Role of Supervised Exercise Program on Exercise Tolerance in Patients with Stable Chronic Heart Failure

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ABSTRACT

*Purpose: The purpose of this study was to evaluate the effect of supervised exercise program on exercise tolerance variables including; peak oxygen uptake ($\dot{V}o_{2peak}$), left ventricular ejection fraction percentage (LVEF%), 6-minute walk distance (6-MWD), cardiopulmonary exercise test duration (ETD) and dyspnea score in patients with stable chronic heart failure (CHF). **Subjects and Methods:** Thirty-two patients with CHF (mean age 67.94 ± 5.37 years); classified according to New York Heart Association (NYHA) as class II or III symptoms were participated in the study. Echocardiography, 6-minute walk test (6-MWT), maximal cardiopulmonary exercise test and dyspnea score were determined for all patients. Patients were categorized randomly into two groups; control and training, each group included 16 patients. Patients of the training group practiced an outpatient supervised exercise program for 12-week, while patients of the control group received a standard medical care. **Results:** The results showed a significant increase of mean $\dot{V}o_{2peak}$, LVEF%, 6-MWD and ETD for the training group where it was 15.0 ± 0.92 vs. 17.28 ± 1.15 (mL/kg/min) for $\dot{V}o_{2peak}$, 37.25 ± 1.65 vs. 41.44 ± 1.63 (%) for LVEF %, 369.38 ± 39.57 vs. 410.88 ± 28.76 (m) for 6-MWD and 7.06 ± 0.68 vs. 11.06 ± 0.93 (min) for ETD for pre- and post-measures respectively (P<0.001). The results also showed that there were positive correlations between; $\dot{V}o_{2peak}$ and ETD (r=0.35), between $\dot{V}o_{2peak}$ and LVEF% (r=0.51), between ETD and LVEF% (r=0.11) among post-measures of the training group. **Conclusion:** Supervised exercise program may increase exercise tolerance and enhance functional status for patients with stable CHF. This could be attributed to the improvement detected in $\dot{V}o_{2peak}$, LVEF%, 6-MWD, ETD and dyspnea score.*
Keywords: Chronic heart failure, LVEF%, $\dot{V}o_{2peak}$, dyspnea, exercise program.

INTRODUCTION

Heart failure (HR) is a complex syndrome that can result from any structural or functional cardiac disorder that impairs the ability of the heart to function as a pump to support a physiological circulation[1]. Left ventricular systolic dysfunction, previous myocardial infarction, angina and diabetes are the most common causes of HF[2].

Due to more effective treatment of cardiovascular diseases, the number of patients living with HF is increasing; men and women have equivalent incidence[3]. HF prevalence increases with age, being most common in

individuals older than 65 years[4]. Chronic heart failure (CHF) leads to significant morbidity and mortality in both genders and imposing a major burden on public health resources[5].

The left ventricular ejection fraction percentage (LVEF%) is the percentage of blood ejected from the left ventricle with each heart beat. HF has been classified into HF with a reduced ejection fraction (systolic HF) and HF with a normal ejection fraction (diastolic HF). An operational definition of systolic dysfunction is an ejection fraction of less than 50 percent[6]. The common symptoms of HF include fatigue, dyspnea, exercise intolerance and inability to perform normal activities of daily living[7,8]. The reason for fatigue and exercise intolerance is attributed to persistent vasoconstrictor drive, endothelial dysfunction, and structural and functional abnormalities of skeletal muscle rather than to ventricular dysfunction[7, 9].

Classification of patients with HF according to severity of illness is essential in order to formulate a management strategy. The New York Heart Association (NYHA) functional classification of HF is widely used in practice and in clinical studies to quantify clinical assessment of HF[10].

There is no single diagnostic test for HF, and diagnosis should rely on clinical judgment based on a combination of history, physical examination and appropriate investigations[1,11]. Echocardiography is the most useful non-invasive test in the assessment of left ventricular function; ideally it should be conducted in all patients with suspected HF[12]. A normal ejection fraction is 50% or higher and for systolic HF, the echocardiographic LVEF% is $\leq$45%. Left ventricular function was assessed qualitatively as normal, mild, moderate or severe systolic dysfunction[13, 14].

Exercise tolerance tests are commonly used to classify the severity of HF and monitor the response to treatment[15]. The 6-minute walk test (6-MWT) is a submaximal exercise test that has become a common measure of function as it is easy to administer and relates more closely to daily activities[16]. Maximal incremental cycle ergometry protocol which is designed to provide gradational stress to the patient, typically to the limit of tolerance, is widely used in clinical practice[17]. Peak oxygen uptake ($\dot{V}O_{2peak}$) measurements offer an objective assessment of functional capacity and should be used when feasible to derive the exercise prescription and to monitor changes in functional status[18,19].

Despite major advances in pharmacological treatment of HF, a number of patients still suffer from dyspnea, fatigue, diminished exercise capacity and poor quality of life[15,20]. The treatment of HF should focus on treating the associated signs and symptoms, and preventing the progression of disease[21]. Effective education and counseling of patients, and of the relatives, is important and may enhance long term adherence to management strategies. Simple explanations about the signs and symptoms of HF, including details on drug and other treatment strategies, are valuable[22].

Although physical activity was avoided in HF patients until the late 1980s, over the last decade, endurance exercise training in CHF patients has proven feasible, in terms of increased exercise capacity, quality of life and to potentially reduce morbidity and mortality rates[7]. So that exercise training has shifted, in clinical practice guidelines, from being contraindicated for patients with severe left ventricular dysfunction to being recommended and indicated as a treatment modality[23]. Patients who are medically stable and well medicated can initiate an exercise program after a baseline exercise test with medical guidance and instructions[24]. Exercise training is known to reduce the debilitating symptoms

of HF, such as dyspnea and fatigue, through effects on the cardiovascular and musculoskeletal systems[19].

The aim of this study was to evaluate the effect of supervised exercise program on exercise tolerance variables including; $\dot{V}o_{2peak}$, LVEF %, 6-minute walk distance (6-MWD), cardiopulmonary ETD and dyspnea score in patients with stable CHF.

SUBJECTS, MATERIAL AND METHODS

Subjects

The study included thirty-two patients (24 males and 8 females) with mean age of 67.94 ± 3.64 years diagnosed as CHF according to the European Society of Cardiology guidelines[25]. The main causes of HF might due to left ventricular systolic dysfunction as the result of ischemic **heart** disease or hypertension. Patients were classified according to New York Heart Association (NYHA) as class II or III symptoms[10] (20 patients of class II and 12 patients of class III). The mean weight of patients was 71.63 ± 5.24 kilograms (kg), mean height was 1.71 ± 0.07 meter (m) and mean body mass index (BMI) was 24.58 ± 2.52 kg/m^2. The mean LVEF% was 37.34 ± 1.68% as determined by echocardiography. Patients were recruited from the internal medicine and cardiac outpatient clinics, and were nonsmokers during the study and were clinically stable for at least 3 months before study entrance.

Patients were excluded from the study if they had diastolic dysfunction, unstable angina, history of sustained ventricular tachycardia or ventricular fibrillation, exercise-induced ischemia or arrhythmias, uncontrolled hypertension, or significant comorbidity that would prevent entry into the

study such as; chronic obstructive pulmonary disease, diabetes mellitus or other disorders limiting physical performance other than HF. All participants signed a written informed consent prior to inclusion in the study program and were asked to attend for an assessment interview to provide baseline anthropometric and clinical data.

Material
- Electrocardiogram (Megacart-R/E, Siemens-Elema AB, Sweden).
- Echocardiogram (Hewlett-Packard 1500 ultrasound system, Andover, Massachusetts, USA).
- Electronically braked upright bicycle ergometer (Sensor Medics/Ergometrics 900, USA).
- Mass flow ventilometry (Vmax Sensor Medics, Yorba Linda, USA).
- Pulse oximetry (Oxi-Radiometer, Boulder, Colorado, USA).

Methods
Physical Examination

All patients underwent a baseline assessment by the cardiologist comprising a detailed history and physical examination. Electrocardiography and chest radiography were performed. Anthropometric measurements were conducted including height and weight. Body weight was measured in kilograms with light clothing. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared[22]. Blood gases analysis and laboratory investigations were conducted as recommended.

Echocardiography

Patients underwent a thorough echocardiographic evaluation[12] (Hewlett-Packard 1500 ultrasound system, Andover,

Massachusetts, USA) included standard echocardiographic variables such as; right and left ventricular; structure, dimensions and functions. Interventricular septal movements, valvular, systolic and diastolic functions were recorded. The end-diastolic volume (EDV) and end-systolic volume (ESV) of the left ventricle were obtained and LVEF% was calculated as follow: $(EDV - ESV)/EDV \times 100$. During the measurements, patient was in the left recumbent position and as close as possible to end-expiration and all readings were made by qualified echo-cardiologist under supervision of the cardiologist.

Submaximal Exercise Test

The 6-MWT was conducted according to American Thoracic Society Guidelines[17]. Patients were instructed to walk from end to end of a 30-meter course at a comfortable speed in the hospital corridor, while attempting to cover as much distance as they could in 6 minutes. They could stop, rest and then continue when they were ready to do so. The time was not stopped during these rest periods. Standardized encouragement consisting of "you are doing well" or "keep up the good work" was given to the patients at 30-seconds intervals. Markers were located along the walking course 5-meter intervals. After 6 minutes, the total distance walked was measured to the nearest meter. Patients were allocated a 5-minute rest period before starting and after completing the walk test.

Maximal Exercise Test

The maximal incremental cycle ergometry protocol[17] was conducted to all patients at the baseline to determine the maximal exercise capacity to the limit of tolerance (symptoms based) through individualized ramp test protocol by using electrically braked cycle ergometer (Sensor Medics/Ergometrics 900, USA). The protocol consisted of 3 minutes of rest, followed by 3 minutes of unloaded pedaling followed by the incremental phase of exercise work rate every 1 to 2 seconds in a steep ramp protocol with total increment per minute of 5 to 25 Watt/minute, patient was verbally encouraged until reached volitional exhaustion or the test was terminated by the medical monitor.

Cardiac activity was recorded continuously during exercise by using the electrocardiogram, (Megacart-R/E, Siemens-Elema AB, Sweden), till 5 minutes after exercise test. Heart rate was calculated from ECG-tracings and maximum heart rate (MHR) during exercise was set as the MHR measured by the electrocardiogram during exercise test. Blood pressure was measured manually during the exercise test. Patient breathed through a mask, with expired gas sampled and analyzed using mass flow ventilometry (Vmax Sensor Medics, Yorba Linda, USA). $\dot{V}O_{2peak}$ was determined as the $\dot{V}O_2$ value relative to body weight in mililleter per minute per kilogram (mL/min/kg), achieved at the patient's maximum work load[11,18]. Every four weeks the maximal incremental cycle ergometry protocol was repeated for all patients to adapt workload for the following four weeks.

Dyspnea during cardiopulmonary exercise test was assessed by means of the 11-point Borg scale rating of perceived exertion by using Modified Borg Scale[26]. The scale ranges from 0 to 10 where the value of zero represents nothing at all or no discomfort and a score of 10 means maximal intensity of dyspnea. Patients were asked to determine the level of dyspnea before and immediately after completing the exercise test. All equipment used were calibrated regularly according to the standard measures[25].

Medications

Optimized medical treatment and medical follow-up were provided by the cardiologist for each patient individually in accordance with recommendations of the European Society of Cardiology[25], aiming to relieve symptoms, maintain normal fluid level and to improve prognosis by delaying progression of HF and reducing cardiovascular risk. Drugs used included; diuretic agents, digoxin, vasodilator agents, nitroglycerine, calcium channel blockers, angiotensin converting enzyme inhibitors, beta blockers or as recommended individually.

Patient Education

Patients were given a simple and clear explanation of HF including its pathophysiologic mechanisms and treatment options. Diagrams, illustrative materials and audiovisual means were used. Smoking hazards, dietary modifications, attention to blood pressure and heart rate monitoring were demonstrated to all patients.

The Study Program

Patients were categorized randomly into two homogenous groups (control and training) each group included 16 patients; by matching closed envelops each one included name of a patient. Males' names were separated from those of females and patients with class II NYHA symptoms were separated from class III. Envelops were selected randomly for both training and control groups and each group included 12 male and 4 female patients, 8 patients with class II and 8 patients with class III.

Patients of control group were provided with usual medical care (standard care); including optimal medications and follow-up. Patients were asked to continue their previous usual level of physical activities, and to keep in contact with the researchers when needed.

In addition to the standard care conducted to the control group, patients of the training group started an outpatient supervised exercise program under the supervision of the physical therapist, the day after conducting the baseline measurements. Patients performed supervised exercise program thrice weekly for 12-week (36 sessions) with the cycle ergometer[23].

Training Program

The training session lasted for about 30 minutes included; a 5-minute warm-up period, consisted of breathing exercises and free upper and lower limbs exercises and, pedaling for two minutes at 20% of maximum work load level determined from cardiopulmonary exercise test followed by interval training, designed for HF patients[17], by using the bicycle ergometer. Patients conducted the interval exercise for 20 minutes as follow; high intensity exercise for 20 seconds at 50% of maximum work load derived from the exercise test alternating with low intensity intervals for 40 seconds at 20% of the maximum work load. Then patients had a slow down period for two minutes ended with a cool down period for 5-minute included stretching of the lower limbs muscle groups and breathing control before completion of the training session. Oxygen saturation level was monitored during and after exercise training by using the pulse oximetry (Oxi-Radiometer, Boulder, Colorado, USA). Blood pressure, heart rate and dyspnea level were measured and reported in each session. The work load on the bicycle ergometer was adapted individually for each patient every four weeks according to the exercise test as physical fitness of the patients changed.

The other part of the training program consisted of a home training program in the form of daily walking training for about 30 minutes. Intensity of training during home program was regularly monitored by heart rate as patients taught during the education session.

Post-measures

All baseline measurements including; echocardiogram, 6-MWT, cardiopulmonary exercise test and dyspnea score were conducted to all patients after 12 weeks at the end of the study program.

Statistical Analysis

Data from pre- and post-measures including; $\dot{V}o_{2peak}$, LVEF%, RHR, MHR, 6-MWD, ETD and dyspnea score were collected and entered into statistical program (SPSS version 13.0). Descriptive analysis was performed for both baseline anthropometric and clinical characteristics of the patients. Values were expressed as means and standard deviations. Paired t-test was used to compare intra-group data (pre- and post-measures) to evaluate the effects of intervention at the end of the program, while unpaired t-test was used for comparisons between post-measures between training and control groups. Pearson's product moment correlation coefficient was used to determine the correlation between pre- and post-measures for both training and control groups and among post-measures of the training group. The selected level of significance was set to be (P<0.05).

RESULTS

Thirty-two patients (24 males and 8 females) were participated in the study, their mean age was 67.94 ± 3.64 years, the mean weight was 71.63 ± 5.24 (kg), the mean height was 1.71 ± 0.07 (m) and the mean BMI was 24.58 ± 2.52 (Kg/m^2).

Table (1) shows the baseline anthropometric and clinical characteristics measures for both training and control groups. There were no significant differences between both groups concerning mean; age, weight, height, BMI, $\dot{V}o_{2peak}$, LVEF%, RHR, MHR, 6-MWD, ETD and dyspnea score.

Table (1): Baseline Anthropometric and Clinical Characteristics Measures for Patients of Training and Control Groups.

Variables	Training Group	Control Group	P-value
Age, y	67.69 ± 3.61	68.19 ± 3.76	0.7
Weight, kg	72.13 ± 5.66	71.13 ± 4.91	0.6
Height, m	1.72 ± 0.08	1.70 ± 0.06	0.58
BMI, Kg/m^2	24.54 ± 2.35	24.54 ± 2.76	0.98
$\dot{V}o_{2peak}$, mL/kg/min	15.0 ± 0.92	15.03 ± 0.98	0.93
LVEF, %	37.25 ± 1.65	37.44 ± 1.75	0.76
RHR, bpm	74.63 ± 8.12	74.25 ± 8.88	0.9
MHR, bpm	132.75 ± 8.16	134.25 ± 8.16	0.54
6-MWD, m	369.38 ± 39.57	362.37 ± 39.89	0.62
ETD, min	7.06 ± 0.68	7.0 ± 0.73	0.8
Dyspnea Score, 0-10	7.06 ± 1.18	7.19 ± 1.17	0.77
Data shown are mean values and standard deviations. y, denotes years; kg, kilograms; m, meter; BMI, body mass index; m^2, square meter; $\dot{V}o_{2peak}$, peak oxygen uptake; mL, millilitre; min, minute; LVEF, left ventricular ejection fraction; %, percentage; RHR, resting heart rate; bpm, beats per minute; MHR, maximum heart rate; 6-MWD, 6-minute walk distance; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale.			

Table 2 shows comparisons between the mean pre- and post-measures of $\dot{V}o_{2peak}$, LVEF%, RHR, MHR, 6-MWD, ETD and dyspnea score for the training group. The results showed a significant difference of mean; $\dot{V}o_{2peak}$ (15.0 ± 0.92 vs. 17.28 ± 1.15 mL/kg/min), LVEF% (37.25 ± 1.65 vs. 41.44 ± 1.63 %), RHR (74.63 ± 8.12 vs. 67.31 ± 5.84 bpm), MHR (132.75 ± 8.16 vs. 139.94 ± 9.60 bpm), 6-MWD (369.38 ± 39.57 vs. 410.88 ± 28.76 m), ETD (7.06 ± 0.68 vs. 11.06 ± 0.93 min) and dyspnea score (7.06 ± 1.18 vs. 5.69 ± 0.70). (Figure 1)
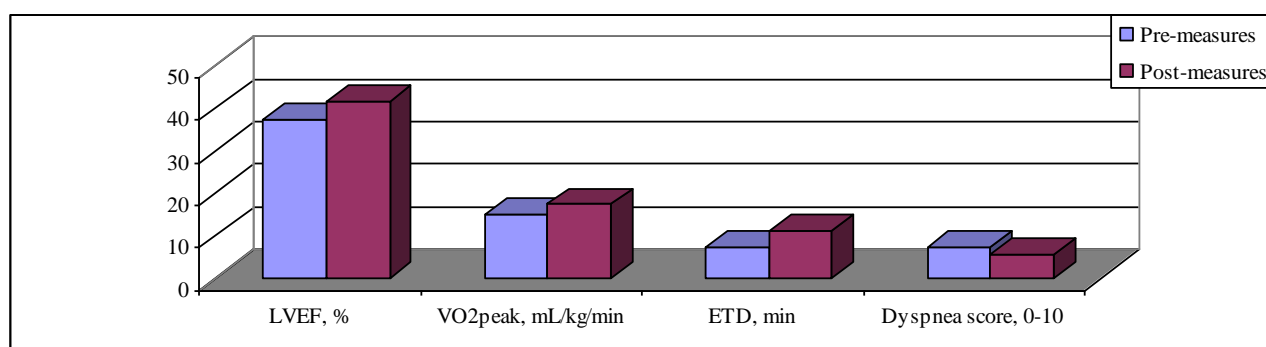
The table shows that there were positive correlations between pre- and post-measures among the training group, where there were; $\dot{V}o_{2peak}$ (r=0.99), LVEF% (r=0.70), RHR (r=0.92), MHR (r=0.92), 6-MWD (r=0.88), ETD (r=0.21) and dyspnea score (r=0.75).

Table 2 shows also the mean differences and percentage changes of pre- and post-measures of the studied parameters for training group. The results showed that the mean difference of $\dot{V}o_{2peak}$ was 2.28 (mL/kg/min) with a percentage increase of 15.2%, the mean difference of LVEF% was 4.19(%) with a percentage increase of 11.25%, the mean difference of RHR was −7.32 (bpm) with a percentage decrease of −9.81%, the mean difference of MHR was 7.19 (bpm) with a percentage increase of 5.42%, the mean difference of 6-MWD was 41.5 (m) with a percentage increase of 11.24%, the mean difference of ETD was 4.0 (min) with a percentage increase of 56.66% and the mean difference of dyspnea score was −1.37 with a percentage decrease of −19.41%.

Table (2): Pre- and Post-measures for Training Group.

Variables	Pre-measures	Post-measures	P-value	r-value	Mean Difference	% Change
$\dot{V}o_{2peak}$, mL/kg/min	15.0 ± 0.92	17.28 ± 1.15	<0.001	0.99	2.28	15.2
LVEF, %	37.25 ± 1.65	41.44 ± 1.63	<0.001	0.70	4.19	11.25
RHR, bpm	74.63 ± 8.12	67.31 ± 5.84	0.007	0.92	−7.32	−9.81
MHR, bpm	132.75 ± 8.16	139.94 ± 9.60	0.03	0.92	7.19	5.42
6-MWD, m	369.38 ± 39.57	410.88 ± 28.76	0.002	0.88	41.5	11.24
ETD, min	7.06 ± 0.68	11.06 ± 0.93	<0.001	0.21	4	56.66
Dyspnea Score, 0-10	7.06 ± 1.18	5.69 ± 0.70	<0.001	0.75	−1.37	−19.41
Data shown are mean values and standard deviations. $\dot{V}o_{2peak}$, denotes peak oxygen uptake; mL, millilitre; kg, kilograms; min, minute; LVEF, left ventricular ejection fraction; %, percentage; RHR, resting heart rate; bpm, beats per minute; MHR, maximum heart rate; 6-MWD, 6-minute walk distance; m, meter; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale; r-value, correlation coefficient.						

Data shown are mean values. LVEF, left ventricular ejection fraction; %, percentage; Vo_{2peak}, peak oxygen uptake; mL, millilitre; kg, kilograms; min, minute; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale.

Fig. (1): Comparisons between Pre- and Post-measures of Training Group.

Table 3 shows comparisons between the mean pre- and post-measures of Vo_{2peak}, LVEF%, RHR, MHR, 6-MWD, ETD and dyspnea score for the control group. The results showed non significant differences of all measured parameters. (Figure 2)

The table shows that there were positive correlations between pre- and post-measures among the control group, where there were; Vo_{2peak} (r=0.99), LVEF% (r=0.96), RHR (r=0.98), MHR (r=0.71), 6-MWD (r=0.99), ETD (r=0.41) and dyspnea score (r=0.63).

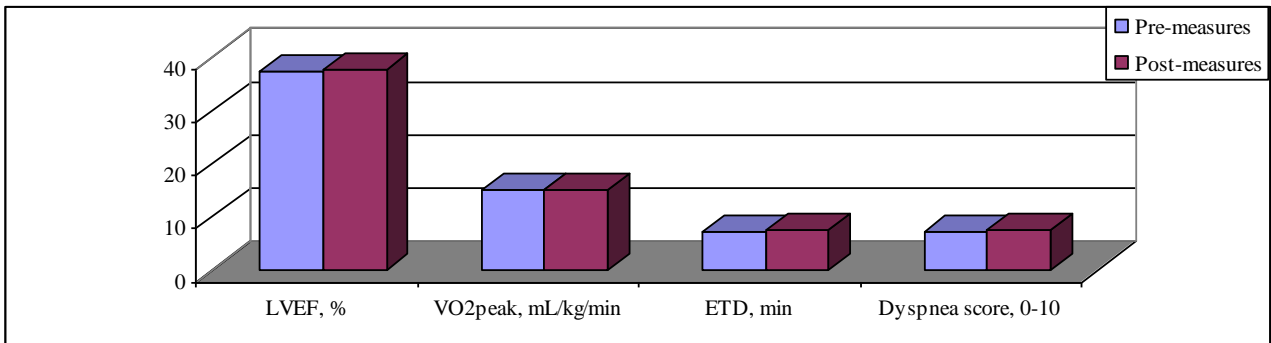Table 3 shows also the mean differences and percentage changes of pre- and post-measures of the studied parameters for control group. The results showed that the mean difference of Vo_{2peak} was −0.03 (mL/kg/min) with a percentage decrease of −0.2%, the mean difference of LVEF% was 0.25 (%) with a percentage increase of 0.67%, the mean difference of RHR was 0.88 (bpm) with a percentage increase of 1.19%, the mean difference of MHR was −0.69 (bpm) with a percentage decrease of −0.51%, the mean difference of 6-MWD was −3.44 (m) with a percentage decrease of −0.95%, the mean difference of ETD was 0.44 (min) with a percentage increase of 6.29% and the mean difference of dyspnea score was 0.19 with a percentage increase of 2.64%.

Table (3): Pre- and Post- Measures for Control Group.

Variables	Pre-measures	Post-measures	P-value	r-value	Mean Difference	% Change
Vo_{2peak}, mL/kg/min	14.96 ± 0.97	14.93 ± 0.98	0.5	0.99	−0.03	−0.2
LVEF, %	37.44 ± 1.75	37.69 ± 1.74	0.7	0.96	0.25	0.67
RHR, bpm	74.25 ± 8.88	75.13 ± 8.31	0.78	0.98	0.88	1.19
MHR, bpm	134.25 ± 8.16	133.56 ± 5.33	0.16	0.71	−0.69	−0.51
6-MWD, m	362.38 ± 39.89	358.94 ± 36.90	0.8	0.99	−3.44	−0.95
ETD, min	7.0 ± 0.73	7.44 ± 0.89	0.14	0.41	0.44	6.29
Dyspnea Score, 0-10	7.19 ± 1.17	7.38 ± 0.81	0.42	0.63	0.19	2.64

Data shown are mean values and standard deviations. Vo_{2peak}, denotes peak oxygen uptake; mL, millilitre; kg, kilograms; min, minute; LVEF, left ventricular ejection fraction; %, percentage; RHR, resting heart rate; bpm, beats per minute; MHR, maximum heart rate; 6-MWD, 6-minute walk distance; m, meter; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale; r-value, correlation coefficient.

Data shown are mean values. LVEF, left ventricular ejection fraction; %, percentage; Vo_{2peak}, peak oxygen uptake; mL, millilitre; kg, kilograms; min, minute; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale.

*Fig. (2): Comparisons between Pre- and Post-measures of Control Group.*

On comparing the mean post-measures of Vo_{2peak}, LVEF%, RHR, MHR, 6-MWD, ETD and dyspnea score between the training and control groups, the results showed significant differences, where it was 17.28 ± 1.15 vs. 14.94 ± 0.95 (mL/kg/min) for Vo_{2peak}, 41.44 ± 1.63 vs. 37.69 ± 1.74 (%) for LVEF%, 67.31 ± 5.84 vs. 75.13 ± 8.31 (bpm) for RHR, 139.94 ± 9.60 vs. 133.56 ± 5.33 (bpm) for MHR, 410.88 ± 28.76 vs. 358.94 ± 36.90 (m) for 6-MWD, 11.06 ± 0.93 vs. 7.44 ± 0.89 for ETD and 5.69 ± 0.70 vs. 7.38 ± 0.81 for dyspnea score. (Table 4 and figure 3)

Table (4): Comparisons of Post-measures between Training and Control Groups.

Variables	Vo_{2peak}, mL/kg/min	LVEF, %	RHR, bpm	MHR, bpm	6-MWD, m	ETD, min	Dyspnea Score, 0-10
Training Group	17.28 ± 1.15	41.44 ± 1.63	67.31 ± 5.84	139.94 ± 9.60	410.88 ± 28.76	11.06 ± 0.93	5.69 ± 0.70
Control Group	14.94 ± 0.95	37.69 ± 1.74	75.13 ± 8.31	133.56 ± 5.33	358.94 ± 36.90	7.44 ± 0.89	7.38 ± 0.81
P-value	$P<0.001$	$P<0.001$	0.004	0.03	$P<0.001$	$P<0.001$	$P<0.001$

Data shown are mean values and standard deviations. Vo_{2peak}, denotes peak oxygen uptake; mL, millilitre; kg, kilograms; min, minute; LVEF, left ventricular ejection fraction; %, percentage; RHR, resting heart rate; bpm, beats per minute; MHR, maximum heart rate; 6-MWD, 6-minute walk distance; m, meter; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale.
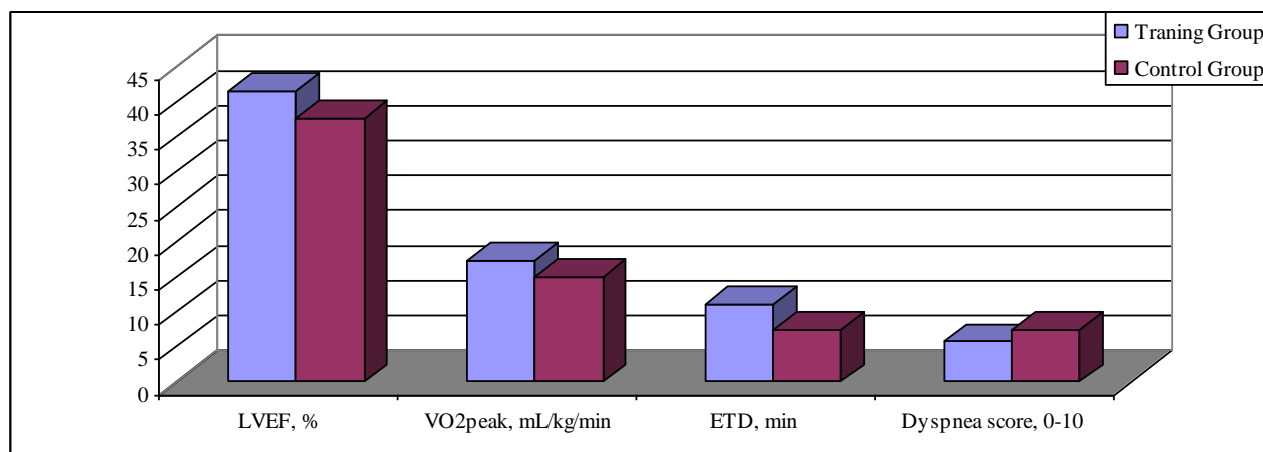
Data shown are mean values. LVEF, left ventricular ejection fraction; %, percentage; $\mathrm{Vo_{2peak}}$, peak oxygen uptake; mL, millilitre; kg, kilograms; min, minute; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale.

Fig. (3): Comparisons of Post-measures between Training and Control Groups.

Table 5 shows the correlations between post-measures for the training group. The results showed that there were positive correlations between; $\mathrm{Vo_{2peak}}$ and ETD (r=0.35), between $\mathrm{Vo_{2peak}}$ and 6-MWD (r=−0.15), between $\mathrm{Vo_{2peak}}$ and LVEF% (r=0.51), between ETD and MHR (r=0.2), between ETD and LVEF% (r=0.11), between MHR and 6-MWD (r=0.006), between MHR and LVEF% (r=0.23), and between 6-MWDand LVEF% (r=0.57). The results showed also that there were negative correlations between; $\mathrm{Vo_{2peak}}$ and MHR (r=−0.05) and between ETD and 6-MWD (r=−0.26).

Table (5): Correlation Coefficient among the Post-measures for the Training Group.

Variables	$\mathrm{Vo_{2peak}}$, mL/kg/min	ETD, min	MHR, bpm	6-MWD, m
ETD, min	0.35	-----	-----	-----
MHR, bpm	−0.05	0.2	-----	-----
6-MWD, m	0.15	−0.26	0.006	-----
LVEF, %	0.51	0.11	0.23	0.57
Data shown are mean values and standard deviations. LVEF, denotes left ventricular ejection fraction; %, percentage; RHR, resting heart rate; bpm, beats per minute; MHR, maximum heart rate; $\mathrm{Vo_{2peak}}$, peak oxygen uptake; mL, millilitre; min, minute; 6-MWD, 6-minute walk distance; m, meter; ETD, exercise test duration; Dyspnea Score, modified Borg dyspnea scale.				

DISCUSSION

Our current study demonstrated that a relatively short term (12 weeks) supervised exercise program significantly improves exercise tolerance in CHF patients (NYHA class II, III). The main findings of this study were the significant increase in $\mathrm{Vo_{2peak}}$, LVEF%, 6-MWD and ETD for patients of the training group. Another important finding is that $\mathrm{Vo_{2peak}}$ is positively correlated with ETD, 6-MWD and LVEF% in these patients.

Several studies[13,26-30] proved that physical training in HF improves exercise

performance expressed as exercise duration or $\dot{V}o_{2peak}$ and showed training to be safe.

Increases in $\dot{V}o_{2peak}$ have been consistently reported with exercise training, and has been used as proof of the efficacy of training programs[31]. In this study, $\dot{V}o_{2peak}$ showed a significant increase in the training group with a percentage increase of 15.2% after practicing the exercise program. Theoretically, the underlying mechanisms responsible for the increase in $\dot{V}o_{2peak}$ can be divided into mechanisms responsible for improvement in cardiac output and factors that improve oxygen extraction[16]. However, results of Papazachou et al[18] indicated that respiratory muscles' dysfunction seemed to play the main role in the reduction of $\dot{V}o_{2peak}$ during exercise and was related to the exercise intolerance of these patients. It was reported that regular exercise improves efficiency of oxygen utilization at the tissue level, thus reducing the workload of the heart in the role of oxygen delivery to end organs and muscles[32].

The results showed a significant increase of LVEF% in the training group, with a percentage increase of 11.25% which indicated an improvement of left ventricular function as the result of practicing the exercise program. Austin et al[26] demonstrated that cardiac rehabilitation focusing on exercise training in stale CHF patients was associated with reduction of peripheral resistance and results in significant improvements in stroke volume and LVEF%. However, Fukuta and Little[6] reported that abnormal left ventricular filling dynamics and impaired relaxation existed in patients with HF regardless of ejection fraction and were related to the reduced exercise tolerance, severity of HF, and prognosis.

The results showed also a positive correlation between $\dot{V}o_{2peak}$ and LVEF% in the training group as the result of practicing the exercise program. It was reported by Davis et al[21] that decreased LVEF% and increased left ventricle size were associated with decreased $\dot{V}o_{2peak}$ in HF patients. The results of this study clearly demonstrated that the improvement in left ventricular functions was associated with an improvement in $\dot{V}o_{2peak}$.

The results of this study also demonstrated that supervised exercise program could improve symptoms, such as dyspnea perception, in patients of the training group. This benefit was associated by the improvement of functional capacity and physical performance as established by the significant increase in duration of submaximal exercise test as proved by the 6-MWD, where the distance walked in 6 minutes increased by 41.5 (m) with a percentage increase of 11.24%. The ability to walk for a distance is a quick and inexpensive performance-based measure, and an important component of quality of life, since it reflects the capacity to undertake day-to-day activities or, conversely, functional limitation[17].

Following completion of the exercise program, patients from the training group demonstrated a lower RHR compared to controls. These findings are similar to those described by Carter et al[33] who reported that adaptive responses of the heart to endurance training was indicated by resting bradycardia, so that it might be used as therapy to improve autonomic activity. In this study, MHR was increased significantly in the training group after practicing the exercise program which is augmented with other studies[33,34] that demonstrated that exercise training resulted in an increase in MHR which reflected improvement in cardiac performance.

Because agreement on a universal exercise prescription for HF patients does not exist, an individualized approach is recommended. Therefore, all stable patients with HF should be encouraged to participate in

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a supervised, simple exercise program[24]. In the present study no adverse events occurred during the exercise training, and all patients in the training group completed the three month exercise program. These results could indicate that supervised exercise program was safe for our HF patients. The results of this study are in agreement with other studies[9,35] that reported than even a relatively short-term (18 weeks) hospital-based supervised exercise program significantly improved exercise tolerance and hemodynamic parameters in severe CHF patients with a relatively safe profile assessed by a longer 6-MWD and $\dot{V}o_{2peak}$.

A home walking exercise program for patients with stable CHF is safe, well accepted, and effective in improving functional status and global perception of symptoms and was considered as a complementary aspect for the supervised exercise program[36-38].

Conclusion

In the current study, although patients with stable CHF from both training and control groups had reduced baseline exercise tolerance, a supervised exercise program significantly increased exercise tolerance as assessed by improvement in $\dot{V}o_{2peak}$, LVEF%, 6-MWD and cardiopulmonary exercise test duration in the training group.

REFERENCES

1- Chronic Heart Failure: National Clinical Guideline for Diagnosis and Management in Primary and Secondary Care. Full version of National Institute for Health and Clinical Excellence (NICE) Guideline, No. 5, 2003.

2- De Keulenaer, G.W. and Brutsaert, D.L.: Systolic and diastolic heart failure: Different phenotypes of the same disease? Eur Heart J., 9: 136-143, 2007.

3- Frazier, C.G., Alexander, K.P., Newby, L.K., Anderson, S., Iverson, E., Packer, M., Cohn, J., Goldstein, S. and Douglas, P.S.: Associations of Gender and Etiology with Outcomes in Heart Failure with Systolic Dysfunction. J Am Coll Cardiol., 49(13): 1450-1458, 2007.

4- Barnes, S., Gott, M., Payne, S., Parker, C., Seamark, D., Gariballa, S. and Small, N.: Prevalence of Symptoms in a Community-Based Sample of Heart Failure Patients. J Pain Symptom Manage, 32(1): 208-216, 2006.

5- Chwan, A.C., Wong, H.S., Yong, A.S. and Sindone, A.P.: Impact of gender on outcomes in chronic systolic heart failure. Int J Cardiol., 117(2): 214-221, 2007.

6- Fukuta, H. and Little, W.: Contribution of Systolic and Diastolic Abnormalities to Heart Failure with a Normal and a Reduced Ejection Fraction. Prog Cardiovasc Dis., 49(4): 229-240, 2007.

7- Ventura-Clapier, R., Mettauer, B. and Bigard, X.: Beneficial effects of endurance training on cardiac and skeletal muscle energy metabolism in heart failure. Cardiovasc Res., 73: 10-18, 2007.

8- Williams, A.D., Selig, S., Hare, D.L., Hayes, A., Krum, H., Patterson, J., Geerling, R.H., Toia, D. and Carey, M.F.: Reduced exercise tolerance in CHF may be related to factors other than impaired skeletal muscle oxidative capacity. J Card Fail, 10(2): 141-148, 2004.

9- Freimark, D., Shechter, M., Schwamenthal, E., Tanne, D., Elmaleh, E., Shemesh, Y., Motro, M. and Adler, Y.: Improved exercise tolerance and cardiac function in severe chronic heart failure patients undergoing a supervised exercise program. Int J Cardiol., 116: 309-314, 2007.

10- Bennett, J., Riegel, B., Bittner, V. and Nichols, J.: Validity and reliability of the NYHA classes for measuring research outcomes in patients with cardiac disease. Heart Lung, 31: 262-270, 2002.

11- Jonsdottir, S., Andersen, K.K., Sigurosson, A.F. and Sigurosson, S.B.: The effect of physical training in chronic heart failure. Eur J Heart Fail, 8(1): 97-101, 2006.

12- Ghio, S., Freemantle, N., Serio, A., Magrini, G., Scelsi, L., Pasotti, M., Cleland, J. and Tavazzi, L.: Baseline echocardiographic characteristics of heart failure patients enrolled in a large European Multicentre trial (CArdiac REsynchronisation heart failure study). Eur J Echocardiogr, 7(5): 373-378, 2006.

13- Senden, P.J., Sabelis, L.W., Zonderland, M.L., Hulzebos, E.H., Bol, E. and Mosterd, W.L.: The effect of physical training on workload, upper leg muscle function and muscle areas in patients with chronic heart failure. Int J Cardiol., 100(2): 293-300, 2005.

14- Regitz-Zagrosek, V., Brokat, S. and Tschope, C.: Role of Gender in Heart Failure with Normal Left Ventricular Ejection Fraction. Prog Cardiovasc Dis., 49(4): 241-251, 2007.

15- Chinnaiyan, K.M., Alexander, D., Maddens, M. and McCullough, P.: Curriculum in cardiology: Integrated diagnosis and management of diastolic heart failure. Am Heart J., 153(2):189-200, 2007.

16- van Tol, B.A., Huijsmans, R.J., Kroon, D.W., Schothorst, M. and Kwakkel, G.: Effects of exercise training on cardiac performance, exercise capacity and quality of life in patients with heart failure: A meta-analysis. Eur J Heart Fail, 8(8): 841-850, 2006.

17- American Thoracic Society and American College of Chest Physicians. ATS/ACCP Statement on Cardiopulmonary Exercise Testing, Am J Respir Crit Care Med., 167: 211-277, 2003.

18- Papazachou, O., Anastasiou-Nana, M., Sakellariou, D., Tassiou, A., Dimopoulos, S., John, J., Maroulidis, G., Drakos, D., Roussos, C. and Nanas, S.: Pulmonary function at peak exercise in patients with chronic heart failure. Int J Cardiol., 118: 28-35, 2007.

19- Witte, K.K. and Clark, A.L.: Why does chronic heart failure cause breathlessness and fatigue? Prog Cardiovasc Dis., 49(5): 366-384, 2007.

20- Colonna, P., Sorino, M., D'Agostino, C., Bovenzi, F., De Luca, L. and Arrigo, F.: Nonpharmacologic care of heart failure: counseling, dietary restriction, rehabilitation, treatment of sleep apnea, and ultrafiltration. Am J Cardiol., 91(9): 41-50, 2003.

21- Davis, R.C., Hobbs, F.D.R., Kenkre, J.E., Roalfe, A.K., Hare, R., Lancashire, R.J. and Davies, M.K.: Prevalence of left ventricular systolic dysfunction and heart failure in high risk patients: community based epidemiological study. BMJ, 325: 1156-1160, 2002.

22- Caldwell, M.A., Peters, K.J. and Dracup, K.A.: A simplified education program improves knowledge, self-care behavior, and disease severity in heart failure patients in rural settings. Am Heart J., 150(5): 983.e7-983.e12, 2005.

23- Whellan, D.J., O'Connor, C.M., Lee, K.L., Keteyian, S.J., Cooper, L.S., Ellis, S.J., Leifer, E.S., Kraus, W.E., Kitzman, D.W. and on behalf of the HF-ACTION Trial Investigators. Heart Failure and A Controlled Trial Investigating Outcomes of Exercise Training (HF-ACTION): Design and rationale. Am Heart J., 53(2): 201-211, 2007.

24- Pina, I.L., Apstein, C.S., Balady, G.J., Belardinelli, R., Chaitman, B.R., Duscha, B.D., Fletcher, B.J., Fleg, J.L., Myers, J.N. and Sullivan, M.J.: Exercise and Heart Failure. A Statement from the American Heart Association Committee on Exercise, Rehabilitation, and Prevention. Circulation, 107: 1210-1225, 2003.

25- The Task Force for the diagnosis and treatment of CHF of the European Society of Cardiology. Guidelines for the diagnosis and treatment of chronic heart failure. Eur Heart J., 10: 1093-1037, 2005.

26- Austin, J., Williams, R., Ross, L., Moseley, L. and Hutchison, S.: Randomized controlled trial of cardiac rehabilitation in elderly patients with heart failure. Eur J Heart Fail, 7(3): 411-417, 2005.

27- Tenenbaum, A., Ahron, D.F., Koren-Morag, N., Schwamenthal, E., Fisman, E.Z., Shechter, M., Tanne, D., Kachlon, D., Motro, M. and Adler, Y.: Long-term versus intermediate-term supervised exercise training in advanced heart failure: Effects on exercise tolerance and

mortality. Int J Cardiol., 113(3): 364-370, 2006.

28- Lloyd-Williams, F., Mair, F.S. and Leitner, M.: Exercise training and heart failure: a systematic review of current evidence. Brit J Gen Pract., 52: 47-55, 2002.

29- Keteyian, S.J., Duscha, B.D., Brawner, C.A., Green, H.J., Marks, C.R., Schachat, F.H., Annex, B.H. and William, E.: Kraus. Differential effects of exercise training in men and women with chronic heart failure. Am Heart J., 145: 912-918, 2003.

30- Marwick, T.H. and Wong, C.Y.: Role of Exercise and Metabolism in Heart Failure with Normal Ejection Fraction. Prog Cardiovasc Dis., 49: 263–274, 2007.

31- Smart, N., Haluska, B., Jeffriess, L. and Marwick, T.: Exercise training in systolic and diastolic dysfunction: Effects on cardiac function, functional capacity, and quality of life. Am Heart J., 153(3): 530-536, 2007.

32- LeMaitre, J.P., Harris, S., Hannan, J., Fox, K.A. and Denvir, M.A.: Maximum oxygen uptake corrected for skeletal muscle mass accurately predicts functional improvements following exercise training in chronic heart failure. Eur J Heart Fail, 8(3): 243-248, 2006.

33- Carter, J.B., Banister, E.W. and Blaber, A.P.: Effect of Endurance Exercise on Autonomic Control of Heart Rate. Sports Med., 33(1): 33-46, 2003.

34- Revill, S.M., Beck, K.E. and Morgan, M.L.: Comparison of the Peak Exercise Response Measured by the Ramp and 1-min Step Cycle Exercise Protocols in Patients with Exertional Dyspnea. Chest, 121: 1099-1105, 2002.

35- Meyer, T., Gorge, G., Schwaab, B., Hildebrandt, K., Walldorf, J., Schafer, C., Kindermann, I., Scharhag, J. and Kindermann, W.: An alternative approach for exercise prescription and efficacy testing in patients with chronic heart failure: A randomized controlled training study. Am Heart J., 149(5): 926.e1-926.e7, 2005.

36- Corvera-Tindel, T., Doering, L.V., Woo, M.A., Khan, S. and Dracup, K.: Effects of a home walking exercise program on functional status and symptoms in heart failure. Am Heart J., 147(2): 339-346, 2004.

37- van den Berg-Emons, R.J., Bussmann, J.B., Balk, A.H. and Stam, H.J.: Factors associated with the level of movement-related everyday activity and quality of life in people with chronic heart failure. Phys Ther., 85: 1340-1348, 2005.

38- Fang, Z.Y. and Marwick, T.H.: Mechanisms of exercise training in patients with heart failure. Am Heart J., 145(5): 904-911, 2003.

الملخص العربي

دور ممارسة برنامج تمرينات مراقب على درجة التحمل البدني لدى مرضى فشل القلب المزمن المستقر

يعتبر مرض فشل القلب من المشاكل الصحية المتزايدة ويمثل مرض تصلب الشرايين التاجية وارتفاع ضغط الدم من أهم أسباب حدوث المرض في كبار السن . من أهم الأعراض المصاحبة لهذا المرض ضيق التنفس والشعور بالتعب عند بذل المجهود مما يمثل إعاقة للمريض في مزاولة أعماله اليومية . أجريت هذه الدراسة على اثنين وثلاثين مريضا متوسط أعمارهم 67.94 ± 3.64 عاما ممن يعانون من مرض فشل القلب المزمن المستقر . تم فحص المرضى بواسطة طبيب القلب وتم تشخيص المرض عن طريق الفحص الإكلينيكي وإجراء الأشعة السينية للصدر وتخطيط القلب وتحاليل دم خاصة للتشخيص. تم استخدام جهاز الموجات فوق الصوتية للقلب لتأكيد التشخيص وقياس نسبة تدفق الدم من البطين الأيسر مع كل نبضه . تم قياس مستوى التحمل البدني للمرضى عن طريق اختبار المشي لمدة ستة دقائق واختبار التحمل البدني باستخدام الدراجة الثابتة مع قياس أقصى استهلاك للأكسجين في الدقيقة وتم تحديد مستوى الإحساس بضيق التنفس أثناء المجهود باستخدام المقياس المعدل لبورج. تم تحديد العلاج الدوائي الأمثل لكل مريض بواسطة الطبيب المعالج . تم تقسيم المرضى على مجموعتين متجانستين ، مجموعة التمرينات ومجموعة التحكم كل مجموعة مكونة من ستة عشر مريضا . في مجموعة التمرينات تم تنفيذ برنامج تمرينات مصمم لمرضى فشل القلب تحت إشراف أخصائي العلاج الطبيعي لمدة ثلاثة أشهر بواقع ثلاث جلسات أسبوعيا . تم إجراء فحص الموجات فوق الصوتية للقلب واختبار المشي لمدة ستة دقائق واختبار التحمل البدني باستخدام الدراجة الثابتة وتحديد أقصى استهلاك الأكسجين وتحديد مستوى الإحساس بضيق التنفس وذلك بعد انتهاء برنامج التمرينات . تم جمع البيانات وعمل الإحصاءات الطبية اللازمة ووجد أن هناك تحسن ذو دلالة إحصائية في نسبة تدفق الدم من البطين الأيسر مع كل نبضه وأقصى استهلاك للأكسجين في الدقيقة وزيادة مسافة اختبار المشي لمدة ستة دقائق وزيادة وقت اختبار التحمل البدني في مجموعة التمرينات . ووجد هناك ارتباط ايجابي بين أقصى معدل استهلاك للأكسجين في الدقيقة ونسبة تدفق الدم من البطين الأيسر مع كل نبضه وزيادة مسافة اختبار المشي لمدة ستة دقائق وزيادة وقت اختبار التحمل البدني في مجموعة التمرينات . أثبتت هذه الدراسة أهمية ممارسة برنامج تمرينات مخصص لمرضى فشل القلب المزمن المستقر تحت إشراف أخصائي العلاج الطبيعي في تحسن مستوى التحمل البدني .