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Effect of Aerobic Training on Ventricular Remodeling After Percutaneous Coronary Intervention

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Abstract

Background: Coronary artery disease (CAD) is one of the most common causes of morbidity and mortality in different communities worldwide, and impair the patient?s quality of life (QoL). Left ventricular ejection fraction (LVEF) as a clinical index of myocardial contractility and its pumping action is a well established predictor of mortality and long term prognosis in acute myocardial infarction (AMI). Exercise training in post event CAD patients could significantly improve not only the myocardial contractility in terms of LVEF but also could be effectively and safely used with low risk and moderate risk CAD patients. The aim of this study was to determine the effect of exercise training on ventricular remodeling and QoL after percutaneous coronary intervention (PCI). Subjects and Methods: Sixty patients of both sexes had been recruited from National Heart Institute (NHI), Cairo, Egypt. All patients were within the first year after PCI. They were randomly assigned to 2 groups equal in numbers. Study group was 30 patients (21 men and 9 women, mean age was 52.2 ± 4.9 years) that had been received aerobic moderate intensity exercise training on bicycle ergometer for 50 minutes, 3 times/week, day after day, for 3 months, while control group was 30 patients (20 men and 10 women, mean age was 53.4 ± 4.8 years) that had been received the traditional cardiac care without any exercise training in form of routine pharmacological therapy and lifestyle education. Doppler echocardiography was used to measure LVEF, left ventricle end diastolic diameter (LVEDD) and left ventricle end systolic diameter (LVESD), and Nottingham health profile (NHP) questionnaire was used to measure differences in QoL between both groups. Both measurements were done before and after the study. Results: After completion of the study, a significant increase was observed in LVEF ($P < 0.05$), without any significant changes in LVEDD and LVESD, also, improvement in QoL were observed in the study group (

Index terms— aerobic exercise, left ventricular ejection fraction, percutaneous coronary intervention, quality of life.

Subjects and Methods: Sixty patients of both sexes had been recruited from National Heart Institute (NHI), Cairo, Egypt. All patients were within the first year after PCI. They were randomly assigned to 2 groups equal in numbers. Study group was 30 patients (21 men and 9 women, mean age was 52.2 ± 4.9 years) that had been received aerobic moderate intensity exercise training on bicycle ergometer for 50 minutes, 3 times/week, day after day, for 3 months, while control group was 30 patients (20 men and 10 women, mean age was 53.4 ± 4.8 years) that had been received the traditional cardiac care without any exercise training in form of routine pharmacological therapy and lifestyle education. Doppler echocardiography was used to measure LVEF, left ventricle end diastolic diameter (LVEDD) and left ventricle end systolic diameter (LVESD), and Nottingham health profile (NHP) questionnaire was used to measure differences in QoL between both groups. Both measurements were done before and after the study.

Results: After completion of the study, a significant increase was observed in LVEF ($P < 0.05$), without any significant changes in LVEDD and LVESD, also, improvement in QoL were observed in the study group ($P < 0.05$) when compared to control group.

1 I. Introduction

oronary artery disease is one of the most common causes of morbidity and mortality in different communities worldwide, and impair the patient's QoL. 1 Various echocardiographic parameters have been shown cardiac dysfunction in CAD patients, such as left ventricular volumes and EF which are strongly related to prognosis of cardiac diseases. 2 LVEF as a clinical index of myocardial contractility and its pumping action is a well established predictor of mortality and long term prognosis in AMI. 3 Many published studies of heart failure patients underwent PCI commonly have a reduced LVEF when compared with normal. 4 Pooled data from clinical trials have shown significant improvement in LVEF after exercise training in patients after PCI. 5 The Exercise in left ventricular dysfunction study reported that 3 months exercise training improved LVEF significantly in patients after PCI, furthermore, this result was confirmed after 3 months exercise in patients after AMI who had undergone successful PCI. LVEF during exercise was significantly improved. 5 However, exercise training is the core component of cardiac rehabilitation (CR) and secondary prevention of CAD, there is an evidence regarding the effectiveness of exercise training on LVEF in patients with CAD who received PCI, an early (within 1 month post discharge) 12 weeks structured exercise training program in post event CAD patients could significantly improve not only the myocardial contractility in terms of LVEF but also could be effectively and safely used with low risk and moderate risk CAD patients. 4 It has been widely shown that exercise based CR in patients with AMI and PCI has several beneficial effects on cardiovascular functional capacity, QoL, risk factors modification, psychological profile and mortality. 6 The degree of ventricular remodelling was regarded as an important prognostic factor associated with cardiac function after AMI, and an increasing number of studies have shown that, in patients with AMI with left ventricular dysfunction, exercise training did not worse ventricular remodelling, and may even prevent this spontaneous deterioration. 7 In cardiac patients, QoL was evaluated on the basis of objective clinical criteria such as mortality, morbidity, angina, complication rates, test results, or simple indicators such as return to work or repeated hospitalizations. 8 This approach ignored the fact that cardiac disease is a life threatening disease and the operation in itself leads, regardless of the result, to changes in patients' psychosocial and social functioning. 8 It also must be realized that QoL is not only an outcome indicator but may itself be a factor that affects health, illness and coping. 8 Poor QoL has been associated with poorer outcomes, such as lower survival rates, increases in the number of hospitalizations, decreased capacity to perform activities of daily living, and decreased compliance with treatments in other populations like cardiac patients. 9 The most commonly sensitive generic instruments in heart disease are the NHP (used in approximately 40% of studies). 10 The NHP is a well validated test, which has been used previously for assessment of QoL before and after cardiac events. 10

2 II. Patients and Methods

This study was conducted in physiotherapy department of NHI, Cairo, Egypt. 60 Patients of both sexes, their ages were 45-60 years old, within the first year after PCI, their BMI was 30-34.9 Kg/m 2 (class I obesity), were selected and assigned to 2 equal groups in numbers. The study group (30 patients, 21 men and 9 women) that had been received aerobic moderate intensity exercise training on bicycle ergometer 3times/week for 3 months, while the control group (30 patients, 20 men and 10 women) that had been received the traditional cardiac care without any exercise training in form of routine pharmacological therapy and lifestyle education.

Exclusion criteria were patients with Postinfarction, residual myocardial ischaemia, severe ventricular arrhythmias, atrioventricular block, hypertrophic cardiomyopathy, valvular disease requiring surgery, pericarditis, acute systemic illness or fever, severe renal dysfunction (i.e. Creatinine > 2.5 mg/dl), severe orthopaedic problems, such as osteoarthritis of both knees, other metabolic problems, such as diabetes mellitus, acute thyroiditis, hypokalaemia, hyperkalaemia and hypovolaemia.

Before starting the study, a meeting was done for all patients to record demographic data, Doppler echocardiography was used to measure LVEF, LVEDD, LVESD, and NHP questionnaire was used to measure QoL presented with each patient. In that stage a face to face instructions and administration of NHP questionnaire to all participants was given, and if the patient was not sure whether to say "yes" or "no" to a problem, they were instructed to answer the one more true at that time. All patients were taking their prescribed medications by their cardiologists.

Participants in the CR program were requested to attend their exercise program 3 times/week, day after day, for a period of 3 months. Moderate intensity aerobic exercise is prescribed based on Borg's rating of perceived exertion (BRPE) scale. The scale is comprised of 15 points where a rating of 6 means no exertion and a rating of 20 means maximal exertion. 11 Patients are encouraged to achieve a rating between 11 (fairly light) and 14 (hard), with training heart rate (60-70% of maximal heart rate). Target heart rate using karvonen method, taking into account the resting heart rate, is calculated as follows: {[(220-age) or (210-age)-resting heart rate]x(60-70)}+ resting heart rate. 12 For participants in the CR program involved in this study, each exercise session is comprised of 5 to 10 minutes warming up and 5 to 10 minutes cooling down, with active phase of approximately 30 minutes

of aerobic exercise training. Aerobic exercise was the dominant mode of exercise which implemented using a bicycle ergometer in the CR program. After 3 months, LVEF, LVEDD, LVESD were measured, and also NHP questionnaire were applied again.

Data were analyzed with SPSS software version 17. The level of significance was set at $P < 0.05$. Paired t-test was applied for each group to compare pre and post values within the same group. Unpaired t-test was applied to compare pre and post values between both groups of the study.

3 III. Results

Base line measurements had shown no statistical significant differences between both groups (P>0.05). The baseline and final values of each group (Table **??**) had shown highly significant increase in LVEF (P<0.000) in the study group but, LVEDD and LVESD did not change significantly (P>0.05). The control group did not show any significant changes in LVEF, LVEDD, and LVESD (P>0.05). Results of LVEF were improved significantly in the study group when compared with the control group after the program (P<0.002).

As shown in (table 2) the six domains of NHP questionnaire of the study group had improved highly significantly (P<0.000). The control group did show significant improves (P>0.05). All domains of NHP questionnaire were improved significantly in the study group when compared with the control group after the program (P<0.05).

4 Volume XV Issue VI Version I

5 IV. Discussion

In this study, the LVEF significantly increased from 56.6±6.8 % at the beginning of the study to 59.6±6.9 % after 3 months of CR program (P<0.05), while no significant changes were observed in the LVEDD and LVESD when compared between those at the onset and those at three months after rehabilitation.

Results of the study were supported by Mohammad et al. baseline LVEF in the study group was 46.9 ± 5.9 and in the control group was 47.9 ± 7.0, there was a significant improvement in LVEF after 12 weeks of exercise training in the study group (46.9 ± 5.9 to 61.5 ± 5.3) compared with the control (47.9 ± 7.0 to 47.6± 6.9) group (P=0.001), Also, he concluded that a structured individually tailored home based training program could be as effective as center based programs and safely used not only in low risk but also in moderate risk CAD patients. 4 Agreed with these results, Huan et al. had showed that 6 months exercise training increased LVEF in study group more than controls, and LVESD and LVEDD decreased in the exercise group but increased in the control group, which suggested that, to a certain extent, exercise could prevent ventricular remodeling in patients after AMI. 6 These findings are in consistent with results from Haddadzadeh et al. that found similar effects with exercise training program in post event CAD patients that significantly improved the myocardial contractility in terms of LVEF. 13 Going with the same line Masoumeh et al. reported that CR had positive effects on patients with EF of about less than 50% that was improved significantly after CR program, Moreover, peak exercise capacity was significantly improved, Also, LVESD and LVEDD had no clinical or statistical change after the program. 2 The results show that, among the patients with LV dysfunction, exercise based rehabilitation is beneficial and has no detrimental effects on ventricular remodeling. 2 Agreed with this study results, Soleimannejad et al. demonstrated that LVEF improved significantly after PCI (with or without the CR exercise program), however, the effect of the CR exercise program on chamber diameters, i.e. LVEDD, LVESD were neutral. 14 Agreed with these results, Sherin et al. in NHI in Egypt, but in dilated cardiomyopathy patients, there was high statistical significant increase in peak VO2, EF, diastolic dysfunction, resting and maximal heart rates after intervention only in the training group. 15 There was no significant change in any parameter within the control group, as for comparison between both groups; there was high significant difference in peak VO2, resting heart rate and EF after intervention, and the number of patients in the training group with normal diastolic pattern was zero before training, while it was 8 (53.3%) after training. 15 Supporting this study results Giallauria et al. showed that 6-month exercise based CR induced a combined reverse left atrial and LV remodeling as well as significant improvement in exercise functional capacity, LVEF, and early LV diastolic filling. 16 In contrast to this study results Chul et al. reported that, in a follow up observation of 70 patients diagnosed with AMI from the fourth day of onset for three years, 14 (20%) showed widening in diameter of the left ventricle, a phenomenon that may ultimately cause severe left ventricular failure. 17 Also, they reported that 12 week CR exercise on 13 patients with AMI of around 16 weeks after onset showed reduction in motility of the myocardial wall and LVEF in echocardiography. 17 Also, Kubo et al. investigated the effects of 3 months exercise training on ventricular remodeling after extensive anterior AMI with LVEF < 45% and found that control group patients' LV diastolic volume index and LV systolic volume index improved, but there was no change in the rehabilitation group. 18 Conversely, Otsuka et al. reported that early exercise training did not deteriorate ventricular remodeling in mild, moderate and severe left ventricular dysfunction in his patients. 19 In a similar study by Jiang et al. they reported that LV diastolic diameter increased in the control group, but not in the exercise group, after 3 months' exercise training. 5 The results obtained in the present study revealed a statistical significant differences in six domains of NHP variables (pain, physical mobility, emotional reactions, energy, social isolation and sleep) between control and study groups ($p < 0.05$) that reflected more improvement of QoL for the study group after CR program. Supporting these results, Marzieh et al. reported that after CR, scores of all physical domains of the short form-36

questionnaire (SF-36) including physical function, physical limitation, body pain, vitality in addition to general health were significantly improved in all patients compared to the baseline and showed that physical activity had influenced QoL, so that increasing physical activity improves QoL. 20 Going with the same line, Arrigo et al. had shown that a comprehensive CR improves QoL even one year after the program. 21 Supporting these results Babaee et al. had shown significant difference in QoL (by SF-36 and NHP) between study and control group, significant improvements in QoL between two groups, as measured by the NHP, were seen in energy, pain, emotional reaction, sleep, physical mobility and total average quality of life. 22 Significant improvements in QoL between two groups, as measured by the SF-36, were seen in physical function, role limitations resulting from emotional status, role limitations resulting from physical status, mental health, vitality and total average QoL, and demonstrated that health education resulted in improved QoL for patients with CABG. 22 In consistent with the study results, Yohannes et al. investigated the long term effects of a 6 week CR on physical activity, psychological well being, and QoL in 147 cardiac patients. The results demonstrated the benefits of CR in improving HRQoL and physical activity, and in reducing anxiety and depression. 23 Furthermore, these benefits were maintained at 12 month follow up. 23 However, there were some investigations with different findings; in Serber et al. study, the impact of CR on patients with severe psychological distress was more than others in physical, mental and social aspects of QoL, and showed that QoL was related to primary level of psychological distress of the patients and CR could improve QoL and anxiety just in these group of patients. 24 In contrast Worcester et al. suggested that CR is not sufficiently intensive to influence recovery of QoL. 25 Briffa et al. reported that CR was only found to affect physical function in a recent randomized controlled trial of an 18 session program which compared CR with usual care, but this may be due to short period of his program. 26 There is a significant and positive relationship between CR and changes in QoL domains. Patients started the study with bad QoL scores and demonstrated significant improvement in QoL scores following the completion of the programme. Likewise, the contractility of the heart increased significantly, physical abilities had increased, they reported feeling less pain and were less limited in activities they did before. According to the reports of the investigators in fields related to the present study, it can be concluded that, all participants's QoL scores and LVEF had improved after the intervention. Exercise based rehabilitation is beneficial to improve cardiac contractility and has no detrimental effects on ventricular remodeling.

6 V. Conclusion

It was concluded that aerobic training has a positive effects on improving LVEF in post PCI patients, also QoL domains of NHP questionnaire as pain, physical mobility, emotional reactions, energy, social isolation and sleep were improved, further more CR is a good method that improve cardiac contractility and ejection fraction, and did not have adverse effects on LVEDD and LVESD nor cause severe cardiovascular complications. [1]

Figure 1:

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Variables	Study group			Control group		
	Pre program Mean ±SD	Post program Mean ±SD	P Value	Pre program Mean ±SD	Post program Mean ±SD	P Value
LVEF (%)	56.6±6.8	59.6±6.9	0.000*	54.1±5.9	55.9±6.6	0.3
LVEDD(cm)	5.01±0.32	5.02±0.31	0.89	5.10±0.20	5.13±0.21	0.6
LVESD (cm)	3.49±0.43	3.44±0.42	0.13	3.55±0.47	3.47±0.43	0.15

SD: standard deviation, LVEF: Left ventricular ejection fraction, LVEDD: Left ventricle end-diastolic diame
end-systolic diameter. Significant level: P<0.05*.

Table (2) : Changes of 6 domains of NHP from baseline to the end of the study within each group and betw
groups:

Variables	Study group			Control group		
	Pre program Mean ±SD	Post program Mean ±SD	P Value	Pre program Mean ±SD	Post program Mean ±SD	P Value
Energy level	51.44±16.06	64.24±15.02	0.000*	47.94±15.99	44.77±15.23	0.44
Pain	40.40±21.52	22.17±12.17	0.000*	38.42±23.44	31.95±18.09	0.22
Emotional reaction	26.01±13.26	13.75±7.22	0.000*	23.67±13.97	21.07±13.78	0.48
Sleep	37.22±13.92	22.30±8.46	0.000*	33.51±17.07	28.96±13.00	0.25
Social isolation	37.04±12.12	24.15±9.07	0.000*	34.48±11.76	31.25±11.55	0.31
Physical ability	35.29±15.52	20.23±11.55	0.001*	30.64±16.21	27.58±13.53	0.41

SD=Standard Deviation, Significant level: P<0.05*.

Figure 2: Table (1

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