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Original Article

High intensity interval training exercise as a novel protocol for cardiac rehabilitation program in ischemic Egyptian patients with mild left ventricular dysfunction

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ABSTRACT

Background: Exercise-based Cardiac rehabilitation (CR) plays a major role in reducing mortality and morbidity in patients with coronary artery disease (CAD). The standard protocol is usually of moderate intensity exercise. High-intensity interval training (HIIT) consists of alternating periods of intensive aerobic exercise with periods of passive or active moderate/mild intensity recovery.

Aim: This study aimed to assess HIIT program for ischemic patients attending CR after percutaneous coronary intervention (PCI) who have mild left ventricular dysfunction and to compare its effect on the functional capacity and quality of life with standard exercise CR program.

Patients and methods: Our study included 40 patients with documented CAD, who participated in the outpatient CR program in Ain Shams University hospital (Al-Demerdash Hospital) divided into two equal groups, each included 20 patients. Group A included the patients who underwent standard cardiac rehabilitation program, while group B joined the high intensity interval training exercise protocol.

Results: Groups A and B showed significant improvement in all items of comparison; especially functional capacity, lipid profile and quality of life. Group B showed better improvements in the emotional well-being items of QOL parameters.

Conclusion: We emphasize the positive effects of exercise-based CR program on patients with CAD and mild left ventricular dysfunction after PCI. The novel high intensity cardiac training proved to be safe and at least as beneficial as the standard moderate intensity cardiac training protocols, with better quality of life improvement.

1. Introduction

Hospital-based cardiac rehabilitation (CR) programs are well-established in the effective management of patients during and after acute coronary syndromes (ACS).[1–4] Although exercise training is considered the basis of the CR program, yet comprehensive CR should include education and counseling to improve psychological well-being, to quit cigarette smoking, and to increase adherence to medical treatment and healthy diet.[5]

There is an increasing evidence that CR improves prognosis, as well as morbidity and hospital readmissions in patients with coronary artery disease (CAD). CR also modifies exercise capacity, improves quality of life and psychological well-being and it is now recommended in international guidelines.[6]

Exercise therapy has long been used for rehabilitation purposes following ACS. In a large *meta*-analysis, exercise training as part of cardiac rehabilitation programs was associated with a 26% reduction in cardiac mortality rate in patients with CAD.[2] The magnitude of this benefit is as large as that seen with the post-myocardial infarction (MI) use of beta blockers or with the use of angiotensin converting enzyme (ACE) inhibitors in left ventricular (LV) dysfunction along with MI. Trials that involve exercise alone still show a 15% mortality reduction.[7] Angina significantly improves during the cardiac rehabilitation exercise program. Recurrent infarctions decrease by 17% and the rate of hospitalizations also decreases.[8]

Although CR is an evidence-based form of secondary prevention,[1,2] referral is still suboptimal and participation rates even in developed countries are as low as 10–30%.[9–11] This low

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participation could be attributed to several factors including: transport difficulties, work schedules, social commitments, lack of perceived need, and functional impairment.[12,13]

The recent modality of high-intensity interval training exercise [HIIT] (consists of alternating periods of intensive aerobic exercise with periods of passive or active moderate/mild intensity recovery)[14] has been shown to reduce all-cause mortality in healthy individuals, independently of activity duration, supporting the need to further investigate the health effects of such protocol.[15–17]

Several data suggest that HIIT is safe, well tolerated, efficient and particularly cost effective, thus it could be a promising modality to improve long-term adherence in CR programs.[18,19] Periods of intermittent ischemia could lead to the phenomenon called ischemic preconditioning, provided that exercise intensity at the end of the test is high enough and that the period between the two stress tests is short.[20] It has been recently shown in animal models that intermittent ischemia induced by HIIT fosters the formation of collateral coronary vessels without causing myocardial injury.[21] Furthermore, HIIT has also been shown to improve endothelial function.[22,23] Few previous data showed that HIIT improved left ventricular compliance, and contributed to the increase in systolic ejection volume and cardiac output, compared to lower-limb muscle building alone.[24]

Furthermore, HIIT resulted in a significant improvement in the rate of restenosis in patients after PCI. The preventive effects of exercise on restenosis can be explained by the fact that exercise improves endothelium-dependent vasodilation by activating synthesis of nitric oxide (NO), which increases levels of NO in coronary endothelial cells, resulting in inhibition of the neo-intimal proliferation.[25] In addition, exercise training also attenuates some inflammatory pathways that are potentially contributing to the pathophysiology of restenosis.[26]

Despite the short and long term benefits of HIIT, it has not been widely implemented and was not assessed adequately in higher risk patients such as those with mild LV dysfunction.[27]

Up to our knowledge, no data are available comparing HIIT to standard exercise during CR programs in Egypt or even in the whole region.

The aim of this work was to assess the effects of HIIT during CR after PCI in patients with mild LV dysfunction and to compare its effect on the functional capacity and quality of life with standard exercise CR program.

2. Patients and methods

The present study was conducted on 40 Patients with CAD, age >18 years old of both sexes with **LV ejection fraction (EF) > 35% and less than 50%**, fully revascularized by PCI, on full anti-ischemic treatment, attending the cardiac rehabilitation clinic in the Cardiology department, Ain Shams University Hospital in the period from April 2016 to February 2017. The patients were recruited two weeks after the last percutaneous interventional procedure.

2.1. Exclusion criteria:

- Patients with residual significant ischemia or decompensated heart failure.
- Patients with active cardiac conditions (acute myocarditis, pericarditis and endocarditis,. . .etc.) or debilitating disease preventing them from attending follow–ups (COPD, chronic renal failure, liver cirrhosis . . . etc.).
- Recent or current acute medical condition (e.g. recent pulmonary embolism, recent stroke or transient ischemic attack.
- Patients with contraindication to exercise (e.g. severe aortic stenosis, severe hypertrophic cardiomyopathy, malignant arrhythmias).
- Patients who live in distant rural areas or have no means of transportation and cannot participate regularly in the program.
- Patients with cognitive impairment.

2.2. Methods

In addition to medical evaluation, routine laboratory investigations, 12 lead electrocardiogram (ECG) and transthoracic echocardiography, all subjects underwent initial modified Bruce exercise test to rule out ongoing ischemia and to estimate the training heart rate range according the heart rate reserve. The exercise intensity was based on the heart rate reserve (HRR), and the target Heart rate (THR) calculated according to the Karvonen method[28]

[HRR = peak heart rate - rest heart rate]

[THR = rest heart rate + required percentage of HRR according to protocol]. Cardiac rehabilitation program included education about heart disease and importance of risk factor modification in addition to advices regarding home-based activities.

All patients were asked to fill a quality of life (QOL) questionnaire [RAND 36-Item Health Survey].[29,30] The 36-Item Health Survey taps eight health concepts: physical functioning, bodily pain, role limitations due to physical health problems, role limitations due to personal or emotional problems, emotional well-being, social functioning, energy/fatigue, and general health perceptions. The 36 items were adapted from longer instruments completed by patients participating in the Medical Outcomes Study (MOS).[29,30] The aggregate summary that measures-in addition to general health- physical component and mental (emotional) component, was constructed on the basis of factor analyses of correlations among the eight SF-36 scales.[31]

The patients were randomly assigned into one of the following groups

a. Group A: Prescribed full '2 times weekly' standard moderate intensity exercise cardiac rehabilitation program for 3 months (total of 24 sessions). Exercise consisted of 5 min of warm-up exercises followed by 30–35 min of continuous treadmill exercise at a level of 40–60% of their initial heart rate reserve, and end by 5 min of cool down under medical supervision.
b. Group B: prescribed full '2 times weekly' high intensity exercise cardiac rehabilitation program for 3 months (total of 24 sessions) . Exercise consisted of 5 min of warm-up exercises followed by 30–35 min of continuous exercise [Alternating brief (2–5 min) higher intensity which aiming to reach 85–95% of their initial heart rate reserve and similar time of moderate-intensity workloads throughout an exercise session], and end by 5 min of cool down.

All the patients were compliant to the program with no missing sessions or dropouts. All patients repeated symptom-limited exercise treadmill test to reassess functional capacity after the end of the program, as well as laboratory testing, transthoracic echocardiographic examination and refilling the QOL questionnaire.

2.3. Statistical analysis

Data were collected, revised, coded and entered to the statistical package for social science (SPSS) version 21. Qualitative (categorical) data were presented as number and percentages, Quantitative (continuous) data were presented as mean, standard deviations and student's paired *t*-test. The comparison between

Table 1
The demographic data, risk factors and initial laboratory results of the two groups.

Demographic data/risk factors/labs		Group A	Group B	Independent *t*-test	
		n = 20	n = 20	t	P-value
Age (years)	Mean ± SD	51.95 ± 8.07	54.65 ± 7.63	−1.087	0.284
	Range	38 –67	35–65		
Gender	Male	16 (80%)	18 (90%)	0.784*	0.376
	Female	4 (20%)	2 (10%)		
Weight (Kg)	Mean ± SD	81.00 ± 8.86	84.85 ± 14.14	−1.032	0.309
	Range	58–95	58–114		
Height (cm)	Mean ± SD	166.15 ± 6.13	167.45 ± 6.85	−0.632	0.531
	Range	155–173	155–180		
Hypertension		6 (30%)	7 (35%)	0.114	0.736
Diabetes mellitus		9 (45%)	6 (30%)	0.960	0.327
Dyslipidemia		2 (10%)	3 (15%)	0.229	0.633
Smoking	Non-Smoker	10 (50%)	7 (35%)	1.815	0.404
	Smoker	8 (40%)	8 (40%)		
	Ex-Smoker	2 (10%)	5 (25%)		
s. Creatinine (mg/dl)	Mean ± SD	1.00 ± 0.20	1.27 ± 0.32	−3.127	0.003
	Range	0.70–1.40	0.80–2.20		
Hb (gm/dl)	Mean ± SD	12.18 ± 1.46	12.82 ± 1.35	−1.440	0.158
	Range	8.70–15.20	10.00–15.50		
Platelet count	Mean ± SD	250.40 ± 82.73	244.45 ± 58.17	0.263	0.794
	Range	136–463	155–361		
WBCs ($\times 10^9$/L)	Mean ± SD	7.31 ± 2.20	8.72 ± 2.69	−1.817	0.077
	Range	4.40–14.40	4.10–13.90		
s. Cholesterol (mg/dl)	Mean ± SD	168.25 ± 44.92	185.70 ± 23.46	−1.540	0.132
	Range	97–250	119–220		
LDL (mg/dl)	Mean ± SD	105.95 ± 22.78	94.45 ± 15.41	1.870	0.069
	Range	67–142	59–123		
HDL (mg/dl)	Mean ± SD	40.28 ± 13.91	35.05 ± 4.49	1.599	0.118
	Range	27–95	24–48		
s. TGs (mg/dl)	Mean ± SD	119.35 ± 47.98	138.60 ± 33.47	−1.472	0.149
	Range	36–258	95–212		
Culprit PCI arteries		Group A	Group B	Chi-square test	
		n = 20	n = 20	X^2	P-value
Artery	LAD	14 (70%)	13 (65%)	4.370	0.627
	LCX	1 (5%)	0 (0%)		
	RCA	3 (15%)	3 (15%)		
	LAD, LCX	1 (5%)	2 (10%)		
	LAD, RCA	1 (5%)	0 (0%)		
	LCX, RCA	0 (0%)	1 (5%)		
	LAD, LCX and RCA	0 (0%)	1 (5%)		
Stent type	BMS	15 (75%)	15 (75%)	0.000	1.000
	DES	5 (25%)	5 (20%)		
TIMI flow	3	20 (100%)	20 (100%)	–	–

BMS: bare metal stent, DES: drug-eluting stent Hb: hemoglobin level, HDL: high density lipoprotein cholesterol, LAD: Left anterior descending artery, Lcx: left circumflex artery, LDL: low density lipoprotein cholesterol, PCI: percutaneous coronary angioplasty, RCA right coronary artery, Sd: standard deviation, TIMI flow: Thrombolysis In Myocardial Infarction trial flow grades, TGs: Triglycerides, WBCs = white blood cell count.

Table 2
Comparison between the two groups regarding functional capacity (METS) achieved by exercise test, Left ventricular function assessed by echocardiography and the quality of life questionnaire (RAND score).

Initial Exercise/echocrdiogrphy		Group A	Group B	Independent *t*-test	
		n = 20	n = 20	T	P-value
METS	Mean ± SD	8.35 ± 2.06	7.60 ± 2.14	1.130	0.265
	Range	5–12	5–11		
EF%	Mean ± SD	43.85 ± 5.30	43.30 ± 5.32	0.327	0.745
	Range	35–50	35–50		
QOL questionnaire scores					
General health	Mean ± SD	256.25 ± 29.10	253.75 ± 24.70	0.293	0.771
	Range	200–300	225–300		
Physical function	Mean ± SD	637.50 ± 42.53	625.00 ± 34.41	1.022	0.313
	Range	550–700	550–700		
Emotional wellbeing	Mean ± SD	273.00 ± 31.97	283.00 ± 20.80	−1.173	0.248
	Range	220 –320	240–320		
TOTAL score	Mean ± SD	1781.25 ± 121.37	1832.50 ± 109.85	−1.400	0.170
	Range	1660–2060	1660–2000		

METS: metabolic equivalents, EF: Ejection fraction, QOL: quality of life, SD: standard deviation.

Table 3
Showing the results of group A patients before and after cardiac rehabilitation (CR).

		Group A		Paired *t*-test	
		Pre-CR	Post-CR	T	P-value
METS	Mean ± SD	8.35 ± 2.06	10.90 ± 2.65	−6.168	0.000
	Range	5–12	5–14		
EF%	Mean ± SD	43.85 ± 5.30	48.25 ± 5.44	−5.100	0.000
	Range	35–50	40–57		
QOL questionnaire					
General health	Mean ± SD	256.25 ± 29.10	356.25 ± 31.28	−13.784	0.000
	Range	200–300	275–400		
Physical function	Mean ± SD	637.50 ± 42.53	757.50 ± 40.64	−10.258	0.000
	Range	550–700	650–800		
Emotional wellbeing	Mean ± SD	273.00 ± 31.97	377.00 ± 31.30	−12.185	0.000
	Range	220 –320	300–420		
TOTAL	Mean ± SD	1781.25 ± 121.37	2967.25 ± 84.03	−44.441	0.000
	Range	1660–2060	2820–3120		
Labs					
s. Creatinine (mg/dl)	Mean ± SD	1.00 ± 0.20	0.99 ± 0.17	0.312	0.759
	Range	0.70–1.40	0.70–1.50		
Hb (gm/dl)	Mean ± SD	12.18 ± 1.46	12.14 ± 1.18	0.309	0.761
	Range	8.70–15.20	9–15		
Platelet count	Mean ± SD	250.40 ± 82.73	251.80 ± 76.62	−0.207	0.838
	Range	136–463	140–400		
WBCs ($\times 10^9$/L)	Mean ± SD	7.31 ± 2.20	6.82 ± 1.44	1.354	0.192
	Range	4.40–14.40	4–10		
s. Cholesterol (mg/dl)	Mean ± SD	168.25 ± 44.92	151.20 ± 45.75	4.123	0.001
	Range	97–250	74–222		
LDL (mg/dl)	Mean ± SD	105.95 ± 22.78	92.41 ± 26.72	2.565	0.019
	Range	67–142	40–140		
HDL (mg/dl)	Mean ± SD	40.28 ± 13.91	37.80 ± 6.61	0.731	0.474
	Range	27–95	27–48		
s. TGs (mg/dl)	Mean ± SD	119.35 ± 47.98	103.40 ± 35.08	2.246	0.037
	Range	36–258	64–206		

EF: Ejection fraction, Hb: hemoglobin level, HDL: high density lipoprotein cholesterol, METS: metabolic equivalents, QOL: quality of life, SD: standard deviation, TGs: Triglycerides, WBCs = white blood cell count.

Table 4
Showing the results of group B patients before and after cardiac rehabilitation (CR).

		Group B		Paired *t*-test	
		Pre-CR	Post-CR	T	P-value
METS	Mean ± SD	7.60 ± 2.14	11.55 ± 1.47	−12.338	0.000
	Range	5–11	10–14		
EF%	Mean ± SD	43.30 ± 5.32	48.30 ± 5.72	−5.590	0.000
	Range	35–50	38–60		
QOL questionnaire					
General health	Mean ± SD	253.75 ± 24.70	345.00 ± 33.05	−12.873	0.000
	Range	225–300	275–400		
Physical function	Mean ± SD	625.00 ± 34.41	747.50 ± 41.28	−9.969	0.000
	Range	550–700	650–850		
Emotional wellbeing	Mean ± SD	283.00 ± 20.80	398.00 ± 15.76	−19.892	0.000
	Range	240–320	380–420		
TOTAL	Mean ± SD	1832.50 ± 109.85	3026.50 ± 79.08	−47.777	0.000
	Range	1660–2000	2900–3200		
Labs					
s. Creatinine (mg/dl)	Mean ± SD	1.27 ± 0.32	1.09 ± 0.26	5.181	0.000
	Range	0.80–2.20	0.67–2.00		
Hb (gm/dl)	Mean ± SD	12.82 ± 1.35	13.23 ± 2.59	−0.825	0.419
	Range	10.00–15.50	10–23		
Platelet count	Mean ± SD	244.45 ± 58.17	232.25 ± 50.35	3.893	0.001
	Range	155–361	150–333		
WBCs ($\times 10^9$/L)	Mean ± SD	8.72 ± 2.69	6.45 ± 1.43	6.047	0.000
	Range	4.10–13.90	4–10		
s. Cholesterol (mg/dl)	Mean ± SD	185.70 ± 23.46	163.90 ± 20.57	8.460	0.000
	Range	119–220	110–200		
LDL (mg/dl)	Mean ± SD	94.45 ± 15.41	84.45 ± 11.56	6.056	0.000
	Range	59–123	62–110		
HDL (mg/dl)	Mean ± SD	35.05 ± 4.49	41.00 ± 3.83	−9.568	0.000
	Range	24–48	30–50		
s. TGs (mg/dl)	Mean ± SD	138.60 ± 33.47	118.95 ± 27.02	8.718	0.000
	Range	95–212	83–170		

EF: Ejection fraction, Hb: hemoglobin level, HDL: high density lipoprotein cholesterol, METS: metabolic equivalents, QOL: quality of life, SD: standard deviation, TGs: Triglycerides, WBCs = white blood cell count.

two groups with qualitative (categorical) data was done by using chi-square test. Correlation between values was done by person correlation coefficients. The p-values was considered significant if less than 0.05.

3. Results

The present study is a prospective study which was conducted on 40 patients, who underwent total revascularization by PCI, and were recruited during the period between from April 2016 to February 2017, from cardiac rehabilitation clinic in the Cardiology department Ain Shams University Hospital. The patients were divided into 2 groups (A and B) Group A underwent standard exercise protocol & Group B underwent high intensity interval training protocol.

The demographic data, risk factors and initial laboratory results are summarized in Table 1. There was no significant deference between the 2 studied groups regarding baseline demographic data, risk factors, baseline labs and outcomes of the PCI.

All patients were discharged on evidence-based medications, including dual antiplatelet therapy with aspirin and clopidogrel, statin and beta blockers. Angiotensin converting enzyme inhibitor/angiotensin receptor blockers were prescribed in 90% of cases in each group.

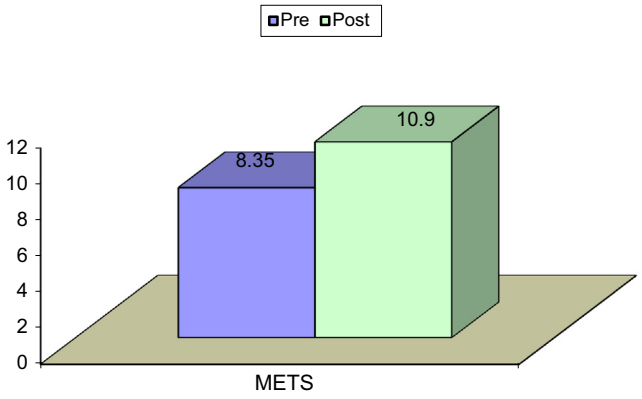

Fig. 1. Comparison between METS pre and post rehabilitation in group A.

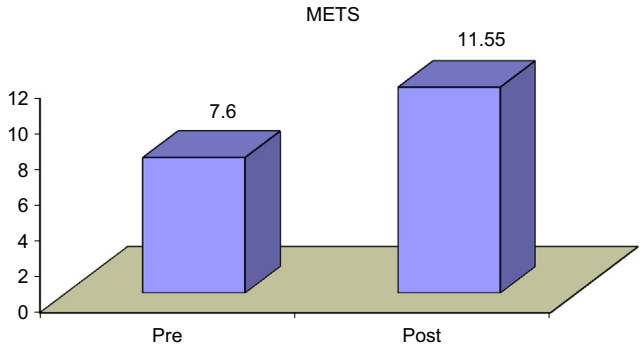

Fig. 3. Comparison between METS before and after rehabilitation in group B.

Initially, there was no significant difference between the two groups regarding each of: functional capacity [Metabolic Equivalents (METs)] achieved by exercise test, and Left ventricular function assessed by echocardiography as well as the quality of life questionnaire (RAND score) (Table 2).

At the end of CR program, all patients were reassessed by exercise test, echocardiography and QOL questionnaire. Each of the two groups showed significant improvement, compared to pre-rehabilitation, regarding functional capacity, most lipid profile parameters, Ejection fraction and QOL questionnaire parameters. (Tables 3 and 4, Figs. 1–4)

Comparison between group A and B post rehabilitation showed no significant difference in most compared parameters except that group B showed better improvement in emotional wellbeing than group A, as assessed by QOL questionnaire (Table 5).

It is worth noting that the high intensity interval training protocol appeared to be safe with no serious complications that occurred during the study.

4. Discussion

In the present study, females represented only 15% of the subjects (20% percent of patients in group A and 10% in group B). The small percentage of women in our study is similar to most studies in CR. This reflects the fact that CAD is more predominant in males, in addition, women are facing several unique barriers to

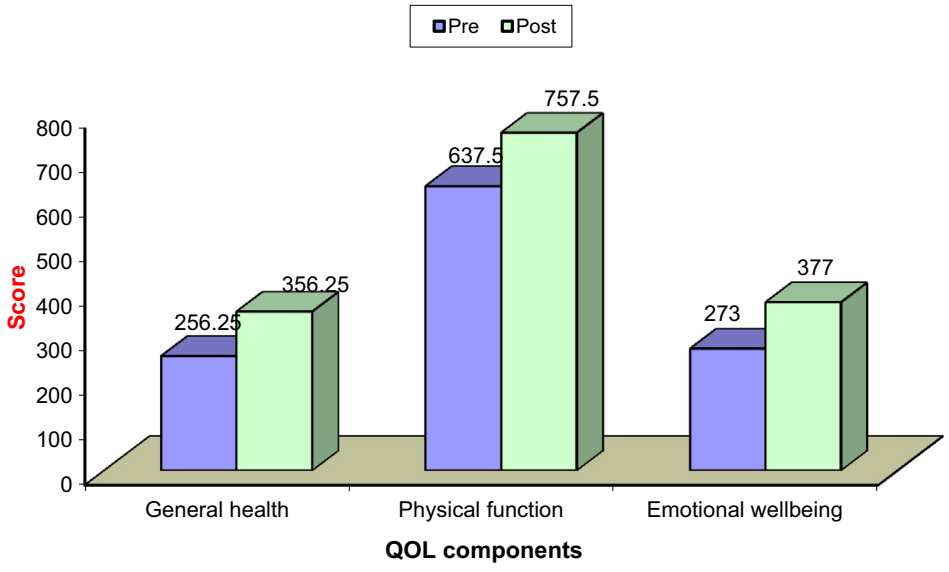

Fig. 2. Comparison between QOL questionnaire pre and post rehabilitation in group A.

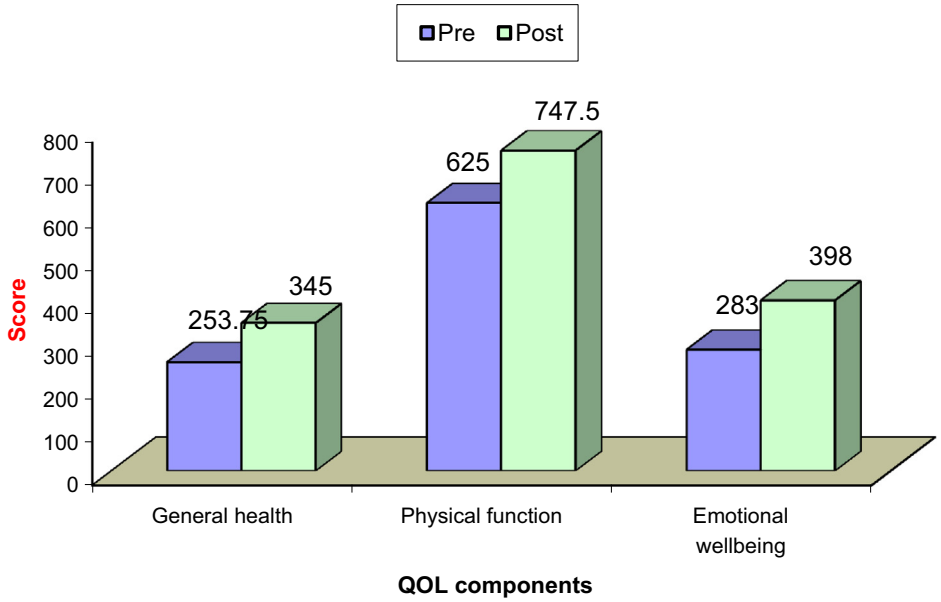

Fig. 4. QOL questionnaire before and after rehabilitation in group B.

Table 5
Comparison between groups A and B post cardiac rehabilitation.

		Group A	Group B	Independent *t*-test	
		n = 20	n = 20	T	P-value
METS	Mean ± SD	10.90 ± 2.65	11.55 ± 1.47	−0.959	0.344
	Range	5–14	10–14		
EF%	Mean ± SD	48.25 ± 5.44	48.30 ± 5.72	−0.028	0.978
	Range	40–57	38–60		
QOL questionnaire					
General health	Mean ± SD	356.25 ± 31.28	345.00 ± 33.05	1.106	0.276
	Range	275–400	275–400		
Physical function	Mean ± SD	757.50 ± 40.64	747.50 ± 41.28	0.772	0.445
	Range	650–800	650–850		
Emotional wellbeing	Mean ± SD	377.00 ± 31.30	398.00 ± 15.76	−2.680	0.011
	Range	300–420	380–420		
TOTAL	Mean ± SD	2967.25 ± 84.03	3026.50 ± 79.08	−2.296	0.027
	Range	2820–3120	2900–3200		
Labs					
s. Creatinine (mg/dl)	Mean ± SD	0.99 ± 0.17	1.09 ± 0.26	−1.517	0.137
	Range	0.70–1.50	0.67–2.00		
Hb (gm/dl)	Mean ± SD	12.14 ± 1.18	13.23 ± 2.59	−1.712	0.095
	Range	9–15	10–23		
Platelet count	Mean ± SD	251.80 ± 76.62	232.25 ± 50.35	0.954	0.346
	Range	140–400	150–333		
WBCs($\times 10^9$/L)	Mean ± SD	6.82 ± 1.44	6.45 ± 1.43	0.805	0.426
	Range	4–10	4–10		
s. Cholesterol (mg/dl)	Mean ± SD	151.20 ± 45.75	163.90 ± 20.57	−1.132	0.265
	Range	74–222	110–200		
LDL (mg/dl)	Mean ± SD	92.41 ± 26.72	84.45 ± 11.56	1.223	0.229
	Range	40–140	62–110		
HDL (mg/dl)	Mean ± SD	37.80 ± 6.61	41.00 ± 3.83	−1.875	0.069
	Range	27–48	30–50		
s. TGs (mg/dl)	Mean ± SD	103.40 ± 35.08	118.95 ± 27.02	−1.571	0.125
	Range	64–206	83–170		

EF: Ejection fraction, Hb: hemoglobin level, HDL: high density lipoprotein cholesterol, METS: metabolic equivalents, QOL: quality of life, SD: standard deviation, TGs: Triglycerides, WBCs = white blood cell count.

program participation that may account for their lower enrolment, poorer adherence, and higher dropout rates.[22,32,33]

One of the most important inclusion criteria in the current study was the baseline ejection fraction which ranged from (35–50%). This was to assess the safety and efficacy of HIIT in higher risk patients with mild LV dysfunction (Patients with EF 40–50% are now newly named as mid-range EF). No serious adverse events occurred throughout the study period. We found few similar studies in the literature that included such group of patients.[22,34,35]

The Functional capacity in our study, assessed by METs achieved during modified BRUCE test pre and post CR, showed significant

improvement in both groups. Similar results were obtained in a previous study even at one year after completion of CR program.[32]

Similarly, a study done by Ulbrich et al. (2015), involving 22 patients who were divided in to 2 groups: moderate exercise and HIIT programs. The outcome of functional capacity was assessed by 6-min walk test (6MWT). The study showed a significant increase of 6MWT in 19.4% and 23.1% in the assigned groups respectively ($p < 0.001$).[35] The difference from our study could be related to the different patient population and ages, as well as different methods of assessment used.

In the present study, there was a noticeable improvement in lipid profile in both groups. However, it was noted that HDL level improved in group B but decreased in group A, however the decrease of HDL in group A was not statistically significant. Such results are not well explained but could be attributed to small number of patients included in the study. Lavie and Milani reported in their study involving 313 cardiac patients that there were significant reductions in total serum cholesterol concentration and in LDL/HDL cholesterol ratios after 36 sessions of cardiac rehabilitation.[36]

When we talk about the effect of CR on the QOL of CAD patients we noticed significant improvement in the both groups post rehabilitation without significant difference except in the item of emotional well-being in QOL questionnaire done by RAND score, which was more significantly improved in the High intensity exercise group. Our data is concordant with Duncan and Pozehl in 2003 in their study, which assessed QOL by Minnesota Living with Heart Failure (MLWHF) questionnaire and showed improvement in the quality of life score.[37] Furthermore, Arrigo et al. (2008) confirmed quality of life improvement in both groups with no differences between the groups as proved by our data.[32]

The outcome of QOL in a study by Ulbrich et al., was measured by (MLWHF and SF-36 Questionnaires). In this study, quality of life improved significantly and in all domains in both groups from baseline.[35] As previously mentioned, the same results were observed in our study with specific improvement in emotional well-being scores.

Another evidence by Wisløff and his colleagues, who randomly assigned the patients to either high intensity exercise (n = 9) [95% of peak heart rate] Moderate intensity exercise (n = 9), [70% of peak heart rate] or a control group (n = 9) [received standard advice regarding physical activity]. They made assessment of QOL by MacNew global score for quality of life in cardiovascular disease, which showed significant improvement in both exercise groups.[22]

5. Conclusion

In this study, we could conclude that cardiac rehabilitation programs are beneficial in improvement of the quality of life, exercise capacity, lipid profile and LV function among patients with CAD who underwent recent PCI and an ejection fraction ranging from 35 to 50%.

Furthermore, no significant difference, in the assessed parameters, was found between effects of HIIT and standard moderate Intensity training in CR programs. Although all parameters improved in both groups, but, the emotional well-being of the quality of life questionnaire improved in the HIIT Group, in comparison to the other group.

6. Study limitations

1. It included a single medical center (Ain Shams University hospitals).
2. The relatively small number of patients, who were characterized by predominantly male gender.
3. Another limitation is that this study was not powered enough to assess cardiovascular morbidity and mortality and cost effectiveness in larger studies & longer follow up.

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