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Cross-sectional Study

The effect of cardiac rehabilitation on left and right ventricular function in post primary PCI patients☆

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ABSTRACT

Objective: Acute myocardial infarction is the most severe manifestation of coronary artery disease. Cardiac rehabilitation programs following percutaneous coronary intervention (PCI) assist patients to get back to their daily routine and can improve their cardiovascular health. The aim of this study was to evaluate the effect of cardiac rehabilitation in patients after primary PCI on the left and right ventricular function.

Methods: In this cross-sectional study, patient who underwent primary PCI following myocardial infarction were included. Month after the PCI procedure, 5 sessions of cardiac rehabilitation program were performed based on the patient's symptoms and according to the diagnosis by cardiologist. The duration of each rehabilitation session started from 20 min in the first session and reached 60 min in the last session. Exercises included walking on a treadmill and pedaling a stationary bike with limbs. Ventricular function was assessed after primary PCI and after the rehabilitation program. Patients were followed up by telephone after one year of the rehabilitation program.

Results: 30 patients were enrolled in the study, 23 of whom were male (76.7%). Right ventricular function did not change after the cardiac rehabilitation program compared to before ($p = 1.00$). Left ventricular function significantly increased after rehabilitation ($p = 0.003$). Increased left ventricular function was significant only in males ($p < 0.001$). Cardiac rehabilitation program in people over 60 years did not change left ventricular function ($p < 0.05$). One year after the cardiac rehabilitation program, 3 patients (10%) died.

Conclusion: The findings of our study showed that the implementation of an exercise-based cardiac rehabilitation program improves left ventricular function in patients with myocardial infarction after primary PCI but does not affect right ventricular function. The findings also showed that cardiac rehabilitation program may be associated with the gender and the age of the patients.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of death and disability, and acute myocardial infarction (AMI) is the leading cause of death from cardiovascular disease in certain age groups [1–3]. Survival following AMI is dependent on rapid medical care which is categorized as medication and percutaneous coronary intervention (PCI) and life-style changes (diet, smoking, psychosocial factors, physical inactivity), including the promotion of physical exercise [2,4].

A cardiac rehabilitation program has been shown to reduce coronary events and mortality in those patients with AMI [5,6]. The programs usually include personal assessment of the patient, counseling about physical activity, exercise, nutritional advice, weight management, fat and blood pressure control, smoking cessation, and psychosocial management [7,8].

Due to the importance of the issue and social and economic reasons, basic measures for primary and secondary prevention for patients are necessary. Secondary prevention strategies include medication and coronary artery bypass surgery with effective cardiac rehabilitation programs [9–11]. Participation of patients with cardiovascular disease in cardiac rehabilitation and prevention programs has been accepted by patients in recent decades and has also increased [12,13].

☆ Written consent was obtained and the study was approved by the institutional review board under the code of ethics IR.GOUMS.REC.1399.316. https://ethics.research.ac.ir/ProposalCertificate.php?id=170823&Print=true&NoPrintHeader=true&NoPrintFooter=true&NoPrintPageBorder=true&LetterPrint=true.

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Cardiac rehabilitation programs are a proven treatment for patients with CVD that use a combination of lifestyle and risk factor management to improve psychological outcomes, reduce premature mortality and CVD events [14].

Cardiac rehabilitation programs are needed to limit the physical and psychological effects of cardiovascular disease, reduce the risk of sudden death or recurrence, control the symptoms of atherosclerosis, and stabilize and reverse the process of atherosclerosis and improve psychosocial status [15,16]. According to clinical studies, cardiac rehabilitation is a useful method for correcting cardiac risk factors such as hypertension, hyperlipidemia, diabetes, obesity, smoking and reducing anxiety and depression after heart surgery [17,18].

Cardiac rehabilitation is classified into three stages, which include the following: The diagnosis of the disease from the time of hospitalization and includes care, education to the patient and family and coronary therapies. The second stage is 2–4 weeks after discharge from the hospital and includes a recovery period and an outpatient exercise training program under the supervision for 2–3 months with the aim of returning the patient to sporting capacity appropriate to his health status, lifestyle modification, meeting the patient's psychological needs and help to return to activities and job. Lastly, self-centered care program at home, which focuses on maintaining cardiovascular stability and physical condition for a long time [19].

The aim of this study is to evaluate the effect of cardiac rehabilitation in post-primary PCI patients on left and right ventricular function following myocardial infarction.

2. Methods

In this cross-sectional study, patients who underwent primary PCI at the hospital of Hospital of (XXX, during our study period from June 2019–June 2020 were enrolled. Patients aged above 20, at least one myocardial infarction and those who underwent PCI were included in the study. Written consent was obtained from all the patients for the participation in the study. Patients who did not complete the cardiac rehabilitation and training process or those who were previously enrolled in such programs were excluded from the study. Patients with primary diagnosis of cardiac failure, vascular failure or the history of myocardial infarction 6 months prior to the enrollment were also excluded.

Sample size: According to the studies of Stecki et al. (51) and considering the mean rehabilitation of heart pre-test 67.40 and standard deviation 6 and the average rehabilitation of post-cardiac test 15.46 and standard deviation 6 with 90% power (second type error 10%) and first type error 0.05 (95% confidence interval) using the following formula, 25 samples were obtained in each group, which was rounded off to 30 samples with a probability of 20% loss.

The process of rehabilitation program for patients after initial PCI was as follows:

One month after the treatment procedure, 5 rehabilitation programs were performed according to the patient's physical condition based on the decision of a cardiologist. The duration of each rehabilitation session started from 20 min in the first session and reached 60 min in the last session, during which the patient exercised actively. The rehabilitation program was performed weekly, and 2 to 3 sessions were held for patients per week. Treadmill and stationary bicycle tools were used to perform the rehabilitation program. The process of doing the exercise with each tool was as follows:

1) Walking on a treadmill: The speed of the treadmill changed from 1.5 Mil/h to 5 Mil/h with more than 5–10° (the speed and inclination of the treadmill increased during the sessions).
2) Pedal and stationary bike with foot: Bike with foot increased from 15 W in the first session for 15 min to 15 W and 20 min in the last sessions.
3) Fixed hand bike riding: The program was set from 5 W for 5 min in the first session to 5 W and 20 min in the final session.

During rehabilitation sessions, the patient underwent cardiac monitoring and the patient's vital signs were closely monitored and recorded. At the end of the sessions, cardiac function was re-evaluated by echocardiography. The demographic information of the patients was extracted from the patients' files and recorded in a checklist made by the researcher based on the objectives of the study.

The data was entered in SPSSv18 for statistical analysis. To describe quantitative variables, mean ± standard deviation, and to describe qualitative variables, the frequency distribution test was used to report the number and percentage of cases. Shapiro-Wilk test was used to evaluate the normality of quantitative data distribution. Wilcoxon test was used to compare left ventricular function before and after rehabilitation because of non-normal data distribution and paired *t*-test was used in gender groups and age groups due to normal data differences. McNemar test was used to compare right ventricular function due to its quality and duality. Significance level was considered less than 0.05 in all tests.

Written consent was obtained and the study was approved by the institutional review board under the code of ethics (XXX).

The unique identification number is: research registry 7824.

The methods were stated in accordance with STROCSS 2021 guidelines [20].

3. Results

In the present study, 30 patients participated and all of them followed up the study till the end. Of these, 7 patients were female, and 23 patients were male. The mean age of participants in the study was 57.1 ± 10.96 years (range 34–78 years).

Determination of changes in cardiac function after rehabilitation program.

Changes in cardiac function were calculated as changes in right and left ventricular function by echocardiography once after angioplasty (before the rehabilitation program) and once after the rehabilitation program. Right ventricular function before and after rehabilitation program did not change significantly, $p = 1.00$.

The mean of left ventricular ejection fraction before and after rehabilitation was 42.41 ± 8.92% and 46.11 ± 6.98%. The difference in the left ventricular function at these two intervals was statistically significant, $p = 0.003$(Table 1). In terms of gender distribution, the difference in left ventricular ejection fraction before and after rehabilitation in men before and after rehabilitation was 41.43 ± 8.82% and 46.19 ± 6.31%, which was significantly different, $p < 0.001$. This difference was no significant in females, $p = 1.00$(Table 2).

Based on different age group, left ventricular ejection fraction was significantly different before and after rehabilitation in patients aged less than 45 years and those between 45 and 60 years of age, $p = 0.043$ and $p = 0.022$, respectively. However, there was no such difference among patients aged more than 60 years, $p = 0.307$(Table 3).

Patients were followed-up on phone call after a year. 3 patients (10%) had died, 6 (20%) reported no change in their health whereas, 21 (70%) reported betterment in their overall health. Among these 21 patients, mean duration for the betterment of their symptoms was 2.67 ± 1.8 weeks and among 27 patients who returned to their jobs, mean duration was the return was 4.92 ± 1.4 weeks.

Table 1
Comparison of left ventricular function after rehabilitation program compared to before.

	SD ± Mean	Min	Max	p-value
LVeF % Before rehabilitation	42.42 ± 8.92	25	55	0.003
LVeF %After rehabilitation	46.11 ± 6.98	30	55	

Table 2
Comparison of left ventricular function after rehabilitation program compared to before by gender.

		SD ± Mean	Min	Max	p-value
Female	LVeF % Before rehabilitation	45.83 ± 9.17	35	55	1.00
	LVeF %After rehabilitation	45.83 ± 9.70	30	55	
Male	LVeF % Before rehabilitation	41.43 ± 8.82	25	55	<0.001
	LVeF %After rehabilitation	46.19 ± 6.31	35	55	

Table 3
Comparison of left ventricular function after rehabilitation program compared to before by age group.

		SD ± Mean	Min	Max	p-value
45 > yr	LVeF % Before rehabilitation	43.33 ± 9.83	35	55	0.043
	LVeF %After rehabilitation	50.00 ± 4.47	45	55	
45–60yr	LVeF % Before rehabilitation	42.50 ± 8.58	25	55	0.022
	LVeF %After rehabilitation	46.50 ± 8.18	30	55	
60<	LVeF % Before rehabilitation	41.82 ± 9.56	30	55	0.307
	LVeF %After rehabilitation	43.64 ± 6.36	35	55	

4. Discussion

The aim of this study was to evaluate the effect of a rehabilitation program in myocardial infarction patients after primary PCI on right and left ventricular function. Echocardiographic findings showed that performing these exercises on right ventricular function was unchanged compared to after initial PCI. However, rehabilitation exercises led to an improvement in left ventricular function after rehabilitation, which was significant.

In a clinical trial in Brazil, Mendes et al., evaluated the effects of exercise-based rehabilitation on cardiac performance among PCI patients. The findings of the study showed that performing cardiac rehabilitation exercise improves the left ventricular function of patients under primary PCI, which is in line with the findings of our study [21]. The study by Zoroufian et al. showed that despite the gradual improvement in RV function parameters after CABG, this improvement was independent of the exercise-based cardiac rehabilitation program [22]. In a study by Acar et al., it was shown that in patients with acute myocardial infarction, performing an exercise-based cardiac rehabilitation program improves left atrial and ventricular function. In another study, this research group showed that performing a cardiac rehabilitation program based on exercise leads to improved ventricular and left atrial function as well as aortic stiffness [23,24]. Madoka Sunamura et al., evaluated the post-primary PCI rehabilitation program in 2018 and concluded that rehabilitation for post-primary PCI myocardial infarction increases 5- and 10-year survival rates compared to patients who do not undergo cardiac rehabilitation. In their study, they stated that the cumulative mortality rate at 5 and 10 years after the cardiac rehabilitation program is 4.6% and 7.14%, respectively [25]. The findings of the present study showed that 10% of patients died one year after the implementation of the cardiac rehabilitation program, which is inconsistent with the findings of the study of Sunamura et al., evaluated the post-primary PCI rehabilitation program in 2018 and concluded that rehabilitation following myocardial infarction increases 5- and 10-year survival rates compared to patients who do not undergo cardiac rehabilitation. In their study, they stated that the cumulative mortality rate at 5 and 10 years after the cardiac rehabilitation program is 4.6% and 7.14%, respectively. The findings of the present study showed that 10% of patients died one year after the implementation of the cardiac rehabilitation program, which is inconsistent with the findings of the study of Sunamura et al. Among the important reasons that can be observed for this disparity are that in the study of tsunami, the rehabilitation program included psychoanalytic interventions and social counseling in addition to physical exercise. The purpose of these oral and written instructions was to deal with exercise, diet, smoking cessation and stress management, lifestyle modification and helping to adhere to a healthy lifestyle [23,26]. While in the present study, the focus was only on the physical aspect and sports exercises. In fact, it can be said that changing the lifestyle and having a hopeful life can be as effective as a physical exercise program on improving people's health Furthermore, the duration of exercise is also likely to affect While the exercise program in the present study consisted of five weeks and 2–3 sessions of exercise each week, ranging from 20 min of physical activity in the first week to 1 h of exercise in the fifth week, which was much less and lighter than the exercise program of the Sunamura study. Both rehabilitation programs used stationary bicycle tools for exercise.

The findings of the present study showed that although exercise-based rehabilitation program improved left ventricular function, in none of the patients this improvement result in LVEF greater than 55%. Also in the present study, improvement of left ventricular function after exercise was observed significantly only in males. However, the number of women in the present study was approximately one-fifth of men, and this small volume could affect the findings. Another point to consider in the present study is that performing an exercise program as performed in the present study only improved left ventricular function in patients younger than 60 years. In other words, the implementation of a rehabilitation program based on exercise has no effect on ventricular function in people older than 60 years.

Our study was based on a small sample size and does not include other factors such as diet and stress that can affect cardiovascular health.

Previous history of physical activity affects patients' ability to perform rehabilitation tasks effectively. One of the significant limitations of this study also include lack of data or recordings of such activities. Furthermore, motivating participants to stay consistent during the exercise was also a challenge which was significantly overcome with pre-exercise counseling by the researchers.

5. Conclusion

The findings of our study showed that the implementation of an exercise-based cardiac rehabilitation program improves left ventricular function in patients with myocardial infarction after primary PCI but does not affect right ventricular function. The findings also showed that cardiac rehabilitation program only affects men and is ineffective in people older than 60 years. We recommend further studies in this field along with the implementation in the changes in lifestyle, diet and stressors.

Availability of data and material

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Ethical approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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No funding was secured for this study.

Conflicts of interest

The authors deny any conflict of interest in any terms or by any means during the study. All the fees provided by research center fund and deployed accordingly.

Author contributions

Dr. Mahdi Zahedi: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript. Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr. Mehrdad Shirmohammadi: Coordinated and supervised data collection and critically reviewed the manuscript for important intellectual content.

Consent

Not applicable.

Registration of research studies

Name of the registry: N/a.

Unique Identifying number or registration ID: IR.GOUMS.REC.1399.316.

Hyperlink to the registration (must be publicly accessible):

Consent to participate

From the under 16 years old was given by a parent or legal guardian.

Guarantor

Dr. Mahdi Zahedi.

Provenance and peer review

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2022.104093.

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