Is cardiac rehabilitation after PCI as effective as CABG? The first experience from the eastern mediterranean region cardiac rehabilitation registry

Peer-reviewed author version

Sadeghi, Masoumeh; Sheikhbahaei, Erfan; HANSEN, Dominique; Hassannejad, Razieh; Rouhani, Sina; Mahdi, Mohammad; Yazdekhasti, Safoura; Behfar, Amir & Roohafza, Hamidreza (2024) Is cardiac rehabilitation after PCI as effective as CABG? The first experience from the eastern mediterranean region cardiac rehabilitation registry. In: ARYA Atherosclerosis, 20 (1) , p. 9 -19.

DOI: 10.48305/arya.2024.42234.2926
Handle: http://hdl.handle.net/1942/43638

Is Cardiac Rehabilitation after PCI as Effective as CABG? The First Experience from the Eastern Mediterranean Region Cardiac Rehabilitation Registry

Abstract

Background: Effectiveness of cardiac rehabilitation (CR) programs after either percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) have been studies, however, similar CR program are conducted for both of them. No study has ever compared the effects of a similar CR programs between PCI and CABG from the Eastern Mediterranean Region.

Aim: The aim of this study was to compare the effects of phase II comprehensive CR in patients recruited following either PCI or CABG on coronary heart disease risk factors, psychological variables, and functional capacity in patients from the Eastern Mediterranean region.

Methods: For this retrospective study, CR program registry of the Isfahan Cardiovascular Research Institute were reviewed from 2008 to 2018. Essential assessments were performed one week before starting CR and one week after the end of this 8-week program. Age, sex, smoking status, clinical data (resting heart rate (HR), resting systolic and diastolic blood pressure (SBP and DBP, respectively), and echocardiography) and laboratory data consisting of lipid profile and fasting blood sugar (FBS) were obtained. Functional capacity was evaluated using the international physical activity questionnaire, and a treadmill exercise test. Anxiety, depression, general quality of life (QoL), and health-related QoL were selected for psychological status.

Results: Patients with CABG (n=557) were more likely to be referred to CR than patients with PCI (n=440). All variables changed significantly after the CR program in comparison to their baseline value in both PCI and CABG groups. However, LDL-C and TC levels, peak SBP, and resting and peak DBP did not change in any of the groups, and FBS (p=0.01) and TG (p=0.01)

levels significantly decreased only in the PCI group. Between-group comparisons indicated that after full-adjustment, no significant difference was observed between PCI and CABG groups except for TG, which was significantly reduced in PCI (p=0.01)

Conclusions: The CR program was equally effective in patients with either PCI or CABG.

Keywords: Cardiac Rehabilitation; percutaneous coronary intervention; coronary artery bypass grafting; coronary heart diseases; psychological factors; risk factor

Introduction

Cardiovascular diseases as the leading cause of death in the world, have some modifiable risk factors (1,2) and can be controlled and intervened by comprehensive exercise-based rehabilitation programs (3). Cardiac rehabilitation (CR) programs have been introduced to patients after coronary events to make changes in their life-style (4–6). Indeed, CR has significant positive effects on patients' functional capacity, lipid profile, glycemic control, echocardiographic indexes, smoking behavior, and blood pressure (6–8). These programs can also improve the quality of life, modify psychological factors, and decrease mortality and readmission rates (9,10). Although CR is highly recommended for all patients with coronary artery disease, globally referral to and participation in CR is low (11–13).

There are extensive studies for the effectiveness of CR after coronary artery bypass grafting (CABG), leading to the accumulation of evidence in favor of CR after this intervention (4). Revascularization in patients with coronary artery diseases is also treated with less invasive procedures like percutaneous coronary intervention (PCI). Plenty of studies have evaluated the impacts of CR in PCI only (10,14); however, there is a lack of evidence from middle-east region in this regard. Furthermore, no study has ever compared the effectiveness of CR after PCI to the CABG. Therefore, we aimed to compare the impact of phase-II comprehensive CR

after PCI vs. CABG on coronary heart disease risk factors, psychological variables, and functional capacity of the CR registry in the Eastern Mediterranean region. We hypothesize that if the value of CR after PCI is not more than CABG, it is not less than that and both PCI and CABG patients will benefit from CR to an equal magnitude.

Material and Methods

Study design:

For this retrospective study, CR program registry of the Cardiac Rehabilitation Research Center of Cardiovascular Research Institute (a WHO-collaborating center in EMRO) were searched and reviewed from January 2008 to December 2018. All of the ischemic heart disease patients who were admitted for either PCI or CABG were advised to participate in this hospital-based CR program. Before being discharged, an invitation card were given to them, which needed to be validated by their cardiologist or surgeon before participating in the program. The inclusion criteria were all registered patients who undergone either PCI or CABG for the first time, underwent the CR program as scheduled, and answered all the questionnaires. The exclusion criteria included the following: patients with serious medical disease (e.g., cerebral vascular attacks, chronic kidney disease, cirrhosis, and chronic obstructive sleep apnea), patients who couldn't tolerate physical activity sessions, > 20% missing data in the medical documents or questionnaires, a previous history of PCI or CABG, and missing two or more CR program sessions.

Cardiac rehabilitation program:

CR was advised to every patient with any indications of CR. This 8-week exercise-based CR program included both physical exercise and educational sessions. The physical exercise sessions were offered three times a week for eight weeks (24 sessions in total) and supervised by a trained sport physician. The eight lecture-based educational sessions for controlling stress, anxiety, and depression, as well as for quitting smoking were led by a trained psychologist with the sessions on following a healthy lifestyle and nutrition plan led by a trained dietician. The patients were contacted regularly before their sessions by the center secretary and reminded of the scheduled classes.

Assessments:

A checklist of demographic variables (age and sex), smoking status (current, former, and never), physical activity level, laboratory data, cardiac function test results, and psychological status was used at the registration time (within one week before starting the program), and was repeated with one week of completing the program.

To assess the physical activity level, the Persian validated long-form version of the international physical activity questionnaires (IPAQ), was used (15). IPAQ is a 7-day recall questionnaire that measures time spent per week on vigorous activity, moderate activity, and walking. Briefly, IPAQ assesses physical activity undertaken across a comprehensive set of domains (work, transportation, housework, and leisure-time). Activity is then calculated as the total time (in minutes) spent in three activity categories. The total time in each category is then weighted by a metabolic equivalent of tasks (METs). According to the reported METs, subjects were categorized into three levels of activity: walking, moderate, and vigorous (15).

Fasting blood samples were obtained before starting and after completing the program. All the samples were taken in the central laboratory at the center by the same team. Fasting blood

glucose (FBS) and a lipid profile (triglyceride (TG)), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C)) were recorded.

Echocardiography was scheduled for all the patients before starting and after completing the CR. All echocardiographies were performed on the left lateral decubitus position with the Philips IE33 ultrasound machine and interpreted by an echocardiologist under standard protocols to obtain left ventricular ejection fraction (EF) (16).

The computer-controlled treadmill exercise test (Stress Test System, AST-3000, AVECINA Company, Iran) was used to evaluate functional capacity. The resting heart rate (HR), systolic and diastolic blood pressure (SBP and DBP, respectively) were measured manually with under the standard protocol before the exercise by an experienced exercise test room nurse. The intensity of the exercise test was scheduled with the graded multi-stage maximal symptom-limited Bruce protocol (17,18), which was continued until physical exhaustion or serious signs/symptoms occurred. The HR, SBP, and DBP were measured once every stage, at peak exercise, and twice during the recovery phase. After completion, test duration, cardiorespiratory function in METs (derived from the walking speed and slope), and electrocardiography were extracted from the program. The exercise test's final result was interpreted by a cardiologist and categorized as positive, negative, or undetermined/unidentifiable.

To evaluate psychological status, the validated Persian versions of the questionnaires were used to assess the anxiety (19), depression (20), general quality of life (QoL) (21), and health-related quality of life (HR-QoL) (22).

Anxiety was assessed with the 20 items Zung's self-rating anxiety scale (S.A.S) questionnaire (23) with scores of normal to mild (20-44), moderate (45-59), severe (60-74), and very severe (75 and more).

The depression level and score were assessed using the Beck depression inventory (second edition) questionnaire (BDI-II), which has 21 questions (20) with scores of low (0-10), mild (11-16), moderate (17-30), and high (31 and more).

The SF-36 questionnaire was used to evaluate the general aspects of QoL (21). This questionnaire has two general domains, namely physical and mental health, with four domains in each. HR-QoL in the cardiac disease was evaluated using the 27-item MacNew questionnaire (22) with questions classified into physical, emotional, and social domains.

Statistical Analysis:

All analyses were carried out with IBM SPSS software version 20.0. The categorical variables are expressed as the number and percentages, while the quantitative variables are expressed as mean and standard deviation. The Kolmogorov-Smirnov test was used to check normality assumption. Baseline measurement assessed by independent t-test or Mann–Whitney test (if the normality assumption was not held) for quantitative variables. Categorical variables were compared using the Chi-square. Bonferroni correction used to determine the significance of any differences. Within-group comparisons were assessed by the paired t-tests for normally distributed variables or Wilcoxon for non-normally distributed variables. Analysis of covariance (ANCOVA) was applied to evaluate between-group comparisons. Variables which were significantly different at baseline or were as confounders were also adjusted in ANCOVA. If the heterogeneity of variance was not met, logarithmic transformation was used. P-values < 0.05 (two-tailed) are considered statistically significant.

Results

The CR program has been conducted more after CABG than PCI (n=557 vs. n=440 patients, respectively). Among these patients, males participated more than females but with no significant difference between two genders (426 (76.48%) in CABG and 316 (71.81%) in PCI, p=0.1). The CABG patients were significantly older than the PCI patients (58.94±8.85 vs. 57.72±9.79 years, p= 0.02). 111 documents were excluded from secondary analysis due to missing data in after CR assessments.

CABG participants had significantly higher LDL-C ($p<0.0001$) and TC ($p<0.0001$) levels compared to PCI. However, the mean EF (p=0.01), exercise test METs (p=0.019), and anxiety ($p<0.0001$) and depression ($p<0.0001$) scores were significantly higher in PCI (Table-1).

As demonstrated in Table-2, all the variables changed significantly after the CR program in comparison to their baseline value in either PCI or CABG group. However, LDL-C and TC levels, peak SBP, and resting and peak DBP did not change in any of the groups, and FBS (p=0.01) and TG (p=0.01) levels significantly decreased only in the PCI group.

Between-group comparisons indicated that after full-adjustment, there is no significant change after CR program between PCI and CABG groups except for TG (Table-3). TG had significant reduction after CR program in patients with PCI rather than CABG.

Discussion

Although it is believed that CR should be recommended to all patients with cardiovascular disease as a secondary prevention strategy (24), CR outcomes have not been compared between PCI and CABG patients in a comprehensive study from an advanced CR center in the Eastern Mediterranean region. Our results suggest that both PCI and CABG patients benefited similarly

166 from CR, as CR outcomes were not significantly different between PCI and CABG in the large
167 majority of the examined variables. These data indicate that CR is a highly effective secondary
168 prevention strategy in coronary artery disease patients and its priority after PCI is as equal as
169 CABG.

170 It has previously been confirmed that after coronary events, CR can decrease mortality and
171 morbidity through modifying cardiovascular risk factors, increasing physical activity, and
172 improving QoL (10). It remained however uncertain whether similar benefits would be
173 observed in PCI vs. CABG patients from the EMRO.

174 Although the CR goal is to educate patients about the harmful effects of smoking on the heart,
175 its efficacy is not comparable to explicit smoking cessation programs in addiction treatment
176 centers. More than half of Portuguese CR participants quit smoking in the follow-up
177 evaluations, and authors have suggested that CR is a great opportunity to educated patients and
178 emphasize the importance of smoking cessation (25). In this study, the smoking status
179 distribution changed significantly before and after CR in each group, which is in agreement
180 with others (25,26) but with no significant difference between PCI and CABG.

181 The positive effects of CR on functional capacity after PCI and CABG has been assessed in
182 many studies with the vast majority of the studies reporting promising effects (27–31), some
183 of which indicated a greater benefit for patients undergoing CABG (28,32,33) probably due to
184 the more extensive surgical procedure with greater postoperative muscle deconditioning than
185 with the less invasive PCI procedure, in which patients are able to ambulate immediately
186 following the procedure. Therefore, CABG patients have a lower functional capacity at the
187 entry of CR, but, by the aid of CR, this phenomenon is reversible and transient (28,32),
188 emphasizing the importance of CR after CABG. In this study, both groups of patients

189 significantly improved after CR although no significant difference was found between CABG
190 and PCI in physical activity, left-ventricular EF, treadmill exercise test duration, and METs.

191 A study on PCI demonstrated that CR positively affected all aspects of the lipid profile level
192 (34) with evidence for lipid profile components significantly decreased with CR following
193 CABG (35). Although there is a lack of evidence for a link between exercised-base CR and
194 FBS in patients with PCI (34), it was revealed that FBS and TG decreased only in the PCI
195 group with HDL-C increasing in both groups and no change in TC and LDL-C with CR.
196 Possible explanations are worsening of insulin sensitivity by statins (34), patients' nutrition at
197 home, their compliance to dietary recommendations, ethnic differences, the intensity of
198 physical activity, and its duration. Besides, except for TG which was significantly decreased
199 in patients with PCI, CR on lipid profile and FBS of CABG and PCI patients had the same
200 effect.
201 Resting and peak HR both significantly changed in both groups with no significant greater
202 change in favor of CABG or PCI patients. Other studies found the greater change in resting
203 HR in patients with CABG than PCI, perhaps as an indicator of greater parasympathetic tone
204 due to the longer convalescence period after surgery (36). Nevertheless, as HR-lowering drugs
205 such as beta-blockers are prescribed to lower the heart demand after any coronary events,
206 therefore, HR-change will be under drug control rather than a CR response.
207 Resting SBP decreased significantly and equally in both groups, however, DBP and peak SBP
208 were not affected by CR. Although some studies support our findings that exercise-based CR
209 does not influence BP in patients with either PCI or CABG (36,37), it was suggested that
210 CABG patients had significantly lower peak DBP as well as resting and peak SBP in
211 comparison with the group without CR (38) and CR participants after PCI had significantly
212 lower SBP and DBP (34). These hemodynamic contradictories can be due to different exercise

protocols with various intensity, age and gender dissimilarities, sample size variations, and medications after each procedure (38).

Improvement in controlling anxiety and depression, along with enhanced general QoL and HR-QoL, are among the established outcomes of CR program (39–41) and were observed in the present study, although no significant difference was found between the two intervention groups. In addition, PCI patients have been shown to have better HR-QoL in the short-term following CR than CABG patients (42). Furthermore, it was suggested that in contrast to the CABG patients, PCI patients would have better HR-QoL after the intervention and before the CR, suggesting that greater improvement may be observed in CABG than PCI (43). Although it remains controversial, these findings are linked to possible confounding factors like age, sex, socioeconomic status, education level, body weight, and comorbid disease (42,44).

This study could have been limited by the fact that medical documents of one CR referral center were reviewed; and socioeconomic status, educational level, and logistic factors were not evaluated. According to our observation, although CR is advised after both PCI and CABG, more CABG patients were participated due to low PCI referral rate. Moreover, its retrospective nature should be taken into account.

Conclusion

Both PCI and CABG patients from the Eastern Mediterranean region benefit significantly, and to the same extend, from CR. Therefore, it indicates that CR should be supported by the health-care insurances, noticed by policymakers, and recommended by the physician to both groups.

Funding: none

Conflict of interests: All authors declare no potential conflict of interest.

Acknowledgment: We express our gratitude toward Professor of Emeritus Dr. Neil Oldridge for his kind help, Isfahan Cardiovascular Research Institute and Cardiac Rehabilitation Research Center staffs, and finally Mr. Amirsalar Moazen Safaei for his technical notes through the manuscript.

Ethical Consideration: all procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee and with 1964 Helsinki declarations and its later amendments. This study commenced after receiving its ethical approval from the institutional review board with the registration number of "IR.MUI.MED.REC.1398.270".

References

1. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Heart disease and stroke statistics-2016 update a report from the American Heart Association. Vol. 133, Circulation. 2016. 38–48 p.

2. Yusuf S, Rangarajan S, Teo K, Islam S, Li W, Liu L, et al. Cardiovascular risk and events in 17 low-, middle-, and high-income countries. N Engl J Med. 2014;371(9):818–27.

3. Jokar F, Yousefi H, Yousefy A, Sadeghi M. Begin again and continue with life: A qualitative study on the experiences of cardiac rehabilitation patients. J Nurs Res. 2017;25(5):344–52.

4. Thomas RJ, Balady G, Banka G, Beckie TM, Chiu J, Gokak S, et al. 2018 ACC/AHA Clinical Performance and Quality Measures for Cardiac Rehabilitation: A Report of the American College of Cardiology/American Heart Association Task Force on Performance Measures. J Am Coll Cardiol. 2018;71(16):1814–37.

5. Thomas RJ, Huang HH. Cardiac Rehabilitation for Secondary Prevention of Cardiovascular Disease: 2019 Update. Curr Treat Options Cardiovasc Med. 2019;21(10):56.

6. Kachur S, Chongthammakun V, Lavie CJ, De Schutter A, Arena R, Milani R V., et al. Impact of cardiac rehabilitation and exercise training programs in coronary heart disease. Prog Cardiovasc Dis [Internet]. 2017;60(1):103–14. Available from: http://dx.doi.org/10.1016/j.pcad.2017.07.002

7. Grace SL, Midence L, Oh P, Brister S, Chessex C, Stewart DE, et al. Cardiac Rehabilitation Program Adherence and Functional Capacity Among Women: A Randomized Controlled Trial. Mayo Clin Proc [Internet]. 2016;91(2):140–8. Available from: http://dx.doi.org/10.1016/j.mayocp.2015.10.021

8. Kotseva K, Wood D, De Bacquer D. Determinants of participation and risk factor control according to attendance in cardiac rehabilitation programmes in coronary patients in Europe: EUROASPIRE IV survey. Eur J Prev Cardiol. 2018;25(12):1242–51.

9. Mehra VM, Gaalema DE, Pakosh M, Grace SL. Systematic review of cardiac rehabilitation guidelines: Quality and scope. Eur J Prev Cardiol. 2019;1–17.

10. Salzwedel A, Jensen K, Rauch B, Doherty P, Metzendorf MI, Hackbusch M, et al. Effectiveness of comprehensive cardiac rehabilitation in coronary artery disease patients treated according to contemporary evidence based medicine: Update of the

283 Cardiac Rehabilitation Outcome Study (CROS-II). Eur J Prev Cardiol.
284 2020;2047487320905719.

285 11. Turk-Adawi K, Supervia M, Lopez-Jimenez F, Pesah E, Ding R, Britto RR, et al.
286 Cardiac Rehabilitation Availability and Density around the Globe. EClinicalMedicine
287 [Internet]. 2019;13:31–45. Available from:
288 https://doi.org/10.1016/j.eclinm.2019.06.007

289 12. Supervia M, Turk-Adawi K, Lopez-Jimenez F, Pesah E, Ding R, Britto RR, et al.
290 Nature of Cardiac Rehabilitation Around the Globe. EClinicalMedicine [Internet].
291 2019;13:46–56. Available from: https://doi.org/10.1016/j.eclinm.2019.06.006

292 13. Pesah E, Turk-Adawi K, Supervia M, Lopez-Jimenez F, Britto R, Ding R, et al.
293 Cardiac rehabilitation delivery in low/middle-income countries. Heart.
294 2019;105(23):1806–12.

295 14. Yang X, Li Y, Ren X, Xiong X, Wu L, Li J, et al. Effects of exercise-based cardiac
296 rehabilitation in patients after percutaneous coronary intervention: A meta-analysis of
297 randomized controlled trials. Sci Rep [Internet]. 2017;7(February):1–9. Available
298 from: http://dx.doi.org/10.1038/srep44789

299 15. Moghaddam MHB, Aghdam FB, Jafarabadi MA, Allahverdipour H, Nikookheslat SD,
300 Safarpour S. The Iranian version of International Physical Activity Questionnaire
301 (IPAQ) in Iran: Content and construct validity, factor structure, internal consistency
302 and stability. World Appl Sci J. 2012;18(8):1073–80.

303 16. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al.
304 Recommendations for cardiac chamber quantification by echocardiography in adults:
305 An update from the American society of echocardiography and the European
306 association of cardiovascular imaging. Eur Heart J Cardiovasc Imaging.

2015;16(3):233–71.

17. Bruce RA. Methods of exercise testing. Step test, bicycle, treadmill, isometrics. Am J Cardiol. 1974;33(6):715–20.

18. Bruce RA, McDonough JR. Stress testing in screening for cardiovascular disease. Bull New York Acad Med J Urban Heal. 1969;45(12):1288–305.

19. HAKIM JAVADI M, GHOLAMALI M, HAGHIGHATGO M, ZEBARDAST O. THE RELATIONSHIP AMONG DEPRESSION, ANXIETY, STRESS AND PERSONALITY IN VETERAN CHILDREN. TEBE-E-JANBAZ [Internet]. 2010;3(9):9–16. Available from: https://www.sid.ir/en/journal/ViewPaper.aspx?ID=257806

20. Ghassemzadeh H, Mojtabai R, Karamghadiri N, Ebrahimkhani N. Psychometric properties of a Persian-language version of the Beck Depression Inventory-second edition: BDI-II-Persian. Depress Anxiety. 2005;21(4):185–92.

21. Montazeri, A., Goshtasebi, A., Vahdaninia, M., & Gandek B. The Short Form Health Survey (SF-36): Translation and Validation Study of the Iranian Version. Qual Life Res. 2005;14(3):875–82.

22. Abbasi M, Momenyan S, Eslamimoqadam F, Sarvi F, Khaki I. Validity and reliability of the macnew heart disease health-related quality of life questionnaire in patients with heart failure: The persian version. Int Cardiovasc Res J. 2017;11(4):137–42.

23. Jafari F, Hadizadeh MH, Zabihi R, Ganji K. Comparison of depression, anxiety, quality of life, vitality and mental health between premenopausal and postmenopausal women. Climacteric [Internet]. 2014;17(6):660–5. Available from: http://dx.doi.org/10.3109/13697137.2014.905528

24. Hansen D, Piepoli MF, Doehner W. The importance of rehabilitation in the secondary prevention of cardiovascular disease. Eur J Prev Cardiol. 2019;26(3):273–6.

25. Magalhães S, Miguel Ribeiro M, Barreira A, Fernandes P, Torres S, Lopes Gomes J, et al. Long-term effects of a cardiac rehabilitation program in the control of cardiovascular risk factors. Rev Port Cardiol (English Ed [Internet]. 2013;32(3):191–9. Available from: http://dx.doi.org/10.1016/j.repce.2013.03.001

26. Tzou W, Vitcenda M, McBride P. Smoking Status after Cardiac Events and Participation in Outpatient Cardiac Rehabilitation. J Cardiopulm Rehabil. 2004;24(2):94–9.

27. Yang X, Li Y, Ren X, Xiong X, Wu L, Li J, et al. Effects of exercise-based cardiac rehabilitation in patients after percutaneous coronary intervention: A meta-analysis of randomized controlled trials. Sci Rep [Internet]. 2017;7(April 2016):1–9. Available from: http://dx.doi.org/10.1038/srep44789

28. Suzuki Y, Ito K, Yamamoto K, Fukui N, Yanagi H, Kitagaki K, et al. Predictors of improvements in exercise capacity during cardiac rehabilitation in the recovery phase after coronary artery bypass graft surgery versus acute myocardial infarction. Heart Vessels. 2018;33(4):358–66.

29. Sadeghi M, Garakyaraghi M, Taghavi M, Khosravi M, Sarrafzadegan N, Roohafza H. The Impacts of Cardiac Rehabilitation Program on Exercise Capacity, Quality of Life, and Functional Status of Coronary Artery Disease Patients with Left Ventricular Dysfunction. Rehabil Nurs. 2015;40(5):305–9.

30. Zhang Y, Cao HX, Jiang P, Tang HQ. Cardiac rehabilitation in acute myocardial infarction patients after percutaneous coronary intervention. Med (United States). 2018;97(8).

31. Da Silva Chaves GS, De Melo Ghisi GL, Grace SL, Oh P, Ribeiro AL, Britto RR. Effects of comprehensive cardiac rehabilitation on functional capacity in a middle-income country: a randomised controlled trial. Heart. 2019;105(5):406–13.

32. Izawa KP, Watanabe S, Oka K, Hiraki K, Morio Y, Kasahara Y, et al. Cardiac rehabilitation outcome following percutaneous coronary intervention compared to cardiac surgery. Recent Pat Cardiovasc Drug Discov. 2011;6(2):133–9.

33. Jelinek HF, Huang ZQ, Khandoker AH, Chang D, Kiat H. Cardiac rehabilitation outcomes following a 6-week program of PCI and CABG Patients. Front Physiol. 2013;4:302.

34. Deskur-Smielecka E, Borowicz-Bienkowska S, Maleszka M, Wilk M, Nowak A, Przywarska I, et al. Early phase 2 inpatient rehabilitation after acute coronary syndrome treated with primary percutaneous coronary intervention: Short- and long-term effects on blood pressure and metabolic parameters. Am J Phys Med Rehabil. 2011;90(7):589–98.

35. Hayta E, Korkmaz Ö. Cardiac rehabilitation increases the reliability of the 6-minute walk test in patients after coronary artery bypass graft surgery. Heart Surg Forum. 2017;20(6):E247–51.

36. Soleimani A, Alidoosti M, Salarifar M, Kassaian SE, Karimi A, Davoodi S, et al. Effect of cardiac rehabilitation program on heart rate recovery after percutaneous coronary intervention and coronary artery bypass grafting. J Tehran Univ Hear Cent. 2008;3(1):11–6.

37. Oldridge N. Exercise-based cardiac rehabilitation in patients with coronary heart disease: Meta-analysis outcomes revisited. Vol. 8, Future Cardiology. 2012. p. 729–51.

38. Ghashghaei FE, Sadeghi M, Marandi SM, Ghashghaei SE. Exercise-based cardiac rehabilitation improves hemodynamic responses after coronary artery bypass graft surgery. ARYA Atheroscler. 2012;7(4):151–6.

39. Rajati F, Feizi A, Tavakol K, Mostafavi F, Sadeghi M, Sharifirad G. Comparative Evaluation of Health-Related Quality of Life Questionnaires in Patients With Heart Failure Undergoing Cardiac Rehabilitation: A Psychometric Study. Arch Phys Med Rehabil [Internet]. 2016;97(11):1953–62. Available from: http://dx.doi.org/10.1016/j.apmr.2016.05.010

40. Pogosova N, Saner H, Pedersen SS, Cupples ME, McGee H, Höfer S, et al. Psychosocial aspects in cardiac rehabilitation: From theory to practice. A position paper from the cardiac rehabilitation section of the European association of cardiovascular prevention and rehabilitation of the European Society of Cardiology. Eur J Prev Cardiol. 2015;22(10):1290–306.

41. Zheng X, Zheng Y, Ma J, Zhang M, Zhang Y, Liu X, et al. Effect of exercise-based cardiac rehabilitation on anxiety and depression in patients with myocardial infarction: A systematic review and meta-analysis. Hear Lung. 2019;48(1):1–7.

42. Yazdani-Bakhsh R, Javanbakht M, Sadeghi M, Mashaiekhi A, Ghaderi H, Rabiei K. Comparison of health-related quality of life after percutaneous coronary intervention and coronary artery bypass surgery. ARYA Atheroscler. 2016;12(3):124–31.

43. Höfer S, Kullich W, Graninger U, Wonisch M, Gaßner A, Klicpera M, et al. Cardiac rehabilitation in Austria: Long term health-related quality of life outcomes. Health Qual Life Outcomes. 2009;7:1–10.

44. Grace SL, Bennett S, Ardern CI, Clark AM. Cardiac rehabilitation series: Canada. Prog Cardiovasc Dis [Internet]. 2014;56(5):530–5. Available from:

http://dx.doi.org/10.1016/j.pcad.2013.09.010

Table-1: Cardiac rehabilitation participants' baseline characteristics before the program

Variables			Total (n=997)	PCI (n=440)	CABG (n=557)	P
Smoking n, (%)	**Never**		761 (76.32)	335 (76.13)	426 (76.48)	0.61
	Current		93 (9.32)	45 (10.22)	48 (8.61)	
	Past		143 (14.34)	60 (13.63)	83 (14.9)	
***Physical Activity* (MET.min/week)**						
Walking			2025.87±2141.84	1885.80±2123.94	2212.63±2157.77	0.03
Moderate			1896.29±3832.13	2391.70±4670.37	1235.73±2118.79	<0.0001
Vigorous			1140.09±4322.76	824.88±2551.24	1560.36±5894.96	0.86
Total			9265.11±5367.67	9451.47±5497.35	9016.25±5195.70	0.52
Lab Data						
Fasting Blood Sugar (mg/dL)			111.08±36.63	112.08±40.39	110.30±33.41	0.80
Triglyceride (mg/dL)			165.54±91.49	163.87±90.98	166.85±91.95	0.38
Low-density lipoprotein (mg/dL)			92.85±35.57	86.66±32.26	97.78±37.30	<0.0001
High-density lipoprotein (mg/dL)			39.54±9.19	38.92±8.58	40.03±9.62	0.14
Total cholesterol (mg/dL)			167.03±45.85	160.33±44.43	172.31±46.29	<0.0001
Cardiac Function tests						
Ejection fraction (%)			51.21±11.27	52.02±11.87	50.57±10.73	0.01
Treadmill Exercise stress test	**Resting HR (bpm)**		79.78±16.03	76.69±15.00	82.23±16.40	<0.0001
	Peak HR (bpm)		125.87±23.85	122.52±23.19	128.53±24.05	<0.0001
	Resting SBP (mmHg)		116.99±17.66	117.07±16.48	116.94±18.57	0.83
	Peak SBP (mmHg)		131.84±22.53	129.35±23.43	133.39±21.85	0.01
	Resting DBP(mmHg)		72.25±10.24	72.72±9.68	71.86±10.67	0.20
	Peak DBP(mmHg)		77.43±10.52	76.84±10.98	77.79±10.23	0.40
	Test Duration (min)		14.41±4.94	14.36±4.64	14.45±5.18	0.67
	METs		8.49±3.06	8.79±3.32	8.25±2.81	0.01
	Result	**Negative**	700 (70.21)	312 (70.9)	388 (69.65)	0.01*
		Positive	100 (10.03)	31 (7.07)	69 (12.38)	
		UD	197 (19.75)	97 (22.04)	100 (17.95)	
Psychological status						
Anxiety Level	**Normal -mild**		711 (71.31)	288 (65.45)	423 (75.94)	<0.0001†
	Moderate		231 (23.16)	123 (27.95)	108 (19.38)	
	Severe		51 (5.11)	26 (5.9)	25 (4.48)	
	Very severe		4 (0.4)	3 (0.68)	1 (0.17)	
Anxiety Score			40.34±10.61	41.89±11.11	39.09±10.02	<0.0001
Depression level	**Low**		735 (73.72)	293 (66.59)	442 (79.35)	<0.0001‡
	Mild		118 (11.83)	65 (14.77)	53 (9.51)	
	Intermediate		90 (9.02)	52 (11.81)	38 (6.82)	
	High		54 (5.41)	30 (6.81)	24 (4.30)	
Depression Score			11.19±9.14	12.50±10.06	10.13±8.18	<0.0001
General Quality of life	**Physical functioning**		59.05±23.33	60.78±24.79	56.96±21.28	0.02
	Role-Health		35.31±37.25	36.92±37.98	33.36±36.31	0.26
	Body pain		63.47±26.24	64.22±26.33	62.56±26.14	0.45
	General health		59.14±19.07	58.95±18.96	59.38±19.22	0.82
	Energy/Fatigue		56.95±22.10	56.45±22.64	57.57±21.45	0.42
	Social functioning		67.46±25.93	68.50±26.36	66.19±25.39	0.18
	Role emotional		53.75±40.93	54.99±41.61	52.24±40.10	0.37
	Emotional Well being		66.11±22.30	66.57±21.79	65.55±22.93	0.64
Health-related Quality of life	**Physical**		4.75±1.08	4.69±1.10	4.79±1.07	0.28
	Social		4.81±1.08	4.78±1.06	4.84±1.09	0.46
	Emotional		4.75±0.93	4.64±0.86	4.83±0.98	0.01

PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting surgery; UD, undetermined; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure

*According to Bonferroni method analysis, this significant P value was seen in two situation: when comparing negative group with positive group and when comparing group "other" with positive group.

† According to Bonferroni method analysis, this significant P value was seen when comparing the normal-mild group with moderate group.

‡ According to Bonferroni method analysis, this significant P value was seen when comparing group "low" with other groups.

450

451 **Table-2:** Comparison of variables before and after the program in each group

Variables			PCI			CABG		
			Before	After	P	Before	After	P
Smoking	**Never**		335 (76.13)	328 (80.19)	<0.0001 *	426 (76.48)	412 (86.37)	<0.0001 *
	Current		45 (10.22)	23 (5.62)		48 (8.61)	12 (2.51)	
	Past		60 (13.63)	58 (14.18)		83 (14.9)	53 (11.11)	
***Physical Activity* (MET.min/week)**								
Walking			1885.80±2123.94	2273.18±1956.64	<0.0001	2212.63±2157.77	3094.22±2797.82	<0.0001
Moderate			2391.70±4670.37	3399.20±3059.22	<0.0001	1235.73±2118.79	3080.00±3686.04	<0.0001
Vigorous			824.88±2551.24	2346.86±9522.90	<0.0001	1560.36±5894.96	1293.04±4097.96	0.16
Total			9451.47±5497.35	11179.09±5078.57	<0.0001	9016.25±5195.70	11218.78±5275.16	<0.0001
Lad Data								
Fasting Blood Sugar (mg/dL)			112.08±40.39	107.31±30.56	0.01	110.30±33.41	108.97±33.44	0.84
Triglyceride (mg/dL)			163.87±90.98	144.94±65.72	0.01	166.85±91.95	156.97±76.48	0.66
Low-density lipoprotein (mg/dL)			86.66±32.26	84.48±27.30	0.81	97.78±37.30	94.38±31.69	0.37
High-density lipoprotein (mg/dL)			38.92±8.58	39.89±10.46	0.03	40.03±9.62	41.41±9.77	0.01
Total cholesterol (mg/dL)			160.33±44.43	154.68±36.03	0.26	172.31±46.29	167.50±37.84	0.44
Cardiac Function tests								
Ejection fraction (%)			52.02±11.87	53.79±10.51	<0.0001	50.57±10.73	53.96±9.59	<0.0001
Treadmill Exercise stress test	**Resting HR (bpm)**		76.69±15.00	74.47±14.42	0.02	82.23±16.40	77.13±15.84	<0.0001
	Peak HR (bpm)		122.52±23.19	131.36±23.68	<0.0001	128.53±24.05	130.03±24.12	0.01
	Resting SBP (mmHg)		117.07±16.48	113.70±16.12	0.02	116.94±18.57	116.05±17.02	0.04
	Peak SBP (mmHg)		129.35±23.43	129.35±21.49	0.85	133.39±21.85	134.68±25.45	0.53
	Resting DBP(mmHg)		72.72±9.68	71.42±9.05	0.48	71.86±10.67	72.11±9.97	0.20
	Peak DBP(mmHg)		76.84±10.98	76.82±10.41	0.47	77.79±10.23	78.42±15.13	0.13
	Test Duration (min)		14.36±4.64	18.09±4.95	<0.0001	14.45±5.18	17.73±4.76	<0.0001
	METs		8.79±3.32	11.93±3.70	<0.0001	8.25±2.81	10.90±3.07	<0.0001
	Result	**Negative**	312 (70.9)	359 (87.77)	<0.0001 †	388 (69.65)	421 (88.05)	<0.0001 †
		Positive	31 (7.07)	16 (3.91)		69 (12.38)	23 (4.82)	
		UD	97 (22.04)	34 (8.31)		100 (17.95)	33 (6.91)	
Psychological status								
Anxiety Level	**Normal -mild**		288 (65.45)	318 (77.75)	<0.0001 ‡	423 (75.94)	387 (81.13)	<0.0001 ‡
	Moderate		123 (27.95)	73 (17.84)		108 (19.38)	83 (17.40)	
	Severe		26 (5.9)	18 (4.4)		25 (4.48)	6 (1.25)	
	Very severe		3 (0.68)	0 (0)		1 (0.17)	1 (0.2)	
Anxiety Score			41.89±11.11	39.72±11.13	<0.0001	39.09±10.02	38.02±9.78	0.000
Depression level	**Low**		293 (66.59)	318 (77.75)	<0.0001 §	442 (79.35)	363 (76.1)	<0.0001 §
	Mild		65 (14.77)	62 (15.15)		53 (9.51)	93 (19.49)	
	Intermediate		52 (11.81)	18 (4.4)		38 (6.82)	12 (2.51)	
	High		30 (6.81)	11 (2.68)		24 (4.30)	9 (1.88)	

Depression Score		12.50±10.06	10.31±9.16	<0.0001	10.13±8.18	8.18±7.34	<0.0001
General Quality of life	**Physical functioning**	60.78±24.79	70.16±20.86	<0.0001	56.96±21.28	68.13±20.93	<0.0001
	Role-Health	36.92±37.98	55.43±39.35	<0.0001	33.36±36.31	51.03±38.60	<0.0001
	Body pain	64.22±26.33	74.39±22.80	<0.0001	62.56±26.14	73.58±21.67	<0.0001
	General health	58.95±18.96	64.03±18.74	<0.0001	59.38±19.22	64.38±17.82	<0.0001
	Energy/Fatigue	56.45±22.64	64.16±20.19	<0.0001	57.57±21.45	62.65±20.56	<0.0001
	Social functioning	68.50±26.36	77.60±22.02	<0.0001	66.19±25.39	76.21±22.63	<0.0001
	Role emotional	54.99±41.61	64.86±38.30	<0.0001	52.24±40.10	64.66±37.56	<0.0001
	Emotional Well being	66.57±21.79	71.77±19.56	<0.0001	65.55±22.93	69.74±21.04	<0.0001
Health related Quality of life	**Physical**	4.69±1.10	5.25±1.00	<0.0001	4.79±1.07	5.27±0.93	<0.0001
	Social	4.78±1.06	5.35±1.01	<0.0001	4.84±1.09	5.38±0.96	<0.0001
	Emotional	4.64±0.86	4.88±0.80	<0.0001	4.83±0.98	5.07±0.86	<0.0001

PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting surgery; UD, undetermined; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure

*Bonferroni correction showed significant difference when comparing the "never" group with either "smoker" or "past" group.

† Bonferroni correction showed significant difference when comparing the "negative" group with either "positive" or "other" group.

‡ Bonferroni correction showed significant difference when comparing the "normal-mild" group with either "moderate" or "severe" group.

§ Bonferroni correction showed significant difference when comparing the "low" group with either "mild", "intermediate" or, "high" group.

Table-3: Comparison of delta difference of each variable between the groups

Variables		Total	PCI [After-Before]	CABG [After-Before]	P*
Quit Smoking n, (%)		58 (5.81)	22 (5)	36 (6.46)	0.10
***Physical Activity* (MET.min/week)**					
Walking		536.37±2672.43	287.84±2533.96	834.62±2810.94	0.15[a]
Moderate		1421.28±4710.96	1054.29±5385.52	1861.66±3718.88	0.86
Vigorous		964.85±7651.86	1533.70±9422.53	282.24±4672.63	0.26
Total		2117.79±6696.30	1995.71±6610.77	2262.70±6820.68	0.58
Lab Data					
Fasting Blood Sugar (mg/dL)		-2.66±28.48	-4.81±28.64	-0.88±28.26	0.31
Triglyceride (mg/dL)		-7.96±74.78	-11.76±61.54	-4.81±84.12	0.01[a]
Low-density lipoprotein (mg/dL)		-1.26±30.88	-0.47±27.43	-1.92±33.54	0.37
High-density lipoprotein (mg/dL)		1.01±9.11	1.01±8.13	1.01±9.86	0.85
Total cholesterol (mg/dL)		-2.57±38.10	-3.48±37.13	-1.82±38.92	0.11
Cardiac Function tests					
Ejection fraction (%)		2.51±6.74	2.03±6.47	2.93±6.94	0.14
Treadmill Exercise stress test	**Resting HR (bpm)**	-3.31±14.42	-1.95±14.87	-4.46±13.95	0.12
	Peak HR (bpm)	5.83±23.83	8.96±25.74	3.15±21.75	0.06
	Resting SBP (mmHg)	-2.30±17.96	-2.60±16.60	-2.04±19.04	0.31
	Peak SBP (mmHg)	1.03±22.37	0.01±21.97	1.70±22.64	0.81
	Resting DBP(mmHg)	-0.70±10.73	-0.66±10.71	-0.73±10.77	0.27
	Peak DBP(mmHg)	1.30±14.31	1.42±13.02	1.22±15.12	0.34
	Test Duration (min)	3.52±4.41	3.53±4.28	3.51±4.53	0.27
	METs	2.73±2.64	2.98±2.89	2.53±2.39	0.98
	Negative results n, (%)	807 (91.08)	382 (93.39)	425 (89.09)	0.72
Psychological status					
Anxiety Score		-1.99±8.31	-2.24±9.11	-1.78±7.57	0.57
Depression Score		-2.04±6.54	-1.71±6.63	-2.30±6.45	0.29
General Quality of Life	**Physical functioning**	10.07±22.62	10.58±22.65	9.49±22.64	0.60
	Role-Health	18.74±43.96	20.23±44.55	17.03±43.32	0.22
	Body pain	9.90±25.56	9.59±24.95	10.26±26.29	0.09
	General health	3.96±17.88	4.00±17.02	3.91±18.85	0.56
	Energy/Fatigue	5.71±19.35	7.30±18.07	3.89±20.59	0.19
	Social functioning	8.13±24.29	8.67±22.25	7.52±26.45	0.40[a]
	Role emotional	11.45±47.55	11.93±45.95	10.91±49.42	0.97
	Emotional Well being	3.82±18.34	4.42±17.27	3.14±19.51	.063
Health related Quality of Life	**Physical**	0.46±0.86	0.48±0.86	0.45±0.86	.058
	Social	0.51±0.90	0.52±0.8	0.51±0.92	.042
	Emotional	0.22±0.76	0.22±0.74	0.22±0.78	.033[a]

PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting surgery; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure

*All p-values were obtained by ANCOVA, except for quit smoking obtained by Logistic regression.

[a] Based on logarithmic transformation due to heterogeneity of variance.