Gender differences among ischemic heart disease patients enrolled in a cardiac rehabilitation program

Ahmed Mohamed El Missiri*, Hany Mohamed Awadalla and Mosadaq Mustafa Almoudi

Abstract

Background: Cardiac rehabilitation programs reduce cardiovascular events and mortality in ischemic heart disease patients. The aim of this study was to assess gender differences among ischemic heart disease patients enrolled in a cardiac rehabilitation program regarding adherence to the program, as well as, changes in clinical, laboratory, and echocardiographic parameters.

Results: A prospective study that included 30 men and 30 women with stable ischemic heart disease who had been totally revascularized by percutaneous coronary intervention. Patients were enrolled in a 12-week cardiac rehabilitation program. Assessment of demographics, anthropometric measurements, risk factors, and functional capacity was performed. Lipid profile, glycated hemoglobin, and left ventricular ejection fraction were assessed. Assessments were performed at baseline and after completion of the program. Time to enrollment in the program was prolonged for women 39.17 ± 40.49 vs. 19.77 ± 10.26 days (p = 0.014). At baseline, more women were diabetic (p = 0.004), hypertensive (p = 0.02), had a larger waist circumference (p = 0.022), a higher BMI (p = 0.011), and higher HbA1c (p = 0.033). More men were active smokers (p < 0.001). After completion of the program, it was found that men attended 19.1 ± 4.77 (79.6%) sessions compared to 15.7 ± 5.72 (65.4%) sessions for women (p = 0.015). Women had more reduction in diastolic BP − 10.93 ± 8.94 vs. − 5.47 ± 12.57 mmHg (p = 0.058). The magnitude of reduction in resting heart rate was significant in men (p = 0.018) but not in women (p = 0.376). The magnitude of reduction in serum total cholesterol and triglycerides was more in men (p = 0.018 and p = 0.014). Women showed more reduction in HbA1c (p = 0.052).

Conclusion: Men are more adherent to cardiac rehabilitation programs. Recruitment of women is significantly delayed. Women have a higher cardiovascular risk burden in the form of prevalence of diabetes, hypertension, and obesity. Completion of a cardiac rehabilitation program causes a reduction in BMI, waist circumference, blood pressure measurements, total cholesterol, triglycerides, LDL-C, HDL-C, HbA1c, and LVEDD with an increase in LVEF in both genders. Men show more reduction in resting HR, total cholesterol, and triglyceride levels while women show more reduction in diastolic BP and HBA1c.

Keywords: Gender, Ischemic heart disease, Cardiac rehabilitation, Cardiac rehabilitation program

* Correspondence: amissiri@med.asu.edu.eg; amissiri@yahoo.com
Cardiology Department, Faculty of Medicine, Ain Shams University, Abbassia square, Abbassia, Cairo 11566, Egypt

© The Author(s). 2020 Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.
Background
Cardiovascular disease is the leading cause of death among men and women in most developed countries. Historically, it was thought that cardiovascular disease mainly affects men. This is a myth. Cardiovascular disease is the leading cause of death for women in the United States and represented 54% in 2009 [1–3].

Women and men share the same traditional risk factors for ischemic heart disease. However, women have other non-traditional risk factors such as those caused by premature menopause, pre-eclampsia, depression, social and vocational disparity, and higher prevalence of autoimmune diseases. Additionally, ischemic heart disease symptoms in women are usually atypical and different from men which leads to delayed presentation, delayed diagnosis or misdiagnosis thus putting women at an increased risk. Women usually present more complications and worse functional outcomes compared to men [4–6].

Women are under-represented in clinical research performed in all aspects of cardiovascular disease. The representation of women in clinical trials is still low at around 31%. Action has been taken to try to fix this. However, since women present with cardiovascular disease nearly 10 years later than men, the incidence of cardiovascular disease shows a decline in men and a rise in women mainly caused by a decrease in ischemic heart disease in younger men and its increase in older women [7–10].

Cardiac rehabilitation programs are tailored exercise, educational, and risk factor modification programs. They have been shown to be associated with a significant reduction in cardiovascular events and mortality in ischemic heart disease patients, as well as, an improvement in functional capacity, and psychological and social well-being [11, 12].

The aim of this study was to assess gender differences among ischemic heart disease patients enrolled in a cardiac rehabilitation program regarding adherence to the program, as well as, changes in clinical, laboratory, and echocardiographic parameters.

Methods
This was a prospective study conducted in the period from January 2017 to January 2018. Approval of the institutional ethical committee was obtained, and informed consent was provided by all participants.

This study included 60 consecutive adult patients (30 men and 30 women) with ischemic heart disease who had been totally revascularized by percutaneous coronary intervention (PCI) in the 3 months prior to their enrollment in the study. All patients were angina-free and on standard anti-ischemic medication at the maximum tolerated doses (it was mandatory that the prescribed doses of lipid-lowering medications remain unchanged during the study period). We enrolled all patients in the 12-week cardiac rehabilitation program provided at our institution.

Subjects were excluded from the study if any of the following conditions were met: age less than 18 years old; ongoing exertional or rest angina; recent (less than 1 month) myocardial infarction or acute coronary syndrome; New York Heart Association (NYHA) functional class 3 or 4 [13]; left ventricular (LV) ejection fraction (EF) less than 40%; decompensated heart failure; moderate or severe valvular stenosis or more than moderate valvular regurgitation; hypertrophic obstructive cardiomyopathy; symptomatic hypotension; acute illness; second- or third-degree atrioventricular block; previously implanted pacemaker or implantable cardioverter defibrillator; physical or mental disability that impedes proper exercise training; prior participation in a cardiac rehabilitation program; or the presence of other debilitating conditions such as chronic renal failure, liver cirrhosis, or cerebrovascular stroke.

Baseline clinical assessment
Thorough history was taken, and detailed clinical examination was performed to obtain each patient’s baseline demographic information, risk factors for ischemic heart disease, as well as, occupational and marital status. Educational level was identified and classified as either being illiterate or having school-level or university-level education. NYHA functional class was identified for all patients. Height in meters and weight in kilograms were recorded. Body mass index (BMI) was calculated according to the formula: BMI = weight in kilograms/square of height in meters (kg/m²) [14]. Waist circumference in centimeters was measured using a tape measure midway between the level of the lower costal margin and the level of the anterior superior iliac spines with the patient standing facing forwards in a relaxed position at the end of expiration.

Laboratory tests
A venous sample was obtained from all patients at baseline to assess 12-h fasting lipid profile to measure total cholesterol, serum triglycerides, and high-density lipoprotein cholesterol (HDL-C) which were assessed using enzymatic methods. While low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula, where LDL-C = [total cholesterol] − [HDL-C] − (1/5 triglycerides) [15]. Glycated hemoglobin (HbA1c) level was also assessed.

Standard trans-thoracic echocardiography
Standard trans-thoracic echocardiography was performed for all patients while lying in the left lateral
decubitus position using a Vivid S5 machine (GE Vingmed, Netherlands) and an M4S matrix array probe with a frequency range 1.7–3.5 MHz by an echocardiographer accredited from the European Association of Cardiovascular Imaging.

Using m-mode echocardiography from the parasternal short-axis view at the level of papillary muscles we measured LV end-diastolic diameter (LVEDD) and end-systolic diameter (LVESD). LVEF was measured using the biplane Simpson’s method of discs by 2D echocardiography from the apical 4- and 2-chamber views [16, 17].

Cardiac rehabilitation program

The cardiac rehabilitation program provided at our institution is a 12-week (24 sessions) multi-disciplinary program that includes cardiologists, physiotherapists, psychologists, diabetologists, and trained nurses.

Patients attend sessions for risk factor education and modification; sessions on the importance of medication adherence and their potential adverse events; nutritional counseling classes; smoking cessation classes; group and individual stress management classes; and individual sexual counseling sessions.

The cornerstone of this program is progressive prescribed exercise training. Exercise sessions are held twice weekly. Each patient’s symptoms are evaluated at each visit and the medications’ list is revised. Exercise sessions are similar for all and consist of graded treadmill exercise. A session may last up to 60 min towards the end of the program including warm-up, aerobic training, and cool down periods.

A symptom-limited exercise testing was performed at baseline using the modified Bruce protocol to identify the patient’s maximal heart rate after which the target heart rate was calculated using the Karvonen formula with an exercise intensity of 60% and 75% of heart rate reserve. Karvonen formula for determination of training heart rate is as follows:

\[
\text{Target heart rate} = (\text{heart rate reserve} \times \text{training percentage required}) + \text{resting heart rate}
\]

Where heart rate reserve = maximal heart rate – resting heart rate \cite{18}.

We assessed the “time to enrollment” for all patients as the time that passed from informing the patient about the program (which was on the day after complete revascularization) to actually joining the program.

Assessments following completion of the cardiac rehabilitation program

Within a week after completion of the program, patients were interviewed to re-assess smoking status, NYHA functional class, blood pressure, resting HR, body weight, BMI, fasting lipid profile, HbA1c, and the same echocardiographic measurements (LVEDD, LVESD, and LVEF).

Adherence to the cardiac rehabilitation program was assessed using the number (and percentage) of sessions actually attended from the total 24 sessions by each patient.

Statistical analysis

Data were collected, revised, coded, and entered into the IBM statistical package for social science (SPSS) version 24. Data were examined for normality. Categorical data were presented as number and percentages, while continuous data were presented as mean and standard deviation. Categorical data were compared using chi-square test or Fisher’s exact test when chi-square was not applicable. Continuous data were compared using paired sample t test for normally distributed data and independent sample t test otherwise. Level of significance (\(p\) value) was set at \(p < 0.05\).

Results

Baseline demographic and clinical data

On comparing men and women at baseline, we found that the time to enrollment in the cardiac rehabilitation program was prolonged for women 39.17 ± 40.49 vs. 19.77 ± 10.26 days (\(p = 0.014\)); a larger proportion of women were diabetic (\(p = 0.004\)) and hypertensive (\(p = 0.02\)); women had a larger waist circumference 108.43 ± 8.31 vs. 102.07 ± 12.3 cm (\(p = 0.022\)) and higher BMI 32.67 ± 5.3 vs. 29.47 ± 4.07 kg/m\(^2\) (\(p = 0.011\)). On the other hand, current smoking was more common amongst men (\(p < 0.001\)); it was more common for men to be employed (80%) and for women to be unemployed (56.77%), \(p = 0.03\).

There was no difference between men and women at baseline regarding age, presence of dyslipidemia, distribution of NYHA functional class, blood pressure measurements, resting heart rate, marital status, and level of education (Table 1).

Baseline laboratory and echocardiographic measurements

At baseline, HbA1c was significantly higher in women 7.43 ± 2.63 vs. 6.14 ± 1.63% (\(p = 0.033\)). There was no difference between men and women in serum total cholesterol, triglycerides, LDL-C, and HDL-C.

Women had smaller LVEDD compared to men. No difference was observed in LVESD and LVEF (Table 2).

Assessments after completion of the 12-week cardiac rehabilitation program

Clinical characteristics

After completion of the program, there was no difference in the number of active smokers between men and women (\(p = 0.718\)) (Table 3). However, the proportion
of active smokers was significantly reduced from 29 (96.77%) to 5 (16.67%) for men (p < 0.001) and from 12 (40%) to 4 (13.33%) for women (p = 0.039).

Similarly, there was no difference between men and women in the NYHA functional classes after completion of the program (p = 1) (Table 3). However, the proportion of patients in NYHA functional class 1 significantly increased from 19 (63.33%) to 29 (96.67%) for men (p = 0.002) and from 15 (50%) to 29 (96.67%) for women (p < 0.001).

There was a significant reduction in BMI and waist circumference for both men and women (Table 4). However, no difference was observed when comparing the magnitude of change between both groups (p = 0.632 for BMI, p = 0.599 for waist circumference). Thus, BMI and waist circumference remained higher in women at the end of the program (p = 0.015, p = 0.041 respectively) (Table 3).

### Vital signs

Systolic and diastolic BP were significantly reduced for men and women, especially with women showing a highly significant reduction in diastolic BP.

No difference was observed when comparing the magnitude of change between men and women for systolic BP (p = 0.145). Women had more reduction in diastolic BP − 10.93 ± 8.94 vs. − 5.47 ± 12.57 mmHg although it did not quite reach statistical significance (p = 0.058) (Table 4).

After completion of the program, there was no difference between men and women regarding systolic and diastolic BP measurements (p = 0.502, p = 0.545 respectively) (Table 3).

The magnitude of reduction in resting heart rate was significant in men (p = 0.018) but not in women (p = 0.376). There was no difference on comparing the magnitude of change between men and women (p = 0.547) (Table 4). There was no difference between both groups of active smokers.

---

### Table 1 Baseline clinical findings and measurements

| Variable               | Men (n = 30) | Women (n = 30) | p value |
|------------------------|-------------|---------------|--------|
| Age, years             | 53.57 ± 7.77| 51.67 ± 6.62  | 0.312  |
| Time to enrolment, days| 19.77 ± 10.26| 39.17 ± 40.49| 0.014  |
| Current smoker, n (%)  | 29 (96.67%)| 12 (40%)      | < 0.001|
| Hypertension, n (%)    | 11 (36.67%)| 20 (66.67%)   | 0.02   |
| Diabetes, n (%)        | 7 (23.33%) | 18 (60%)      | 0.004  |
| Dyslipidemia, n (%)    | 4 (13.33%) | 9 (30%)       | 0.117  |
| BMI, kg/m²             | 29.47 ± 4.07| 32.67 ± 5.3  | 0.011  |
| Waist circumference, cm| 102.07 ± 12.3| 108.43 ± 8.31| 0.022  |
| Marital status—married, n (%)| 28 (93.33%)| 26 (86.67%) | 0.704  |
| Level of educational, n (%)| 5 (16.67%)| 6 (20%)      | 0.351  |
| Illiterate             | 15 (50%)    | 12 (40%)      |        |
| School level education | 10 (33.33%)| 12 (40%)      |        |
| University level education |        |              |        |
| Employed, n (%)        | 24 (80%)    | 13 (43.33%)   | 0.003  |
| NYHA functional class, n (%)| 19 (63.33%)| 15 (50%)     | 0.435  |
| Class 1                | 11 (36.67%)| 15 (50%)      |        |
| Class 2                |             |               |        |
| Systolic BP, mmHg      | 121.17 ± 14.6| 128.83 ± 7   | 0.066  |
| Diastolic BP, mmHg     | 76.17 ± 10.14| 80.3 ± 7.61  | 0.079  |
| Resting heart rate, bpm| 73.1 ± 9.69 | 75.43 ± 10.91| 0.385  |

### Table 2 Baseline laboratory and echocardiographic measurements

| Variable                  | Men (n = 30) | Women (n = 30) | p value |
|---------------------------|-------------|---------------|--------|
| Laboratory measurements   |             |               |        |
| Total cholesterol, mg/dl  | 193.37 ± 25.31| 186.33 ± 21.82| 0.254  |
| Serum triglycerides, mg/dl| 147.3 ± 59.78| 131.4 ± 26.54| 0.188  |
| LDL-C, mg/dl              | 123.37 ± 20.33| 118.39 ± 18.04| 0.32   |
| HDL-C, mg/dl              | 40.47 ± 5.92 | 41.57 ± 4.66  | 0.427  |
| Hba1c, %                  | 6.14 ± 1.63 | 7.43 ± 2.63   | 0.033  |
| Echocardiographic measures|             |               |        |
| LVEDD, mm                 | 51.17 ± 4.34 | 48.9 ± 2.63   | 0.017  |
| LVESD, mm                 | 3.66 ± 3.78 | 35.3 ± 2.77   | 0.134  |
| LVEF, %                   | 53.6 ± 5.19 | 52.2 ± 4.26   | 0.258  |

### Table 3 Clinical findings and measurements after completion of the cardiac rehabilitation program

| Variable                  | Men (n = 30) | Women (n = 30) | p value |
|---------------------------|-------------|---------------|--------|
| Current smoker, n (%)     | 5 (16.67%)  | 4 (13.33%)    | 0.718  |
| BMI, kg/m²                | 28.82 ± 4.15| 31.88 ± 5.22  | 0.015  |
| Waist circumference, cm   | 99.07 ± 12.32| 104.97 ± 9.29| 0.041  |
| NYHA functional class, n (%)| 29 (96.67%)| 29 (96.67%) | 1       |
| Class 1                   | 1 (3.33%)   | 1 (3.33%)     |        |
| Class 2                   |             |               |        |
| Systolic BP, mmHg         | 114.5 ± 11.47| 116.37 ± 9.87| 0.502  |
| Diastolic BP, mmHg        | 70.7 ± 10.03 | 69.37 ± 6.56  | 0.545  |
| Resting heart rate, bpm   | 69.37 ± 8.93 | 73.73 ± 7.51  | 0.065  |
| Total number of sessions attended, n (%)| 19.1 ± 4.77| 15.7 ± 5.72 | 0.015  |

Continuous variables are expressed as mean and standard deviation whereas categorical variables are expressed as number (percentage). BMI means body mass index, NYHA means New York heart association, BP means blood pressure.
at the end of the program regarding resting HR ($p = 0.065$) (Table 3).

**Laboratory measurements**

Serum total cholesterol, triglycerides, LDL-C, and HDL-C were significantly reduced in both groups ($p < 0.001$ for all). The magnitude of reduction in serum total cholesterol and triglycerides was more in men $-46.87 \pm 22.43$ vs. $-34.48 \pm 16.62$ mg/dl ($p = 0.018$) and $-41.03 \pm 45.62$ vs. $-19.03 \pm 13.55$ ($p = 0.014$) respectively. There was no difference in the magnitude of change between men and women regarding LDL-C and HDL-C (Table 4).

At the end of the program, there was no difference between men and women regarding serum levels of total cholesterol, triglycerides, LDL-C and HDL-C (Table 3).

There was a significant reduction in HbA1c in both men and women. Women showed more reduction in HbA1c $-1.33 \pm 1.94$ vs. $-0.53 \pm 1.05$% that was near significance ($p = 0.052$). There was no difference in HbA1c levels at the end of the program between men and women (Table 5).

**Echocardiographic measurements**

After completion of the program, LVESD was reduced and LVEF increased for both men and women ($p < 0.001$ for all). No difference was observed for LVEDD (Table 4).

On comparing the magnitude of change between men and women, no difference was observed for LVEDD, LVESD, and LVEF (Table 4). Thus, at the end of the program LVEDD remained smaller in women $48.96 \pm 1.99$ vs. $51.35 \pm 4.01$ mm ($p = 0.008$) (Table 5).

---

**Table 4** Paired change in clinical, laboratory and echocardiographic measurements after completion of the cardiac rehabilitation program for each gender and comparison of the magnitude of change between them

| Variable                  | Paired change for men ($n = 30$) | Comparing paired results in men, $p$ value | Paired change for women ($n = 30$) | Comparing paired results in women, $p$ value | Comparing both groups for the magnitude of change, $p$ value |
|---------------------------|----------------------------------|-------------------------------------------|-----------------------------------|-------------------------------------------|------------------------------------------------------------|
| **Clinical measurements** |                                  |                                           |                                   |                                           |                                                            |
| BMI, kg/m$^2$             | $-0.65 \pm 0.92$                 | $< 0.001$                                | $-0.79 \pm 1.3$                   | $0.002$                                   | $0.632$                                                    |
| Waist circumference, cm   | $-3 \pm 3.71$                    | $< 0.001$                                | $-3.47 \pm 3.15$                  | $< 0.001$                                 | $0.599$                                                    |
| Systolic BP, mmHg         | $-6.67 \pm 15.22$                | $0.023$                                  | $-12.47 \pm 15.17$                | $< 0.001$                                 | $0.145$                                                    |
| Diastolic BP, mmHg        | $-5.47 \pm 12.57$                | $0.024$                                  | $-10.93 \pm 8.94$                 | $< 0.001$                                 | $0.058$                                                    |
| Resting heart rate, bpm   | $-3.73 \pm 8.19$                 | $0.018$                                  | $-2.07 \pm 12.58$                 | $0.376$                                   | $0.547$                                                    |
| **Laboratory measurements** |                                  |                                           |                                   |                                           |                                                            |
| Total cholesterol, mg/dl  | $-46.87 \pm 22.43$               | $< 0.001$                                | $-34.48 \pm 16.62$                | $< 0.001$                                 | $0.018$                                                    |
| Serum triglycerides, mg/dl| $-41.03 \pm 45.62$               | $< 0.001$                                | $-19.03 \pm 13.55$                | $< 0.001$                                 | $0.014$                                                    |
| LDL-C, mg/dl              | $-46.3 \pm 21.29$                | $< 0.001$                                | $-37.48 \pm 17.07$                | $< 0.001$                                 | $0.082$                                                    |
| HDL-C, mg/dl              | $7.7 \pm 4.2$                    | $< 0.001$                                | $7.45 \pm 4.66$                   | $< 0.001$                                 | $0.829$                                                    |
| HbA1c, %                  | $-0.53 \pm 1.05$                 | $0.014$                                  | $-1.33 \pm 1.94$                  | $< 0.001$                                 | $0.052$                                                    |
| **Echocardiographic measurements** |                                  |                                           |                                   |                                           |                                                            |
| LVEDD, mm                 | $0.31 \pm 1.17$                  | $0.164$                                  | $-0.08 \pm 1.09$                  | $0.723$                                   | $0.187$                                                    |
| LVESD, mm                 | $-1.03 \pm 1.57$                 | $< 0.001$                                | $-1.35 \pm 1.41$                  | $< 0.001$                                 | $0.014$                                                    |
| LVEF, %                   | $5.31 \pm 3.01$                  | $< 0.001$                                | $5.15 \pm 3.13$                   | $< 0.001$                                 | $0.841$                                                    |

Continuous variables are expressed as mean and standard deviation. BMI means body mass index, BP means blood pressure, LDL-C means low-density lipoprotein cholesterol, HDL-C means high-density lipoprotein cholesterol, HbA1c means glycated hemoglobin, LVEDD means left ventricular end-diastolic diameter, LVESD means left ventricular end-systolic diameter, LVEF means left ventricular ejection fraction
Adherence to the cardiac rehabilitation program

We measured adherence as the number of sessions actually attended of the total 24 sessions. Men were found to be more adherent attending 19.1 ±4.77 (79.6%) sessions compared to women attending 15.7 ± 5.72 (65.4%) sessions (p = 0.015).

Discussion

This was a prospective study conducted on 30 men and 30 women with stable ischemic heart disease who had been fully revascularized by PCI with the aim of assessing gender differences in adherence to a 12-week comprehensive cardiac rehabilitation program and differences in the expected benefits from participating in the program.

The main findings of this study are (1) men were more adherent to the cardiac rehabilitation program. (2) Women joined the program following revascularization after a significantly longer period of time (20 days on average) compared to men. (3) After completion of the program, both men and women had a significant reduction in BMI, waist circumference, blood pressure measurements, total cholesterol, triglycerides, LDL-C, HDL-C, HbA1c, and LVEDD with an increase in LVEF. Men had a significant reduction in resting HR while women did not. (4) On comparing magnitude of change after completion of the program, no differences were observed between men and women except that women had more reduction of diastolic BP and HbA1c, while men had more reduction of total cholesterol and triglyceride levels. (5) The proportion of patients in NYHA functional class 1 increased significantly after completion of the program for both men and women.

Cardiac rehabilitation currently has a class 1 recommendation in patients with stable ischemic heart disease following cardiac surgery or PCI [19–21]. The benefits of participating in the cardiac rehabilitation program provided at our institution were similar to those widely reported in the literature from other institutions [21–24].

Secondary findings of this study included differences observed in baseline characteristics of these stable, revascularized ischemic heart disease patients, where a larger proportion of women were hypertensive and diabetic, had a higher BMI, larger waist circumference, higher HbA1c, and smaller LVEDD. These differences persisted even after completion of the program, except for HbA1c level where the difference became non-significant. Smoking was less prevalent among women at baseline and a smaller proportion of women was employed. After completion of the program, there was no difference between men and women regarding the number of active smokers.

It can be concluded from these secondary findings that women have more risk factors for ischemic heart disease in general (diabetes, hypertension, obesity, and unemployment). Cardiac rehabilitation seems to significantly improve better control of diabetes as assessed by HbA1c level in women.

Several clinical studies reported that women participating in cardiac rehabilitation programs tend to have a high-risk burden, namely, hypertension, diabetes mellitus, obesity, dyslipidemia, and to a lesser extent, smoking. Studies also reported that women who complete such programs gain significant benefits [25–28].

Of note is that compared to other studies, our results show a significantly larger number of active smokers at baseline among men but not among women. This is probably a social and cultural effect as smoking for women is negatively perceived in our society and women are aware of the risks posed by smoking on their children and reproductive health which makes them refrain from smoking. Similar results were found in a study done in Iran [28], while studies performed in Western countries showed no difference between men and women in the proportion of active smokers [25–27].

In contrast to other studies, no difference was noted between men and women in the baseline lipid profile, as other studies found that women tend to have higher levels of total cholesterol, LDL-C and HDL-C [29]. The higher level of HbA1c in women at baseline was reported by others [30].

Adherence to cardiac rehabilitation

Women in our study had a longer time to enrollment compared to men (39.17 ± 40.49 vs. 19.77 ± 10.26 days, p = 0.014). In a systemic review and meta-analysis examining the differences between men and women regarding enrollment in a cardiac rehabilitation program that included 297,219 participants from the year 2000 to 2011, it was concluded that women are 36% less likely to be enrolled in a program and thus less likely to achieve the morbidity and mortality benefits of cardiac rehabilitation. The enrollment rate for men was 45 ± 18.5% vs. 38.5 ± 20.7% for women (p < 0.001) [30].

Using the number of sessions attended as an indicator of adherence to the program, we found that women were less adherent as they attended 15.7 ± 5.72 (65.4%) sessions compared to 19.10 ± 4.77 (79.6%) sessions for men (p = 0.015). Local cultural, social, and educational barriers that face women may be responsible for this outcome. A meta-analysis examining the differences between men and women regarding adherence to a cardiac rehabilitation program that included 8176 participants from fourteen studies reported that the mean adherence rate was 68.6% for men and 64.2% for women. It was concluded that, in general, patients adhere to over two thirds of sessions. However, adherence is significantly lower in women (p < 0.001) [31].
Another study examining the reasons for withdrawal from a 12-month cardiac rehabilitation program in Canada examined 1089 women and 4833 men. Researchers reported that women were more likely than men to withdraw from the program. Causes were attributed to medical problems, especially musculoskeletal problems. Family obligations and transportation were important barriers for women, while work and lack of interest were barriers for men [32].

The same message can be concluded from a recent systemic review examining the barriers and possible solutions to the limited participation of women in cardiac rehabilitation programs. Researchers stated that a complex combination of modifiable and non-modifiable social, economic, medical, psychological, demographic, and medical challenges face women and recommended the search for solutions such as providing home-based programs designed for women to work on this gender gap [33].

Changes observed after completion of the program
Several studies reported changes (benefits) after completion of the program similar to ours. Gender disparity was investigated in a study on 12,976 patients of which 69% completed a cardiac rehabilitation program. They reported that both men and women greatly improved but women were less likely to reach target goals of the American Heart Association/American College of Cardiology (AHA/ACC) in serum triglyceride levels and HbA1c, while they were more likely to achieve them for HDL-C. No gender differences were observed regarding achieving AHA/ACC goals of BP, total cholesterol, LDL-C, BMI, smoking cessation, and medication use [34].

Another study on 858 patients assessed the prevalence of women in cardiac rehabilitation programs and their response to the program. They reported that women represented 24% of participants in their program and that improvement was observed in total cholesterol, triglycerides, LDL-C, HDL-C, fasting blood sugar, HbA1c, and N-terminal pro-brain natriuretic peptide levels in the blood, in addition to, improvements in functional capacity and heart rate recovery [29].

Study limitations
The limitations of the current study are that it comes from a single medical center with a relatively small number of patients. We did not measure the quality of life parameters and did not assess depressive symptoms which have been shown to affect outcome and adherence to cardiac rehabilitation programs in other studies. While nutritional and lifestyle advice was provided to all, actual adherence to such measures at home could not be controlled. The results of this study should be considered with the confounding effect of possible changes in the medication regimen during the 3 months period taken into account.

Conclusion
Men are more adherent to cardiac rehabilitation programs. The recruitment of women is significantly delayed. Women have a higher cardiovascular risk burden in the form of the prevalence of diabetes, hypertension, and obesity. Completion of a cardiac rehabilitation program causes a reduction in BMI, waist circumference, blood pressure measurements, total cholesterol, triglycerides, LDL-C, HDL-C, HbA1c, and LVEDD with an increase in LVEF in both genders. Men show more reduction in resting HR, total cholesterol, and triglyceride levels while women show more reduction in diastolic BP and HBA1c.

Abbreviations
BMI: Body mass index; HbA1c: Glycated hemoglobin; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; LV: Left ventricle; EF: Ejection fraction; LVEDD: LV end-diastolic diameter; LVESD: LV end-systolic diameter; HR: Heart rate; BP: Blood pressure; PCI: Percutaneous coronary intervention; NYHA: New York Heart Association; SPSS: Statistical package for social science; AHA/ACC: American Heart Association/American College of Cardiology

Acknowledgements
Not applicable.

Authors’ contributions
AME analyzed and interpreted the patient data and was a major contributor in writing the manuscript. HMA revised the data set and contributed to writing the manuscript. MMA collected, analyzed, and interpreted the patient data and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

Funding
Not applicable.

Availability of data and materials
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
Approval of Ain Shams University ethical committee was obtained for this study (Committee reference number: not applicable). Written informed consent was provided by all participants.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Received: 2 January 2020 Accepted: 20 March 2020
Published online: 30 March 2020

References
1. Roger VL, Go AS, Lloyd-Jones DM et al (2011) Heart disease and stroke statistics—2011 update: A report from the American Heart Association. Circulation 123:e118–e209
2. Wenger NK (2004) You’ve come a long way, baby: cardiovascular health and disease in women: Problems and prospects. Circulation 109:558–560
3. Mosca L, Mochari-Greenberger H, Dolor RJ et al (Mar 2010) Twelve-year follow-up of American women’s awareness of cardiovascular disease risk
and barriers to heart health. Circulation. Cardiovascular quality and outcomes. 3(2):120–127
4. Shaw LJ, Bugiardini R, Merz CN (2009) Women and ischemic heart disease: evolving knowledge. J Am Coll Cardiol 54:1561–1575
5. Stramba-Badiale M, Fox KM, Priori SG et al (2006 Apr) Cardiovascular diseases in women: a statement from the policy conference of the European Society of Cardiology. Eur Heart J. 27(8):994–1005
6. Shah T, Palaskas N, Ahmed A (2016 May) An update on gender disparities in coronary heart disease care. Curr Atheroscler Rep. 18(5):28
7. Castelli WP (1988) Cardiovascular disease in women. Am J Obstet Gynecol 158:1553–1567
8. Mosca L, Grundy SM, Judelson D et al (1999 May) AHA/ACC scientific statement: consensus panel statement. Guide to preventive cardiology for women. American Heart Association/American College of Cardiology. J Am Coll Cardiol. 33(8):1751–1755
9. Melloni C, Berger JS, Wang TY et al (2010 Mar) Representation of women in randomized clinical trials of cardiovascular disease prevention. Circ Cardiovasc Qual Outcomes. 3(2):135–142
10. Tunstall-Pedoe H, Kuulasmaa K, Mahonen M et al (1999 May 8) Contribution of trends in survival and coronary-event rates to changes in coronary heart disease mortality: 10-year results from 37 WHO MONICA project populations. Monitoring trends and determinants in cardiovascular disease. Lancet. 353(9166):1547–1557
11. Oldridge NB, Guyatt GH, Fischer ME et al (1988 Aug 19) Cardiac rehabilitation after myocardial infarction. Combined experience of randomized clinical trials. JAMA. 260(7):945–950
12. Witt BJ, Jacobsen SJ, Weston SA et al (2004 Sep 1) Cardiac rehabilitation after myocardial infarction in the community. J Am Coll Cardiol. 44(5):988–996
13. Raphael C, Briscoe C, Davies J et al (2007) Limitations of the New York Heart Association functional classification system and self-reported walking distances in chronic heart failure. Heart 93:476–482
14. Elagizi A, Kachur S, Lavie CJ et al. An overview and update on obesity and the obesity paradox in cardiovascular diseases. Prog Cardiovasc Dis 55(1):38–55.
15. Friedewald WT, Levy RI, Fredrickson DS (1972 Jun) Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 18(6):499–502
16. Chetrit M, Roujol S, Picard MH et al. Optimal technique for measurement of linear left ventricular dimensions. J Am Soc Echocardiogr. 2019 Apr;32(4):476–483.e1.
17. Schiller NB, Shah PM, Crawford M et al (2009) Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. J Am Soc Echocardiogr. 2:358–367
18. Jae SY, Kurf S, Lauknken JA, et al. Exercise Heart Rate Reserve and Recovery as Predictors of Incident Type 2 Diabetes. Am J Med. 2016 May;129(5):536.e7-536.e12.
19. Fihn SD, Gardin JM, Abrams J et al. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. J Am Coll Cardiol. 2012;60(14):e144–e164.
20. Knutti J, Wijns W, Saraste A et al (2019) ESC Guidelines for the diagnosis and management of chronic coronary syndromes. Eur Heart J. (2019 Aug 31).
21. Simon M, Korn K, Cho L et al (2018 Jul) Cardiac rehabilitation: a class 1 recommendation. Cleve Clin J Med. 85(7):551–558
22. Kachur S, Chongthammakun V, Lavie CJ et al (2017) Impact of cardiac rehabilitation and exercise training programs in coronary heart disease. Prog Cardiovasc Dis 60(1):103–114
23. Solestannejad K, Nouzari Y, Ahsani A et al (2014) Evaluation of the effect of cardiac rehabilitation on left ventricular diastolic and systolic function and cardiac chamber size in patients undergoing percutaneous coronary intervention. J Tehran Heart Cent. 9(2):54–58
24. Lavie CJ, Milani RV (2011 May-Jun) Cardiac rehabilitation and exercise training in secondary coronary heart disease prevention. Prog Cardiovasc Dis. 53(6):397–403
25. Sanderson BK, Bittner V (2005 Nov) Women in cardiac rehabilitation: outcomes and identifying risk for dropout. Am Heart J. 150(5):1052–1058
26. Cannistra LB, Balady GJ, O’Malley CJ et al (1992 May 15) Comparison of the clinical profile and outcome of women and men in cardiac rehabilitation. Am J Cardiol. 69(16):1274–1279
27. Thomas RJ, Miller NH, Lamendola C et al (1996 Nov-Dec) National survey on gender differences in cardiac rehabilitation programs. Patient characteristics and enrollment patterns. J Cardiopulm Rehabil. 16(6):402–412
28. Sarrafzadeh N, Rabiei K, Shirani S et al (2007 Apr) Drop-out predictors in cardiac rehabilitation programmes and the impact of sex differences among coronary heart disease patients in an Iranian sample: a cohort study. Clin Rehabil. 21(4):362–372
29. Anjo O, Santos M, Rodrigues P et al (2014) The benefits of cardiac rehabilitation in coronary heart disease: A gender issue? Rev Port Cardiol. 33:79–87
30. Samayo L, Grace SL, Gravely S et al (2014 Jul) Sex differences in cardiac rehabilitation enrollment: a meta-analysis. Can J Cardiol. 30(7):793–800
31. Osenbrug E, Marinho RP, Zhang J et al (2016 Nov) Sex differences in cardiac rehabilitation adherence: A Meta-analysis. Can J Cardiol. 32(11):1316–1324
32. Marzolini S, Brooks D, Oh PI (2008) Sex differences in completion of a 12-month cardiac rehabilitation programme: an analysis of 5922 women and men. Eur J Cardiovasc Prev Rehabil. 15:698–703
33. Supervia M, Medina-Inojosa JR, Yeung C et al (2017 Mar) Cardiac Rehabilitation for women: a systematic review of barriers and solutions. Mayo Clin Proc. 13
34. Turk-Adawi KI, Oldridge NB, Vtcendra MJ et al (2016 May-Jun) Secondary prevention recommendation attainment with cardiac rehabilitation: is there a gender disparity? Womens Health Issues. 26(3):278–287

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.