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Original Article

Impact of Cardiac Rehabilitation Schedule on Cardiovascular Compliance in Patients with Coronary Artery Disease Undergoing Coronary Artery Bypass Surgery or Angioplasty

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Keywords
Cardiac rehabilitation; Coronary artery bypass surgery; Percutaneous transluminal angioplasty

Abstract

Background: In Iran, coronary artery disease (CAD) is responsible for the highest cardiovascular mortality rate. Many studies show significant improvements in cardiovascular status in patients with CAD and undergoing percutaneous transluminal coronary angioplasty (PTCA) or coronary artery bypass grafting (CABG) after cardiac rehabilitation (CR) programs. In this study, the impacts of CR were evaluated on Iranian patients who had undergone CABG or PTCA.

Methods: This single-center, case-crossover study was conducted on 69 patients with CAD; 39 and 30 patients had undergone PTCA and CABG, respectively. The patients completed a 24-session structured multidisciplinary CR program. Exercise tolerance testing, echocardiographic data, and laboratory parameters were recorded before and after the program.

Results: Mean age of the subjects was 62.8 years, and 14.5% of them were women and 85.5% were men. The most frequent risk factors for CAD in the study population were systolic hypertension (42.0%) followed by current smoking (27.5%) and diabetes mellitus (24.5%). Compared with pre-CR, the metabolic equivalent (MET) attained was significantly increased after completion of the CR program (P = 0.002). Significant improvements in left ventricular ejection fraction (LVEF) (P = 0.012) and high density lipoprotein (LDL) (P = 0.005), and decrease in serum triglycerides (TG) (P = 0.046) were reported after CR. In the above-mentioned parameters, no differences were seen between the PTCA or CABG groups. Moreover, men and women benefited from CR programs to the same degree.

Conclusion: CR after PTCA or CABG significantly improved exercise capacity and cardiovascular risk factors. No significant differences were detected between these two groups. These preliminary data suggest that CR must be offered to cardiac patients and such courses must be accepted by insurance companies as an integrated medical program which cannot be ignored in the management of patients.

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Introduction

Cardiovascular disease (CVD) remains the leading cause of death and disability in many countries. In Iran, coronary artery disease (CAD) is responsible for the highest cardiovascular mortality rate.[1] Lack of physical activity is a well-known risk factor for CAD.[2] In the US Railroad Study, caloric expenditure of activity performed at any intensity, even light and moderate activity, showed relationship to cardiovascular death and all-cause mortality.[3] These associations were slightly stronger in occupationally sedentary men.[3]

Many studies in Iran and other countries show significant improvements of cardiovascular status in patients with CAD undergoing percutaneous transluminal coronary angioplasty (PTCA) or coronary artery bypass grafting (CABG) after cardiac rehabilitation (CR) programs.[4-11] CR can also enhance quality of life (QOL) and independence. In the US, CR after PTCA or CABG is covered by insurance services.[12] In Germany, CR has been based on specific laws and the regulations of insurance providers since 1885; CR is mainly offered after an acute cardiac event and CABG. It is also recommended in severe heart failure and special cases of PTCA. After CABG or acute coronary syndrome, CR can usually be started within 10 days. The multidisciplinary rehabilitation team consists of cardiologists, psychologists, exercise therapists, social workers, nutritionists, and nurses. The positive effects of CR are also important economically, for example, improvement of secondary prevention and vocational integration.[13]

A cohort study on 418 patients (70% were men) with CAD enrolled in CR programs, showed that the parameters that significantly predicting mortality included older age, diabetes, low exercise capacity [≤ 4 metabolic equivalents (METs)], 3-vessel disease, lack of PTCA performance, and a low ejection fraction.[14] The lung function is identified as a predictor of time of hospitalization in heart surgery. Moreover, the 6-minute walk test (6MWT) has been used to establish the functional capacity of cardiac patients. In a prospective cohort study on 18 patients, it was shown that patients with increased postoperative capacity to walk have a shorter time of hospitalization.[15] Their study findings also suggested that the distance in the 6MWT can better represent the functional capacity of these patients than pulmonary function alone.[15]

Although strong evidence exists that CR is an important component of recovery from coronary events, unfortunately the rate of uptake of and adherence to such programs are below the recommended levels.[16-26] Some authors have recently emphasized on factors like patient's age, gender and pre-rehabilitation cardiac procedures. The Italian Survey on Cardiac Rehabilitation-2008 (ISYDE-2008) showed that women are less frequently admitted to CR than men.[18] In addition, the women admitted to CR were older, and were at a greater cardiovascular risk compared to men.[18]

Methods

This single-center, case-crossover study was conducted on 69 consecutive coronary patients during 2016-2017; 39 patients had undergone PTCA (at least 3 weeks before) and 30 patients had undergone CABG (at least 4 weeks before). Those with underlying systemic, neurological or orthopedic conditions as impediments for exercise testing or rehabilitation training were excluded. All participants were referred by cardiologists. A medical file comprising medical history and physical examination was filled out for each patient. Then, a physiatrist visited the subjects and the rehabilitation program was ordered based on the patient's general condition and results of submaximal exercise tolerance test. After each 3 sessions, the patients were visited by the prescribing physiatrist and the program was re-evaluated based on tolerance.

The rehabilitation program was comprised of 24 exercise sessions of structured CR program 3 times a week scheduled over 8

weeks. An ergometer or treadmill (Ergoline GmbH, Germany) were used alternatively for each patient. The rehabilitation program was performed as an in-hospital program from the beginning to the last session. Each session took 30-45 minutes; beginning with 5-10 minutes of warm-up, followed by 20-25 minutes of aerobic exercise, and was terminated with 5-10 minutes of cool-down. The exercise was performed under electrocardiographic monitoring supervised by a professional nurse and a physiatrist. Exercise parameters, laboratory indices, and left ventricular ejection fraction (LVEF) (measured by 2-dimensional echocardiography) were recorded before and after the CR program. For submaximal exercise testing, the Bruce protocol was used. All patients were visited by a psychologist and a nutritionist at least once during the course of the program.

Statistical analysis: Data were analyzed in SPSS software (version 18.1, SPSS Inc., Chicago, IL, USA). For comparison between pre-rehabilitation and post-rehabilitation results, paired t-test and Wilcoxon signed-rank test were used. For comparison between two independent groups (male vs. female, and CABG vs. PTCA), independent t-test and Mann-Whitney test were used. For comparison between the three age groups (< 55, 55-70, and ≥ 70 years), ANOVA and Kruskal-Wallis test were used.

Results

Mean age of the subjects was 62.80 ± 10.16 years. Of these patients, 10 (14.5%) were women and 59 (85.5%) were men.

The most frequent risk factors for coronary disease in the study population were systolic hypertension (42.0%) followed by current smoking (27.5%) and diabetes mellitus (24.5%) (Table 1).

Table 1. Risk factors (n = 69)

Risk Factors (by history)	n (%)
HTN	29 (42)
DM	17 (24.5)
Smoking	19 (27.5)
HLP	0
Family history of CAD	14 (20.3)

HTN: Hypertension; DM: Diabetes mellitus; HLP: Hyperlipidemia; CAD: Coronary artery disease

Compared with pre-CR, the metabolic equivalent attained was significantly increased after completion of the CR program (P = 0.002). Significant improvements in LVEF (P = 0.012), increase in high density lipoprotein (P = 0.005), and decrease in serum triglycerides (TG) (P = 0.046) were reported after CR (Table 2).

Table 2. General comparison between individuals before and after cardiac rehabilitation

	Pre-CR	Post-CR	r	P
LVEF (%)	51.91 ± 11.13	53.96 ± 10.03	0.822	0.012
METs	8.60 ± 2.39	11.29 ± 15.67	0.311	0.002
Treadmill time (minute)	10.35 ± 2.15	10.52 ± 2.07	0.271	0.597
HR_R (b/minute)	77.91 ± 14.51	80.19 ± 12.30	0.320	0.242
HR_E (b/minute)	132.32 ± 16.33	136.64 ± 13.31	0.131	0.081
SBP_R (mmHg)	117.39 ± 11.80	119.24 ± 13.50	0.312	0.367
DBP_R (mmHg)	76.02 ± 14.12	77.31 ± 14.96	0.430	0.375
SBP_E (mmHg)	147.14 ± 15.12	148.38 ±17.24	0.284	0.468
DBP_E (mmHg)	87.52 ± 5.99	89.49 ± 13.44	0.108	0.420
FBS (mg/dl)	111.68 ± 41.93	129.14 ± 156.41	0.137	0.795
TG (mg/dl)	144.36 ± 68.55	131.17 ± 49.96	0.625	0.046
CHOL (mg/dl)	151.49 ± 39.79	147.79 ± 33.18	0.490	0.413
LDL (mg/dl)	83.61 ± 25.78	78.01 ± 22.60	0.538	0.082
HDL (mg/dl)	40.45 ± 11.77	44.75 ± 12.16	0.606	0.005

Data are presented as mean ± SD

LVEF: Left ventricular ejection fraction; CR: Cardiac Rehabilitation; r: Correlation coefficient; METs: Metabolic equivalents; HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; R: Rest; E: Exercise; FBS: Fasting blood sugar; TG: Triglycerides; CHOL: Cholesterol; LDL: Low density lipoprotein; HDL: High density lipoprotein

Table 3. Effect of procedure (CABG vs. PCI) on pre and post rehabilitation differences of cardiac indices

	Pre and post rehabilitation difference in CABG patients	Pre and post rehabilitation difference in PTCA patients	P
LVEF (%)	3.27 ± 6.71	1.12 ± 6.08	0.126
METs	0. 63 ± 2.03	4.25 ± 19.91	0.723
Treadmill time (minute)	-0.75 ± 3.34	0.87 ± 2.50	0.029
HR_R (b/minute)	1.28 ± 18.14	3.02 ± 13.90	0.660
HR_E (b/minute)	7.50 ± 22.05	1.91 ± 17.57	0.260
SBP_R (mmHg)	-1.42 ± 15.56	4.26 ± 14.13	0.108
DBP_R (mmHg)	-2.67 ± 21.79	4.23 ± 18.54	0.339
SBP_E (mmHg)	-3.65 ± 21.09	4.67 ± 17.67	0.200
DBP_E (mmHg)	2.34 ± 8.33	1.70 ± 17.17	0.230
FBS (mg/dl)	40.26 ± 236.46	-3.61 ± 30.02	0.370
TG (mg/dl)	-8.96 ± 61.19	-16.43 ± 48.24	0.573
CHOL (mg/dl)	4.60 ± 44.60	-10.07 ± 29.52	0.105
LDL (mg/dl)	-8.20 ± 27.67	-3.58 ± 19.76	0.473
HDL (mg/dl)	2.91 ± 13.39	5.36 ± 7.98	0.410

Data are presented as mean ± SD

LVEF: Left ventricular ejection fraction, r: Correlation coefficient; METs: Metabolic equivalents; HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; R: rest; E: exercise; FBS: Fasting blood sugar; TG: Triglycerides; CHOL: Cholesterol; LDL: Low density lipoprotein; HDL: High density lipoprotein; CABG: Coronary artery bypass grafting

In the abovementioned parameters, no differences were seen between the PTCA or CABG groups (Table 3). Furthermore, men and women took benefit from CR programs to the same degree (Table 4).

Pre and post rehabilitation values for LVEF, metabolic equivalent (METs), serum TG, and high density lipoprotein (HDL) showed significant improvements after the rehabilitation program. The highest correlation coefficient was recorded for LVEF (0.82) followed by lipid profile; 0.63 for TG, 0.60 for HDL, 0.54 for low density lipoprotein (LDL), and 0.49 for total cholesterol (Table 2).

Comparing the three age groups, the only variable which showed a significant change was METs; that is, it was improved better in those aged 55-70 years than subjects in other age groups (Table 5).

Discussion

Many studies in Iran and other countries have shown significant improvements in cardiovascular compliance among patients with CAD and undergoing PTCA or CABG after CR programs.[4-11]

Table 4. Effect of gender on pre and post rehabilitation differences of cardiac indices

	Pre and post rehabilitation difference among men	Pre and post rehabilitation difference among women	P
LVEF (%)	1.76 ± 6.32	3.88 ± 6.97	0.360
METs	2.98 ± 16.39	1.13 ± 2.44	0.927
Treadmill time (minute)	0.10 ± 2.1	0.57 ± 3.55	0.583
HR_R (b/minute)	0.85 ± 16.01	10.30 ± 11.73	0.080
HR_E (b/minute)	2.92 ±19.71	12.00 ± 18.49	0.182
SBP_R (mmHg)	2.33 ±15.76	-1.00 ± 8.75	0.526
DBP_R (mmHg)	2.96 ± 16.70	-8.00 ± 33.26	0.824
SBP_E (mmHg)	-0.03 ± 19.96	8.00 ± 15.49	0.205
DBP_E (mmHg)	1.39 ± 14.93	5.00 ± 8.49	0.077
FBS (mg/dl)	17.06 ± 168.91	6.00 ± 24.31	0.898
TG (mg/dl)	-11.66 ± 54.57	-22.20 ± 51.96	0.572
CHOL (mg/dl)	-1.06 ± 36.42	-19.20 ± 40.42	0.156
LDL (mg/dl)	-4.34 ± 22.33	-12.00 ± 29.03	0.375
HDL (mg/dl)	4.02 ± 10.66	5.66 ± 10.98	0.677

Data are presented as mean ± SD

LVEF: Left ventricular ejection fraction; r: Correlation coefficient; METs: Metabolic equivalents; HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; R: rest; E: exercise; FBS: Fasting blood sugar; TG: Triglycerides; CHOL: Cholesterol; LDL: Low density lipoprotein; HDL: High density lipoprotein

Table 5. Effect of age on pre and post rehabilitation differences of cardiac indices

	Pre and post rehabilitation difference in the < 55 years age group	Pre and post rehabilitation difference in the 55-70 years age group	Pre and post rehabilitation difference in the ≥ 70 years age group	P
LVEF (%)	0.23 ± 6.39	1.75 ± 6.26	1.95 ± 6.86	0.280
METs	0.33 ± 2.19	3.63 ± 20.24	1.77 ± 2.49	0.029
Treadmill time (minute)	0.05 ± 2.27	-0.11 ± 3.11	0.59 ± 3.00	0.618
HR_R (b/minute)	4.35 ± 14.40	1.69 ± 14.77	1.59 ± 16.96	0.826
HR_E (b/minute)	2.52 ± 22.92	0.69 ± 15.73	8.66 ± 22.83	0.475
SBP_R (mmHg)	0.58 ± 12.48	2.77 ± 16.49	2.81 ± 12.55	0.881
DBP_R (mmHg)	-5.88 ± 26.47	-0.13 ± 10.31	8.68 ± 22.09	0.156
SBP_E (mmHg)	0.31 ± 18.11	-1.20 ± 18.41	3.00 ± 22.44	0.622
DBP_E (mmHg)	-0.93 ± 5.83	1.88 ± 18.06	2.40 ± 7.14	0.526
FBS (mg/dl)	-20.11 ± 52.05	-7.94 ± 40.85	62.52 ± 262.96	0.097
TG (mg/dl)	-17.88 ± 62.82	-15.13 ± 47.60	-9.52 ± 53.74	0.892
CHOL (mg/dl)	-14.05 ± 39.20	3.26 ± 41.08	-6.91 ± 25.15	0.221
LDL (mg/dl)	-7.93 ± 26.47	-0.35 ± 23.98	-8.84 ± 21.52	0.525
HDL (mg/dl)	5.35 ± 8.41	5.00 ± 6.62	4.36 ± 15.35	0.885

Data are presented as mean ± SD

LVEF: Left ventricular ejection fraction, r: Correlation coefficient; METs: Metabolic equivalents; HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; R: rest; E: exercise; FBS: Fasting blood sugar; TG: Triglycerides; CHOL: Cholesterol; LDL: Low density lipoprotein; HDL: High density lipoprotein

In addition, CR programs have been shown to be beneficial in post-myocardial infarction (MI) patients.[19]

CR is a fundamentally comprehensive intervention composed of exercise training, risk factor education, psychological support, life-style behavior changes, and multiple approaches to handling common coronary heart disease (CHD) risk factors. Activity is the best medicine.[20]

In a prospective randomized clinical trial on 134 patients with CAD, Hansen et al. compared 40-minute and 60-minute exercise training sessions of a 7-week rehabilitation program.[21] As a result of rehabilitation, exercise capacity, ventilatory threshold, and blood plasma lipid profile improved significantly in the total population ($P < 0.050$), without differences between subgroups ($P > 0.050$). Body weight and waist circumference decreased significantly in the total population ($P < 0.010$), but with a greater magnitude in the 40-minute exercise session group compared to the 60-minute exercise session group ($P < 0.050$).[21] In the present study, pre and post rehabilitation values for LVEF, METs, serum TG, and HDL showed significant improvements after the CR program. The highest correlation coefficient was recorded for LVEF (0.82) followed by lipid profile; 0.63 for TG, 0.60 for HDL, 0.54 for LDL, and 0.49 for total cholesterol.

Although in the present study no one reported hyperlipidemia in his/her medical history, hyperlipidemia plays a strong role in CAD and is the second major risk factor in Isfahan, Iran. In a study on the effect of CR on serum lipids among 120 patients, it was shown that in the intervention group, total cholesterol, TG and LDL cholesterol (LDL-C) decreased in 42 (70%), 36 (62%), and 46 (76%) patients respectively, and HDL-C increased in 52 (86%) patients.[22] A 20 mg, 56 mg/dl, and 30 mg/dl reduction in total cholesterol, TG, and LDL-C were noted after 8 weeks of intervention, respectively. There was a 0.8 mg/dl reduction in LDL-C/HDL-C ($P < 0.050$) and 5 mg/dl increase in serum HDL-C ($P < 0.050$) in the intervention group compared to the control group.[22]

It has been shown in previous studies that there is an association between treadmill time and coronary disease risk factors especially lipid profile and obesity.[23] The present study showed that treadmill time was improved in

patients who enrolled in a CR program after PTCA, but not in the CABG group. It has been shown in the literature that each 1 MET increase in exercise capacity conferred a 12% improvement in survival.[24] Among our defined age groups, middle aged patients (55-70 years old) benefited most from CR with regard to the improvement in METs. MET as an indicator for energy cost of physical activity is directly affected by patients' age. It has been demonstrated that older patients achieved a lower workload measured by MET in comparison with younger patients.[25]

Patients undergoing cardiac procedures benefit from CR in the preservation of carrier status. Appropriate supportive protocols guarantee return to work (RTW) after CR and improve patients' attitude toward continuing their jobs. In a prospective follow-up study conducted in Tehran Heart Center, Iran, 246 consecutive patients undergoing different types of cardiac procedures between May and September 2007 were studied.[26] They found that rehabilitated patients in comparison with control group had higher rates of RTW 3 months (55.4% vs. 26.2%) and 8 months (94.7 vs. 81.0%) after CR. Moreover, positive attitude toward RTW was observed more in rehabilitated patients 3 months and 8 months after cardiac procedures. In addition, CR programs (OR: 3.507, P = 0.027), preoperative functional class (OR: 6.541, P < 0.001), experience of regular physical activity at home before RTW (OR: 3.836, P = 0.004), and job support programs (OR: 4.050, P = 0.022) were the main predictors for RTW 8 months after cardiac procedures.[26] Smith and O'Rourke found that employment-related physical activity and perception of health status were significant predictors of RTW.[27]

In a prospective randomized study on 137 male patients who underwent an uncomplicated coronary revascularization procedure, 2 types of CR, physical training plus information about their disease during 6 weeks was compared with comprehensive CR which included weekly psycho-education sessions and relaxation therapy for 8 weeks.[18] QOL improved in both treatment groups in the course of time up to 9 months after CR and there was no difference between the two types of CR. Exercise capacity improved likewise, blood lipid profile was unaffected and energy intake decreased in each treatment group, but, again, there were no inter-group differences.[18]

After CABG, patients' are prescribed a complex drug regime and recommended to adopt a healthy lifestyle, including smoking cessation, diet, moderate exercise, and psychological stress control. The adherence to these behaviors is usually voluntarily adopted early after CABG, but becomes more difficult in the long term.[28]

Although there are numerous reports of the desirable effects of CR on patients after CABG or PTCA, we have to take caution on our results, and we need strong clinical trials and meta-analyses to better support the theories behind the effects of exercise.[20,28]

Conclusion

Patients undergoing cardiac procedures benefit from CR in the preservation of work status. The need for appropriate supportive protocols can guarantee RTW after CR and improve patients' attitude toward continuing their jobs. Furthermore, we believe that job support from employers such as insurance support or a redesigning of the job description to allow the person to perform the job would be necessary. In addition, long-term follow-up of the patients is necessary for evaluating their adherence to a healthy life style.

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None

Conflict of Interest

Authors have no conflict of interest.

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