart rate (THR). The session ended with a 5-minute recovery and relaxation phase [10]

4. The anaerobic exercise training program

The anaerobic treadmill-based training program (Zan 800, made in Germany) was started with a 5-minute warm-up phase performed on the treadmill at a low load. The active phase of the training session was started firstly with 2 minutes, which was gradually increased by 5 seconds each session until reaching 3 minutes then resting for 2 minutes; this bout was repeated 5 times each session in the form of running on the electronic treadmill with a gradual increase from 70% to 80% of the maximum heart rate (HRmax) according to a modified Bruce protocol. This rate was defined as the training heart rate (THR). The session ended with a 5-minute recovery and relaxation phase. All patients performed three weekly sessions. Maximum heart rate (HRmax) = 220-age [11] and [12]

5. The prescribed low calorie diet

The interview-based food survey was performed for all patients by dieticians to specify previous food habits and possible anomalies in dietary behavior. The prescribed low calorie diet was balanced, with 15% as protein, 30 to 35% as fat and 50 to 55% as carbohydrate, on average, in order to provide about 1000 calories daily for two months for all participants in this study.

The prescribed diet included a breakfast consisting of 2 boiled eggs (80 calories), 50g cheese (100 calories) and one slice of bread (105 calories); and a lunch consisting of 2 pieces of boiled meat 100g

(240 calories) or chicken (300 calories), 500g salad (105 calorie), 300g boiled vegetables (110 calories), and 100g of banana (100 calories). However, the dinner consisted of 200g skimmed milk (120 calories). We checked that the food was eaten as three daily meals, and we emphasized the need to have a substantial breakfast. The two groups underwent an identical dietary monitoring program, with an initial consultation and with one check-up in the middle of the program and another during the final sessions by a dietician who was blinded to the type of program that the subject had been following.

Statistical analysis

The mean values of systolic blood pressure, diastolic blood pressure, heart rate, maximum voluntary ventilation (MVV), myocardial oxygen consumption and body mass index (BMI) obtained for both groups before and after the exercise program were compared using paired "student's" *t* test. An independent "student's" *t test* was used for the comparison between the two groups ($P<0.05$).

Results

Forty obese subjects, whose age ranged from 18 to 25 years old. Patients were divided into 2 equal groups: group (A) received aerobic exercise training in addition to dietary measures, and group (B) received anaerobic exercise training for 3 months in addition to dietary measures. The mean BMI, SBP, DBP and HR values were significantly decreased, whereas the mean MVV and VO_2 max. values were significantly increased in group (A) after treatment. The mean BMI, SBP, DBP, HR and VO_2 max. values were not significant and the mean MVV values were significantly increased in group (B) after treatment (Tables 1 & 2 and Figures 1 & 2). There were significant differences between mean levels of the investigated parameters in group (A) and group (B) after treatment ($P<0.05$) (Table 3 and Figure 3).

Table (1): Mean values and significance of group (A) measured parameters before and after treatment.

Item		BMI (Kg/m²)	SBP(mmHg)	DBP(mmHg)	HR(beat/min)	MVV(L/min.)	VO_2 max. (L./min./Kg)
Mean ± SD	Before	36.45±3.36	136±5.9	87.5±4.4	82.1±2.7	96.2±10.8	3.35±0.64
	After	30.01±2.56	124.5±6.8	80.1±5.02	74.3±3.8	126.6±16.6	3.92±0.53
t- test		3.51	5.2	8.5	8.801	12.4	5.12
Significance		P <0.05	P <0.05	P <0.05	P <0.05	P <0.05	P <0.05

SBP = Systolic Blood Pressure **DBP = Diastolic Blood Pressure**
HR = Heart Rate **MVV = Maximum Voluntary Ventilation**
BMI = Body Mass Index **VO_2 max. = Maximal Oxygen Consumption**

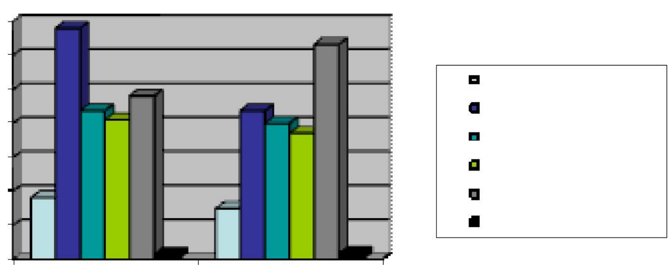

Figure (1): Mean values and significance of group (A) measured parameters before and after treatment.

Table (2): Mean values and significance of group (B) measured parameters before and after treatment.

Item		BMI (Kg/m²)	SBP(mmHg)	DBP(mmHg)	HR(beat/min.)	MVV(L/min.)	VO_2 max. (L./min./Kg)
Mean ± SD	Before	35.95±3.72	136.5±4.8	88±4.1	81.6±3.6	98.02±7.7	3.42±0.75
	After	33.54±2.26	136.4 ±5.8	88.5±3.6	82±4.6	104.4±11.9	3.61±0.82
t- test		2.76	0.01	1.1	0.479	4.3	2.53
Significance		P >0.05	P >0.05	P >0.05	P >0.05	P <0.05	P >0.05

SBP = Systolic Blood Pressure **DBP = Diastolic Blood Pressure**
HR = Heart Rate **MVV = Maximum Voluntary Ventilation**
BMI = Body Mass Index **VO_2 max. = Maximal Oxygen Consumption**

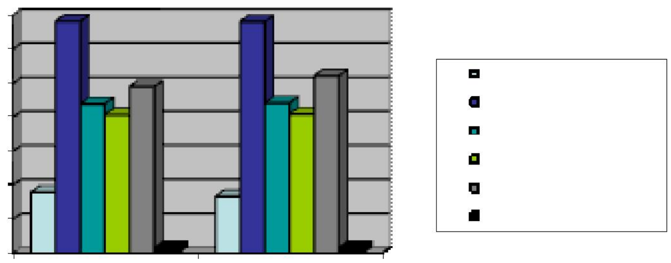

Figure (2): Mean values and significance of group (B) measured parameters before and after treatment.

Table (3): Comparison of mean values and significance of group (A) and group (B) measured parameters after treatment.

Item		BMI (Kg/m^2)	SBP(mmHg)	DBP(mmHg)	HR(beat/min.)	MVV(L/min.)	VO_2 max. (L./min./Kg)
Mean ± SD	Group (A)	30.01±2.56	124.5±6.8	80.1±5.02	74.3±3.8	126.6±16.6	3.92±0.53
	Group (B)	33.54±2.26	136.5±5.8	88.5±3.6	82±4.6	104.4±11.9	3.61±0.82
t- test		2.82	3.7	3.8	3.5	3.02	3.01
Significance		P <0.05	P <0.05	P <0.05	P<0.05	P<0.05	P <0.05

SBP = Systolic Blood Pressure **DBP = Diastolic Blood Pressure**
HR = Heart Rate **MVV = Maximum Voluntary Ventilation**
BMI = Body Mass Index **VO_2 max. = Maximal Oxygen Consumption**

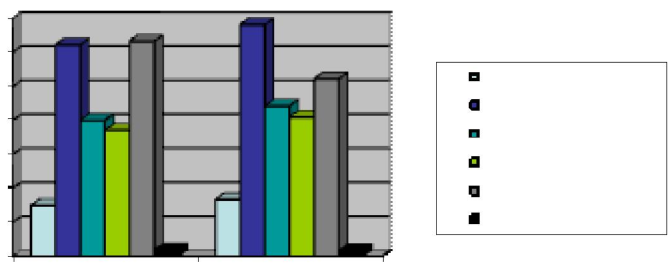

Figure (3): Mean values and significance of group (A) and group (B) measured parameters after treatment.

Discussion

The results of this study concerning body mass index in the aerobic exercise group indicated a significant reduction. This result is supported by studies indicating that aerobic exercise induces a significant reduction in body mass index, which is associated with subsequent cardiovascular risk factors, so this reduction will reduce the risk of cardiovascular disease in these subjects [13] and [14]

The results also indicated that there was a significant increase in MVV in both the aerobic exercise group and the anaerobic exercise group where the aerobic exercise group obtained a greater increase in MVV than did the anaerobic exercise program. This result is supported by a study reporting that aerobic training induces significant physiological adaptations in the cardio-respiratory system of middle-aged men. The best markers of these adaptations were the smaller sympathetic tachycardia at comparable workloads and the improvement of oxygen transport, as documented by the increase in the anaerobic threshold and VO_2 peak during dynamic exercise [15]. This result was also supported by a study comparing the cardio-pulmonary function between a moderate exercise program and a severe exercise program; they reported that there was a significant improvement in VO_2 max and maximum voluntary ventilation after both types of exercise [16].The results also indicated that there was a significant reduction in heart rate and in systolic and diastolic blood pressure in the aerobic exercise group at the end of the aerobic exercise program.

Regular aerobic training induces significant adaptations both at rest and during maximum exercise in a variety of dimensional and functional capacities related to the cardiovascular and respiratory regulation system, thus enhancing the delivery of oxygen into active muscles. These changes include decreases in resting and maximal exercise heart rate and enhanced stroke volume and cardiac output [17] and [18]. The reduction of heart rate and of systolic and diastolic blood pressure in the aerobic exercise group after aerobic training might be due to Nitric oxide, an important and potent endothelium-derived relaxing factor that facilitates blood vessel dilatation and decreases vascular resistance [19].

The results of our study also indicated that there were no significant changes in heart rate or in systolic and diastolic blood pressure in the anaerobic exercise group after finishing the program of anaerobic exercise, but there was a significant reduction after the aerobic exercise program. This reflects an increased cardio respiratory load related to the increased duration of the training session from 20 to 30 minutes. However, the greater blood flow under the influence of the rise in heart rate and systolic blood pressure does not satisfy the increased oxygen requirements during anaerobic exercise. This explains the significant augmentation of pulmonary ventilation and ventilation capacity in the trial to satisfy the expanding oxygen transport requirements during maximal exercise. Participation in heavy resistance anaerobic training over an extended period of time increases cardiac workload, and thus it could not be sustained over an extended period of time [20].

The results concerning myocardial oxygen consumption in our study indicated that there were no significant changes in myocardial oxygen consumption after finishing the program of anaerobic exercise. However, there was a significant reduction after the aerobic exercise program. The improvements in the resting heart rate and systolic blood pressure are reflected in the myocardial oxygen consumption in this study. This improvement in myocardial oxygen consumption might be due to an improvement in endothelium–dependant vasodilatation in both epicardial coronary vessels. Also, it might due to the recruitment of coronary collateral vessels and enhanced blood flow with regulation of the vasomotor tone toward vagal modulation. The myocardial oxygen consumption was lowered after eight weeks of the training program from 60 to 80% of the maximum HR. This improvement might be due to increased peripheral vasodilatation and, consequently, a decrease after load following exercise and a reduction in the adrenergic efferent stimuli [21] and [22]

Conclusion

Aerobic exercise improves cardiorespiratory fitness in obese subjects with less cardiac workload as evidenced by the low myocardial oxygen consumption while anaerobic exercise increases cardiac work and is difficult to maintain for extended periods of time, Moreover, low-intensity aerobic exercise is less difficult and more easily tolerated and can be practised daily over an extended period of time.

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References

[1] Bennett B, Sothern MS. Diet, exercise, behavior: the promise and limits of lifestyle change. Seminars in Pediatric Surgery 2009; 18 (3): 152-158.
[2] Ogden CL, Carroll MD, Flegal KM. High body mass index for age among US children and adolescents, 2003-2006. JAMA 2008; 299(20):2401-5.
[3] Bradford NF. Overweight and Obesity in Children and Adolescents. Primary Care Clinics. Clinics in Office Practice 2009; 36 (2): 319-339.
[4] WHO, 2000. Obesity. Preventing and managing the global epidemic. WHO technical report series 894. Geneva, Switzerland.WHO, 2000: 5–37.
[5] Trost, S.G., Kerr L.M., Ward D.S. and Pate R.R., 2001. Physical activity and determinant of physical activity in obese and non obese children. Int. J. Int. Obes. Relat. Metab. Disord., 30 (2) : 222 - 6.
[6] Greene, H.L., Prior T. and Frier H.I., 2001. Foods, health claims, and the law: comparisons of the United States and Europe. Obes. Res., 9 (Supple. 4): 276S – 283S.
[7] Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, Hergenroeder AC, Must A, Nixon PA, Pivarnik JM, Rowland T, Trost S, Trudeau F. Evidence based physical activity for school-age youth, J Pediatr 2005; 146 (6): 732–737.
[8] Hassink SG, Zapalla F, Falini L, Datto G. Exercise and the obese child. Progress in Pediatric Cardiology 2008; 25(2): 153-157.
[9] Ross R, Dagnone D, Jones PJ, Smith H, Paddags A, Hudson R, Janssen I. Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. Ann Intern Med. 2000; 133(2):92-103.
[10] Perna F, Bryner R, Donley D, Kolar M, Hornsby G, Sauers J, Ullrich I, Yeater R. Effect of diet and exercise on quality of life and fitness parameters among obese individuals. Journal of Exercise Physiology 1999; 1 (2):125-131.
[11] Janssen P. Training at anaerobic threshold. Lactate threshold training. 2nd ed. United States. Human Kinetics 2001. 25-41.
[12] Irwin S, Tecklin JS. Cardiopulmonary physical therapy: A guide to practice. 4th ed. New York, Mosby company 2004. 84.

[13] Planas A, Clará A, Pou JM, Vidal-Barraquer F, Gasol A, de Moner A, Contreras C, Marrugat J. Relationship of obesity distribution and peripheral arterial occlusive disease in elderly men. International Journal of Obesity 2001; 25 (7): 1068-1070.
[14] Young DR, Sharp DS, Curb JD. Associations among baseline physical activity and subsequent cardiovascular risk factors. Med Sci Sports Exerc 1995; 27 (12): 1646-1654.
[15] Juel C, Klarskov C, Nielsen JJ, Krustrup P, Mohr M, Bangsbo J. Effect of high-intensity intermittent training on lactate and H+ release from human skeletal muscle. Am J Physiol Endocrinol Metab 2004; 286 (2): 245-251.
[16] O'Donovan G, Owen A, Bird SR, Kearney EM, Nevill AM, Jones DW, Woolf-May K. Changes in cardio-respiratory fitness and coronary heart disease risk factors following 24 wk of moderate- or high-intensity exercise of equal energy cost. J Appl Physiol 2005; 98 (5): 1619-1625.
[17] Fagard RH. Exercise characteristics and the blood pressure response to dynamic physical training. Med Sci Sports Exerc. 2001; 33(6 Suppl):S484-92; discussion S493-4.
[18] Skinner JS, Jaskólski A, Jaskólska A, Krasnoff J, Gagnon J, Leon AS, Rao DC, Wilmore JH, Bouchard C. Age, sex, race, initial fitness, and response to training: the heritage Family Study. J Appl Physiol 2001; 90 (5):1770-1776.
[19] Joyner MJ, Tschakovsky ME. Nitric oxide and physiologic vasodilatation in human limbs: where do we go from here? Can J Appl Physiol 2003; 28 (3): 475-490.
[20] Deschenes MR, Kraemer WJ. Performance and physiologic adaptations to resistance training. Am J Phys Med Rehabil. 2002; 81(11 Suppl):S3-16.
[21] Carlson JJ, Johnson JA, Franklin BA, VanderLaan RL. Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. Am J Cardiol. 2000; 86(1):17-23.
[22] Maiorana A, O'Driscoll G, Cheetham C, Collis J, Goodman C, Rankin S, Taylor R, Green D. Combined aerobic and resistance exercise training improves functional capacity and strength in CHF. J Appl Physiol. 2000; 88(5):1565-70.

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