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. 7 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. 8 Angina significantly improves during the cardiac rehabilitation exercise program. Recurrent infarctions decrease by 17% and the rate of hospitalizations also decreases. 9

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
participation could be attributed to several factors including: transport difficulties, work schedules, social commitments, lack of perceived need, and functional impairment.\textsuperscript{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)\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{21} Furthermore, HIIT has also been shown to improve endothelial function.\textsuperscript{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.\textsuperscript{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.\textsuperscript{25} In addition, exercise training also attenuates some inflammatory pathways that are potentially contributing to the pathophysiology of restenosis.\textsuperscript{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.\textsuperscript{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\textsuperscript{28}

\[ [HRR = \text{peak heart rate} - \text{rest heart rate}] \]

THR was then added. Patients who live in distant rural areas or have no means of transportation and cannot participate regularly in the program.

All patients were asked to fill a quality of life (QOL) questionnaire [RAND 36-Item Health Survey].\textsuperscript{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).\textsuperscript{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.\textsuperscript{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 |
|------------------------------------|---------|---------|--------------------|
| Age (years) Mean ± SD              | 51.95 ± 8.07 | 54.65 ± 7.63 | t = −1.087, P = 0.284 |
| Range 38 – 67                      | 35–65 |
| Gender Male 16 (80%)               | 2 (10%) |
| Female 4 (20%)                     | 2 (10%) |
| Weight (Kg) Mean ± SD              | 81.00 ± 8.86 | 84.85 ± 14.14 | t = −1.032, P = 0.309 |
| Range 58–95                        | 58–114 |
| Height (cm) Mean ± SD              | 166.15 ± 6.13 | 167.45 ± 6.85 | t = −0.632, P = 0.531 |
| Range 155–173                      | 155–180 |
| Hypertension 6 (30%)               | 7 (35%) |
| Diabetes mellitus 9 (45%)          | 6 (30%) |
| Dyslipidemia 2 (10%)               | 3 (15%) |
| Smoking Non-Smoker 10 (50%)        | 7 (35%) |
| Smoker 8 (40%)                     | 8 (40%) |
| s. Creatinine (mg/dl) Mean ± SD    | 1.00 ± 0.20 | 1.27 ± 0.32 | t = −3.127, P = 0.003 |
| Range 0.70–1.40                    | 0.80–2.20 |
| Hb (gm/dl) Mean ± SD               | 12.18 ± 1.46 | 12.82 ± 1.35 | t = −1.440, P = 0.158 |
| Range 8.70–15.20                   | 10.00–15.50 |
| Platelet count Mean ± SD           | 250.40 ± 82.73 | 244.45 ± 58.17 | t = 0.263, P = 0.794 |
| Range 136–463                      | 155–361 |
| WBCs (>10^9/L) Mean ± SD           | 7.31 ± 2.20 | 8.72 ± 2.69 | t = −1.817, P = 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 | t = −1.540, P = 0.132 |
| Range 97–250                       | 119–220 |
| LDL (mg/dl) Mean ± SD              | 105.95 ± 22.78 | 94.45 ± 15.41 | t = 1.870, P = 0.069 |
| Range 67–142                       | 59–123 |
| HDL (mg/dl) Mean ± SD              | 40.28 ± 13.91 | 35.05 ± 4.49 | t = 1.599, P = 0.118 |
| Range 27–95                        | 24–48 |
| s. TGs (mg/dl) Mean ± SD           | 119.35 ± 47.98 | 138.60 ± 33.47 | t = −1.472, P = 0.149 |
| Range 36–258                       | 95–212 |
| Culprit PCI arteries                | Group A | Group B | Chi-square test |
| Artery LAD 14 (70%)                | 13 (65%) | 4.370 | 0.0627 |
| 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/echocardiography | Group A | Group B | Independent t-test |
|-----------------------------------|---------|---------|--------------------|
| METS Mean ± SD                    | 8.35 ± 2.06 | 7.60 ± 2.14 | t = 1.130, P = 0.265 |
| Range 5–12                        | 5–11 |
| EF% Mean ± SD                     | 43.85 ± 5.30 | 43.30 ± 5.32 | t = 0.327, P = 0.745 |
| Range 35–50                       | 35–50 |
| QOL questionnaire scores          | General health Mean ± SD | 256.25 ± 29.10 | 251.75 ± 24.70 | t = 0.293, P = 0.771 |
| Range 200–300                     | 225–300 |
| Physical function Mean ± SD       | 637.50 ± 42.53 | 625.00 ± 34.41 | t = 1.022, P = 0.313 |
| Range 550–700                     | 550–700 |
| Emotional wellbeing Mean ± SD     | 273.00 ± 31.97 | 283.00 ± 20.80 | t = −1.173, P = 0.248 |
| Range 220–320                     | 240–320 |
| TOTAL score Mean ± SD             | 1781.25 ± 121.37 | 1832.50 ± 109.85 | t = −1.400, P = 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 ± 46.04 | −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 (×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 ± 34.21 | 747.50 ± 41.28 | −9.896   | 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 (×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                 | 59–212   | 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.

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
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

![QOL components](image)

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

|                          | 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)    | 0.99 ± 0.17 | 1.09 ± 0.26 | -1.517             | 0.137    |
| Range                    | 0.70–1.50   | 0.67–2.00   |                    |          |
| Hb (gm/dl)               | 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 (× 10^9/L)          | 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.
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 Wisloff 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.

References

1. Clark AM, Hartling L, Vandermeer B, et al. Meta-analysis: secondary prevention programs for patients with coronary artery disease. Ann Intern Med. 2005;143:659–672.
2. Taylor RS, Brown A, Ebrahim S, et al. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. Am J Med. 2004;116:682–692.
3. Bjarnason-Wehrens B, McGhee H, Zwiersel AD, et al. Cardiac rehabilitation in Europe: results from the European Cardiac Rehabilitation Inventory Survey. Eur J Cardiovasc Prev Rehabil. 2010;17:410–418.
4. Bethell HJ, Turner SC, Evans JA, et al. Cardiac rehabilitation in the United Kingdom: how complete is the provision? J Cardiopulm Rehabil. 2001;21:111–115.
5. Grace SL, Gravely-Witte S, Brujal J, et al. Contribution of patient and physician factors to cardiac rehabilitation referral: a prospective multilevel study. Nat Clini Pract Cardiovasc Med. 2008;10:653–662.
6. Perk J, De Bacter G, Gohlke H, et al. The fifth joint task force of the European society of cardiology and other societies on cardiovascular disease prevention in clinical practice. Eur heart J. 2012;33:1635–1701.
7. Alter DA, Oh PI, Chong A. Relationship between cardiac rehabilitation and survival after acute cardiac hospitalization within a unilateral health care system. Eur J Cardiovasc Prev Rehabil. 2009;11:102–113.
8. Giannaura F, Galizia G, Lucchi R, et al. Favourable effects of exercise-based cardiac rehabilitation after acute myocardial infarction on left atrial remodeling. Int J Cardiol. 2009;136:300–306.
9. Chiu DP, French J, Briffa TG, et al. Acute coronary syndrome care across Australia and New Zealand: the SNAPSHQT ACS study. Med J Aust. 2013;199:1–7.
10. Bunker S, McBurney H, Cox H, et al. Identifying participation rates at outpatient cardiac rehabilitation programs in Victoria, Australia. J Cardiopulm Rehabil. 1995;19:334–338.
11. Scott IA, Lindsay KA, Harden HE. Utilisation of outpatient cardiac rehabilitation in Queensland. Med J Aust. 2003;179:341–345.
12. Fornal C. A woman’s dilemma: cardiac rehabilitation barriers. Kansas Nurse. 2011;86:10–13.
13. Barber K, Stommel M, Kroll J, et al. Cardiac rehabilitation for community-based patients with myocardial infarction: factors predicting discharge recommendation and participation. J Clin Epidemiol. 2001;54:1025–1030.
14. Billat V. Interval training for performance: a scientific and empirical practice. Special recommendations for middle- and long-distance running. Part I: aerobic interval training. Sports Med. 2001;31:13–31.
15. Ten aesseu M, Letzmann MF, Rimon EB, et al. Exercise type and intensity in relation to coronary heart disease in men. JAMA. 2002:288:1994–2000.
16. Lee IM, Sesso HD, Oguma Y, et al. Relative intensity of physical activity and risk for coronary heart disease. Circulation. 2008;107:1110–1116.
17. Wisloff U, Nilsen TI, Droyvold WB, et al. A single weekly bout of exercise may reduce cardiovascular mortality: how little pain for cardiac gain? The HUNT study. Norway. Eur J Cardiovasc Prev Rehabil. 2006;13:798–804.
18. Bartlett JD, Close GL, MacLaren DP, et al. High-intensity interval training is perceived to be more enjoyable than moderate-intensity continuous exercise: implications for exercise adherence. J Sports Sci. 2011;6:547–553.
19. Guiraud T, Gayda M, Juneau M, et al. A single bout of high-intensity exercise does not increase endothelial or platelet microparticles in stable, physically fit men with coronary heart disease. Can J Cardiol. 2013;10:1285–1291.
20. Tuomanen P, Hartikainen J, Vanninen E, et al. Warm-up phenomenon and cardiac autonomic control in patients with coronary artery disease. Life Sci. 2005;76:2147–2158.
21. Lu X, Wu T, Huang P, et al. Effect and mechanism of intermittent myocardial ischemia induced by exercise on, coronary collateral formation. Am J Phys Med Rehabil. 2008;87:803–814.
22. Wisloff U, Stoylen A. Exercise training as an intervention strategy for patients with coronary artery disease and post-prandial lipemia: complete protection afforded by high-intensity aerobic interval exercise. J Am Coll Cardiol. 2009;53:200–206.
23. Helgerud J, Karlsen T, Kim WT, et al. Interval and strength training in CAD patients. Int J Sports Med. 2011;1:54–59.
24. Lipke EA, West JL. Localized delivery of nitric oxide from hydrgols inhibits neotima formation in a rat carotid balloon injury model. Acta Biomater. 2005;6:597–606.
25. Munk PS, Beilund UM, Aukrust P, et al. High intensity interval training reduces systemic inflammation in post-PCI patients. Eur J Cardiovasc Prev Rehabil. 2011;18:850–857.
26. Munk PS, Beilund UM, Aukrust P, et al. High intensity interval training reduces inflammatory and platelet response in patients with coronary artery disease. Circulation. 2011;128:873–934.
28. Karvonen MJ. Problems of training of the cardiovascular system. *Ergonomics*. 1959;2:207–215.
29. Hays RD, Shapiro MF. An overview of generic health-related quality of life measures for HIV research. *Qual Life Res*. 1992;1:91–97.
30. Steward AL, Sherbourne C, Hayes RD. Summary and discussion of MOS measures. In: Stewart AL, Ware JE, eds. *Measuring functioning and well-being: the medical outcome study approach*. Durham, NC: Duke University Press; 1992:345–371.
31. Taft C, Karlsson J, Sullivan M. Do SF-36 summary component scores accurately summarize subscale scores? *Quality Life Res, Springer*. 2001;10:395–404.
32. Arrigo I, Brunner-LaRocca H, Lefkovits M, et al. Comparative outcome one year after formal cardiac rehabilitation: the effects of a randomized intervention to improve exercise adherence. *Eur J Cardiovasc Prev Rehabil*. 2008;15:306–311.
33. Allen JK, Scott LB, Stewart KJ, Young DR. Disparities in women’s referral to and enrollment in outpatient cardiac rehabilitation. *J Gen Int Med*. 2004;19:747–753.
34. Milani RV, Lavie CJ, Mehra MR, et al. Impact of exercise training and depression on survival in heart failure due to coronary heart disease. *Am J Cardiol*. 2011;107:64–68.
35. Ulbrich AZ, Angarten VG, Netto AS, et al. Comparative effects of high intensity interval training versus moderate intensity continuous training on quality of life in patients with heart failure. *Clin Trials Regul Sci Cardiol*. 2016;13:21–28.
36. Lavie CJ, Milani RV. Effects of cardiac rehabilitation and exercise training on low-density lipoprotein cholesterol in patients with hypertriglyceridemia and coronary artery disease. *Am J Cardiol*. 1994;74:1192–1195.
37. Duncan K, Pozehl B. Effects of an exercise adherence intervention on outcomes in patients with heart failure. *Rehabil Nurs*. 2003;28:117–122.