Effect of Aerobic Exercises on Physical Fitness in Patients with Ischemic Heart Disease

Shehab M. Abd el Kader* and Heba K. Sedrak**
* Faculty of Physical Therapy, Cairo University.
** Faculty of Medicine, Cairo University.

ABSTRACT

Objective: *This study was designed to determine changes in physical fitness inpatients with ischemic heart disease after aerobic exercises training program.* ***Subjects, material and methods:*** *Thirty male patients with coronary heart disease. Their age ranged between 43 to 52 years old and the subjects were divided into two equal groups. The first group performed aerobic exercise training program the duration of exercise was 16 weeks, at a frequency of 4 sessions per week in addition medical treatment and the second group received only medical treatment. Measurements included maximal oxygen consumption (VO_2 max.), anaerobic threshold and work capacity (METs). Measurements taken before the study and after 16 weeks at the end of the study.* ***Results:*** *Training group showed a significant improvement in maximal oxygen consumption (VO_2max.), anaerobic threshold and work capacity (METs) but there was a significant difference between both groups.* ***Conclusion:*** *It is recommended to use aerobic exercise in clinical management of patients with ischemic heart disease.*

INTRODUCTION

Ischemic heart disease (coronary heart disease) continues to be a leading cause of morbidity and mortality in most developed countries and many developing countries. While its incidence is decreasing in Europe and United States, it is steeply increasing in Africa and to some extent in Asia[25]. Coronary heart disease (CHD) is definite when there is stenosis in any proximal or middle coronary artery of major branch equal or greater than fifty percent of diameter[18].

The American Heart Association classified physical inactivity as a major risk factor. All of the epidemiological studies examining the relationship between CHD and physical inactivity or physical fitness, and have observed lower rate among persons with level of physical activity, on average, about a two fold difference in risk exists[6].

Advice regarding physical activity is an important part of the management of cardiovascular disease. In addition to its role in primary prevention, it is now clear that patients with established ischemic heart disease and cardiac failure can benefit from exercise training. One study which randomized patients with stable coronary disease to either exercise therapy or percutaneous coronary intervention (PCI), found improved functional capacity and greater event-free survival in the exercise group[14].

Physical activity and exercises resulted in significant improvements in exercise capacity and total peak oxygen uptake VO2 max. in diabetic and non-diabetic patients, so the combined cardiac training is well tolerated and useful in secondary prevention in patients with type 2 diabetes and ischemic heart disease[22].

Patients with established CHD are at serious risk of subsequent vascular events non-fatal myocardial infarction, non-fatal strokes, and cardiac death. These risks can be reduced by effective clinical and preventive care[15].

Exercise training has now shown to improve exercise capacity, reduce various CHD risk factors, improve quality of life, and reduce subsequent hospitalization costs. As well, as reduces major CHD events, including fatal myocardial infarction (MI), sudden death, and all cause mortality[9].

Exercise training has assumed a major role in cardiac patient, mostly because of its positive effect on myocardial perfusion in patients with CHD[10].

Exercise capacity is the strong predictor of the risk of death in CHD Patients .The benefits of exercise training in patients with CHD include an improvement in exercise tolerance as assessed not only by exercise duration but also more importantly by peak myocardial oxygen consumption[16].

Formal exercise training in CHD patients and a prior MI has established benefits including improvement of ejection fraction (EF), metabolic activity and contractile reserve of myocardium[19].

The aim of this study was to detect changes in physical fitness in patients with ischemic heart disease after aerobic exercises training program.

SUBJETS MATERIAL AND METHODS

Subjects

Thirty male patients with coronary heart disease selected randomly from the physical therapy department in the National Heart Institute. All patients had a history of anginal chest discomfort.

This was proved by angiographic documentation of equal or lesser than 50% stenosis of a major epicardial coronary artery. Their age ranged from 43 to 52years. Patients with uncontrolled hypertension or those patients with diabetes mellitus (DM), or smokers were excluded. Patients with heart failure, cardiomyopathy, valvular disease or bundle branch block were also excluded.

Also those with severe or moderate degree of degenerative joints disease or with BMI > 25 kg/m^2 were excluded.

Patients were randomly divided into two equal groups: Group 1 (training group) and group2 (control group). The program lasted for four months, three sessions a week and duration of each session was 40 minutes.

Instrumentation

1- Treadmill (Track master 400E, gas fitness system, England) it was used in exercise stress test with other exercise test equipment to estimate exercise capacity and in aerobic exercise training. The treadmill has front and side rails to aid in subject stability.
2- Electrocardiogram (ECG) (ES500, Hellige, Germany) to study the electricity of the heart at rest and during exercise stress test protocol.
3- Mercurial sphygmomanometer (Speidel, Keller, Minia Tur 300, Germany) and Stethoscope (Littmann, classic II, USA) to measure blood pressure in order to exclude hypertensive patients.
4- Weight and Height scale (Metro type-England) was used to measure weight and height to calculate the body mass index (BMI) in order to exclude obese patients.

Procedures of the study

The procedures of this study were divided into two main procedures.

1- Evaluation procedures

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

<u>Cardiopulmonary exercise test procedure (CPET)</u>

Before conducting the exercise tolerance test, all subjects had to visit the laboratory to be familiarized with the equipment in order to be cooperative during conducting the test. Each subject underwent continuous progressive exercise tolerance test according to Bruce standard protocol which consists of warming up phase and five active phases and recovery phase.

Measurements which were recorded included maximal oxygen consumption (VO_2 max.), anaerobic threshold and work capacity (METs) .Measurements taken before the study and after 16 weeks at the end of the study.

2- Training procedures

<u>Group (1):</u> Patients in this group received the usual medical treatment in addition to aerobic exercise training for 16 weeks as the following steps:

<u>A-warming up:</u> Before the exercise program, include walking on the treadmill for 5 minutes at speed 1.5 km/h with zero inclination.

<u>B-Active phase:</u> It was gradually increased from 20 to 40 minutes in the form of walking/running on electronic treadmill with zero inclination four times per week for twelve weeks, its intensity gradually from 60 to 70 % of each patient calculated training heart rate; according to Karovenen formula.

<u>C-Cooling down</u>: Included walking on the treadmill for 5 minutes at speed 1 km/h with zero inclination and gradually decreased speed until reach zero.

Group (2): Patients in this group received only the usual medical treatment.

Statistical Analysis

The paired t-test was used to compare between pre and post test in both groups, where the independent t- test was used for the comparison between the two groups ($P<0.05$).

RESULTS

This study comprised thirty male patients with coronary heart disease. The data was collected from subjects and classified into pre and posttest values. The subjects were divided into 2 groups: Group (I) received the usual medical treatment in addition to aerobic exercise and group (II) received only the usual medical treatment.

Table (1) and figure (1) show the difference of mean and standard deviation values of maximal oxygen consumption (VO_2 max.) between both groups before and after the exercise program. As noticed there was statistical no significant difference between both groups before treatment (P value <0.05), while after treatment it was 3.39 ± 0.15 L/min/kg in the training group and 3.09± 0.16 L/min/kg in the control group, which was statistically significant (P value <0.05). Also, There was statistically significant difference in the maximal oxygen consumption in the training group after the exercise program as compared with the pre-treatment value, which changed from 3.07 ± 0.16 to 3.39 ± 0.15 L/min/kg. While there was statistical no significant difference in the control group after treatment as compared with the pre treatment value

Table (1): Statistical analysis of maximal oxygen consumption (L./min./Kg) between both groups before and after the exercise program.

	Training group	Control group	t-value	Significance
Pre	3.07±0.16	3.06±0.17	0.86	Non sig.
Post	3.39±0.15	3.09±0.16	3.79	Sig.
t-value	5.11	1.01		
Significance	Sig.	Non sig.		

Level of significance P<0.05 Sig. = Significant L. = liter Min.= minute Kg= kilogram

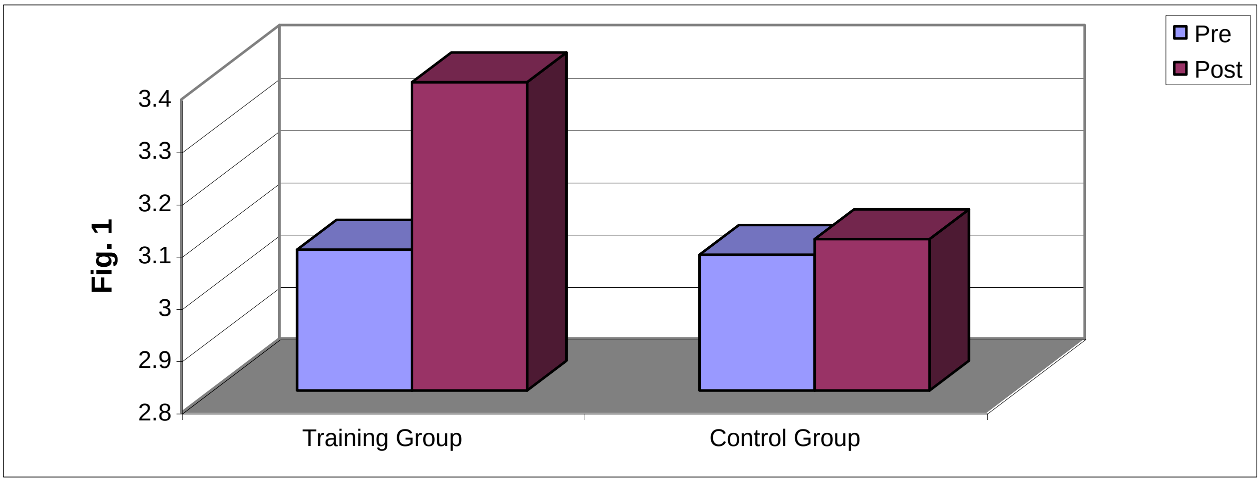

Table (2) and figure (2) show the difference of mean and standard deviation values of work capacity (METs) between both groups before and after the exercise program.

The same statistical changes were also obtained when comparing the results of the work capacity in both groups. Again the statistical significant differences were only noticed in the post treatment values in the training group; which changed from 8.67 ± 1.16 to 11.49 ± 1.14L/min/kg and when comparing the post treatment values of both groups; 11.49 ± 1.14 & 8.78 ± 1.12L/min/kg, respectively. While in the control group no statistical significant differences were obtained.

Table (2): Statistical analysis of work capacity (ml./min./Kg) between both groups before and after the exercise program.

	Training group	Control group	t-value	Significance
Pre	8.67±1.16	8.23±1.11	0.98	Non sig.
Post	11.49±1.14	8.78±1.12	4.75	Sig.
t-value	4.12	0.87		
Significance	Sig.	Non sig.		

Level of significance P<0.05 Sig. = Significant ml. = mili-liter Min.= minute Kg= kilogram

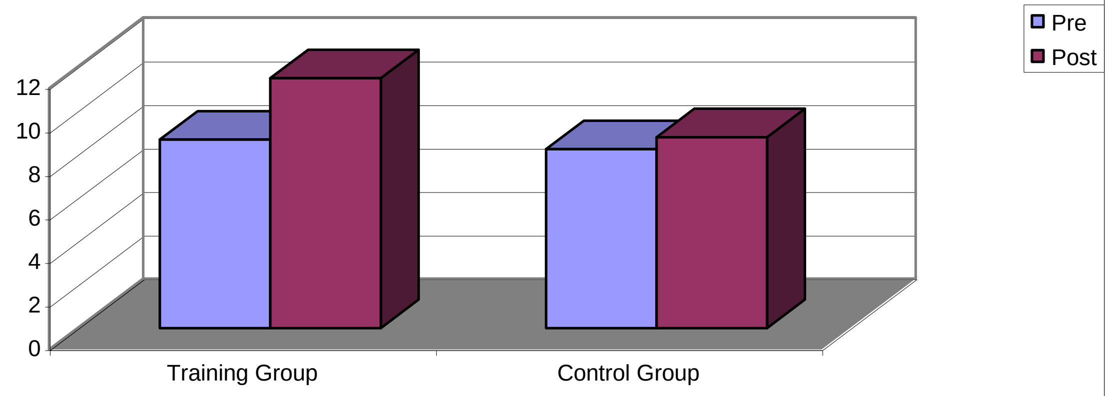

Fig.2

Table (3) and figure (3) show the difference of mean and standard deviation values of anaerobic threshold between both groups before and after the exercise program. One can noticed the statistical significant difference in the anaerobic threshold in the training group after treatment, which increased from 50.81± 2.67 to 56.32±3.12 (P value <0.05), but in the control group it changed only from 50.14 ± 2.98 to51.11 ± 3.15. Also, there was significant difference on comparing the post treatment values in both groups (P value <0.05), although the pre treatment values of both groups showed nonsignificant difference.

Table (3): Statistical analysis of anaerobic threshold between both groups before and after the exercise program.

	Training group	Control group	t-value	Significance
Pre	50.81±2.67	50.14±2.98	0.88	Non sig.
Post	56.32±3.12	51.11±3.15	3.22	Sig.
t-value	4.33	1.13		
Significance	Sig.	Non sig.		

Level of significance P<0.05

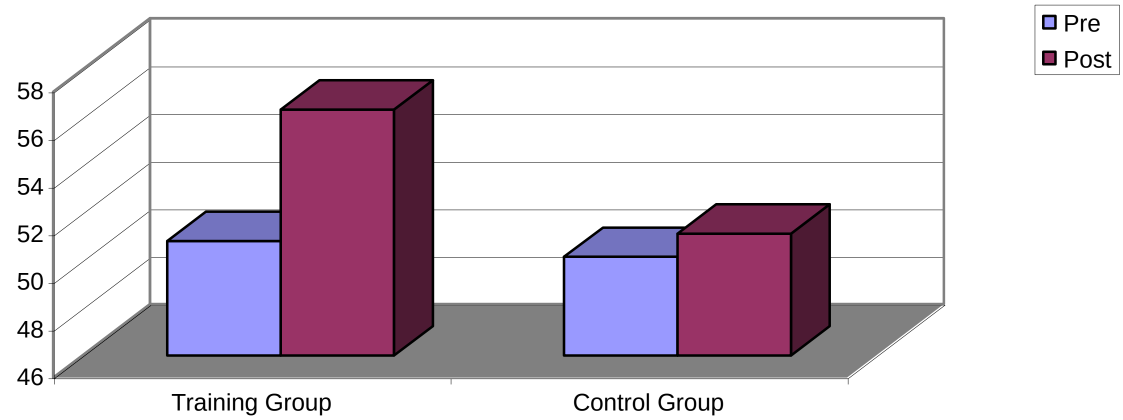

Fig.3

DISCUSSION

This study was designed to detect changes in physical fitness in patients with ischemic heart disease after aerobic exercises training program. All patients had a history of anginal chest discomfort that proved by angiographic documentation of equal or lesser than 50% stenosis of a major pericardial coronary artery.

Exercise capacity termed by metabolic equivalents (METs) improved in this study. This favorable change may be due to improvement in the endothelium –dependant vasodilatation both in epicardial coronary vessels and in resistance vessels in patients with Ischemic heart disease. Another explanation was that exercise training is commonly associated with increased in agonist –mediated blood flow velocity and coronary blood –flow reserve. This may be due to increase in the capacity of the cardiovascular system to deliver oxygen increased cardiac out put (COP) and the muscles to use that oxygen (greater arteriovenous difference).

Exercise capacity consistently improved by 30-50% after three months of aerobic conditioning at an intensity of 70% to 85% of target heart rate. The possible physiological mechanism of aerobic conditioning in patients by central (cardiac) and peripheral (skeletal muscles and vascular) adaptations resolution in a widened difference in oxygen content between arterial and venous blood during maximal exercise and an increased capacity to deliver substrate to skeletal and cardiac muscles[1,3,11].

Long-term exercise training is useful for maintaining or improving the beneficial results of the standard 3-month exercise training program on cardiovascular capacity and HRR. This observation may bear beneficial prognostic effects on patients after AMI[8,17].

A 3-month endurance exercise training program augments coronary collateral supply to normal vessels, and even to previously stenotic arteries having undergone percutaneous coronary intervention before initiating the program. There appears to be a dose-response relation between coronary collateral flow augmentation and exercise capacity gained. They showed increased endurance (VO_2max in ml/min per kg) and performance (W/kg)[26].

The effect of six months of regular exercise training at 80% of target heart rate in patients who had Q-wave MI. They showed that a significant improvement in exercise capacity was only in the training group but not in control group. They explained their results because physical training induces peripheral changes in skeletal muscles and beneficial lipoprotein modulation[9].

Results also indicated that there was a significant increase in VO_2 max and anaerobic threshold in training group and no significant change in the control group.

The significant increase in VO_2 max was due to improved the respiratory functions as vital capacity, inspiratory reserve volume and expiratory reserve volume of the lungs, also the stroke volume of the heart increased by regular exercise. These respiratory adaptations facilitate oxygen supply to tissues and add further evidence of respiratory fitness improvement[4,23].

There are several mechanisms by which endurance training may improve the relative balance between myocardial oxygen supply – demands and thereby result in an anti-ischemic effect. Increased metabolic capacity and improved mechanical performance of myocardium are well-substantiated adaptation to endurance training. Lowered heart rate and systolic blood pressure during submaximal exertion reduce myocardial work, its oxygen demands and coronary blood flow needed. Among patients with coronary heart disease, this allows a greater absolute workload to accomplish before reaching the ischemic threshold. In addition, heart rate slowing with training allows more time during diastole for coronary flow to perfuse the myocardium[5,16].

Older sedentary men subjects who exercised for ten months at 60-70 % of $VO_{2\,max}$ and increase progressively to 70-80 % of it, resulted in a 28% increase in exercise capacity. In addition to improvement in ejection fraction, these improvements may be due to increased pre-load and /or lowered aortic impedance afterload[21].

Brief but intense sprint interval training can result in an increase in both glycolytic and oxidative muscle enzyme activity, maximum short-term power output, and VO_2 max[2]. Also, there was a significant improvement in VO_2 max and minute ventilation after moderate and severe exercise program[7].

Cardiopulmonary functions improved after aerobic exercise (walking) and anaerobic exercise (vigorous activity) and the improvement in maximum oxygen consumption (VO_2 max) after vigorous exercise group was greater than after walking exercise group[13].

After regular aerobic training there was a peripheral vascular adaptation, which may arise from structural modifications of the vasculature and alterations in the control of vascular tone. An increase in the capillary density of muscle has also been shown after training. Both capillary density and blood flow increase in proportion to the rise in maximal aerobic power during long-term aerobic training[12].

Regular aerobic training induces significant adaptations both at resting and during maximum exercise in a variety of dimensional and functional capacities related to the cardiovascular and respiratory regulation system; enhancing the delivery of oxygen into active muscles these changes include decreases in resting and maximal exercise heart rate, enhanced stroke volume and cardiac output and as a result increase maximum oxygen consumption (VO_2 max)[20,24].

Finally, it was concluded that exercise training base on cardiac rehabilitation program is a cornerstone in treating ischemic heart diseased patients. Aerobic training in particularly, improved physical fitness in those patients through improving maximum oxygen consumption (VO_2 max.), work capacity and anaerobic threshold. Such improvement may be related to cardio-pulmonary adaptations and exercise conditioning. The results of this study emphasis also on the communication between physician and physical therapists that concern cardiac rehabilitation programs not only after cardiac surgery or post infarction, but should extend to prevention program for patients who are at coronary risk factors.

REFERENCES

1- Ades, P.: Cardiac rehabilitation and secondary prevention of coronary heart disease. N Enl J Med, 345: 892-902, 2001.
2- Audrey, L., Jay, R. and Kelly M.: Muscle performance and enzymatic adaptations to sprint interval training. J Appl Physiol, 84: 2138-2142, 1998.
3- Carlson, J., Jonson, J., Franklin, B. and Vanderlaan, R.: Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. Am J Cardiol, 86: 17-23, 2000.
4- Carsten, J., Christina, K. and Jens, B.: Effect of high-intensity intermittent training on lactate and H+ release from human skeletal muscle. Am J Physiol Endocrinol Metab, 286: 245-251, 2004.
5- Farrel, S., Kampert, J. and Kohl, M.: Strength training: rationale for current guidelines for adult fitness program .Sports Med, 25: 44-64, 1999.
6- Fleg, J., Pina, I. and Bazzare, T.: Assessment of functional capacity in clinical research applications .Circulation, 102: 1591-1635, 2000.
7- Gary, O., Andrew, O. and Kate, W.: 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, 98: 1619-1625, 2005.
8- Giallauria, F., De Lorenzo, A., Pilerci, F., Manakos, A., Lucci, R., Psaroudaki, M., D'Agostino, M., Del Forno, D. and Vigorito, C.: Long-term effects of cardiac rehabilitation on end-exercise heart rate recovery after myocardial infarction.Eur J Cardiovasc Prev Rehabil, 13(4): 544-550, 2006.
9- Giannuzzi, P., Temporelli, P. and Tavazzi, L.: Attenuation of unfavorable remolding by exercise training in post infarction patients with left ventricular dysfunction. Circulation, 96: 1790-1797, 1997.
10- Gielen, S., Schuler, G. and Hamrecht, R.: Exercise training in coronary artery vasomotor .Circulation, 103: 101-106, 2001.
11- Hambrecht, R., Wolf, A. and Schuler, G.: Effect exercise on coronary endothelial function in patients with coronary artery disease. N Eng J Med, 342: 454-460, 2000.

12- Hepple, R.: Skeletal muscle: microcirculatory adaptation to metabolic demand. Med Sci Sports Exerc, 32: 117-123, 2000.

13- Joann, E., Philip, G. and David, S.: Walking Compared with Vigorous Exercise for the Prevention of Cardiovascular Events in Women. The New England Journal of Medicine, 347: 716-725, 2002.

14- Joshi Subodh: Exercise training in management of cardiac failure and ischemic heart disease. Heart lung and circulation, 16, supplement 3: S83-S87, 2007.

15- Moher, M., Yudkin, P. and Fuller: Cluster randomized controlled trail to compare three methods of promoting secondary prevention of coronary heart disease in primary care. BMJ , 322: 1338 -1345, 2001.

16- Myers, J., Prakash, M. and Atwood, J.: Exercise capacity and mortality among men referred for exercise testing .N Eng J Med, 346: 793-801, 2002.

17- Legramante, J., Iellamo, F., Massaro, M., Sacco, S. and Galante, A.: Effects of residential exercise training on heart rate recovery in coronary artery patients. Am J Physiol Heart Circ Physiol., 292(1): H510-515, 2007.

18- Olderidge, N., Guatt, G. and Rimm, A.: Cardiac rehabilitation after myocardial infarction. JAMA, 260: 945-950, 1988.

19- Pina, I., Apstein, C. and Sullivan, M.: Exercise and heart Failure: A statement from the American Heart Association committee on Exercise, rehabilitation and prevention. Circulation, 107: 1201-1225, 2003.

20- Skinner, J., Jaskolski, A. and Bouchard, C.: Age, sex, race, initial fitness, and response to training: the heritage Family Study. J Appl Physiol; 90: 1770-1776, 2001.

21- Spina, R., Rashid, S. and Ehsani, A.: Adaptation in β- adrenergic cardiovascular responses to training in older men. Am J Heart Circ physiol, 43: 397-404, 1998.

22- Svacinova, H., Novakova, M., Placheta, Z., Kohzuki, M., Nagasaka, M., Minami, N., Dobsak, P. and Siegelova, J.: Benefit of combined cardiac rehabilitation on exercise capacity and cardiovascular parameters in patients with type 2 diabetes. Tohoku J Exp Med., 215(1): 103-111, 2008.

23- Tomohiro, O., Yoshio, N. and Kiyoji, T.: Effects of Exercise Intensity on Physical Fitness and Risk Factors for Coronary Heart Disease. Obesity Research, 11: 1131-1139, 2003.

24- Dic Thompson, P.: Exercise prescription and prescription for patients with coronary artery disease. Circulation, 112: 2354-2363, 2005.

25- Wilson, P., Agostino, B. and Kannel, W.: Prediction of coronary heart disease using risk factor categories. Circulation, 97: 1837-1847, 1998.

26- Zbinden, R., Zbinden, S., Meier, P., Hutter, D., Billinger, M., Wahl, A., Schmid, J., Windecker, S.., Meier, B. and Seiler, C.: Coronary collateral flow in response to endurance exercise training. Eur J Cardiovasc Prev Rehabil., 14(2): 250-257, 2007.

الملخص العربي

تأثير التمرينات الهوائية على اللياقة البدنية في مرضى قصور الشريان التاجي

هدف الرسالة هو دراسة تأثير التمرينات الهوائية على اللياقة البدنية في مرضى قصور الشريان التاجي . أجرى البحث على ثلاثين شخص يعانون من قصور الشريان التاجي وتم تقسيمهم إلى مجموعتين متساويتين : المجموعة الأولى تلقت تمرينات هوائية لمدة ستة عشر أسبوعا بمعدل أربعة جلسات أسبوعيا بالإضافة إلى العلاج الدوائي . المجموعة الثانية (الضابطة) تلقت العلاج الدوائ ي فقط . وقد تم قياس القيمة القصوى لاستهلاك الأكسيجين والعتبه اللاهوائي والكفاءة التدريبي قبل بدء البرنامج وبعد الانتهاء من البرنامج . وقد أظهرت النتائج وجود فروق ذات دلالة إحصائية تشير إلى وجود تحسن ملحوظ في المجموعة الأولى التي تلقت تمرينات هوائي فقط ، في حين لم تظهر المجموعة الثانية أية فروق ذات دلالة إحصائية في جميع القياسات . لذلك يوصى باستخدام برنامج تمرينات هوائي مع مرضى قصور الشريان التاج ي لتحسين اللياقة البدنية لديهم .