



The Effect of Cardiac Rehabilitation Program on the Functional Characteristics of Patients with Acute Coronary Syndrome

Arsalan Salari, Farsima Faragh Nia, Aseme Pourrajabi, Amir Aris, Fateme Baharvand and Tolou Hasandokht*

Cardiovascular Diseases Research Center, Department of Cardiology, Heshmat Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran

* Corresponding author

Tolou Hasandokht, MD

Cardiovascular Diseases Research Center, Department of Cardiology, Heshmat Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran

Tel: +98 9111432003

Fax: +98 13 3366 8718

Email: tolou.hasandokht@gmail.com

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Abstract

Background: This study aimed to investigate the 6-minute walk test to evaluate the functional capacity of patients with acute coronary syndrome who underwent cardiac rehabilitation programs.

Methods: 44 patients with Acute Coronary Syndrome (ACS) underwent Percutaneous Coronary Intervention (PCI) or Coronary Artery Bypass Graft (CABG) three months before the study and were subsequently referred to the Cardiac Rehabilitation (CR) clinic. A six-Minute Walk Test (6-MWT) and echocardiography were performed for all participants. Twelve CR sessions (twice a week for six consecutive weeks) were conducted, each lasting 60-90 min. Throughout the CR program, Electrocardiogram (ECG), heart rate, blood pressure, and percent oxygen saturation were monitored. Lipid & hepatic profile & blood sugar were assessed before and after CR sessions. Patients' psychological status was assessed. IBM SPSS Statistics software was utilized for statistical analyses, with a level of statistical significance set at $p < 0.05$.

Results: A significant improvement was observed in both functional and echocardiographic characteristics at the peak of endurance before and after CR. The distance walked in 6-MWT and duration walked on the treadmill without cardiac symptoms and new ST-T change increased significantly. The speed of walking on the treadmill improved notably in the final CR session ($p = 0.001$). The percentage of maximum heart rate during exercise endurance increased significantly to 79% without symptoms ($p = 0.010$). Anxiety and stress among participants decreased significantly after completing the 12 CR sessions.

Conclusion: In conclusion, results showed that 6-MWT can be a helpful and more economical test for evaluating functional capacity.

Keywords: Acute coronary syndrome, Anxiety, Cardiac rehabilitation, Echocardiography

Introduction

Cardiovascular Diseases (CVDs) rank among the leading causes of global mortality (1,2). Over the years, there has been a noteworthy increase in the incidence of CVD, particularly Acute Coronary Syndrome (ACS), a significant contributor to cardiovascular-related mortality, especially among elderly ACS patients (3,4). Fortunately, advances in medical technology have led to a reduction in the mortality rate among ACS patients (5). These improvements have not only enhanced patient survival but also underscored the importance of secondary prevention measures, such as Cardiac Rehabilitation (CR) (6,7). CR programs are cost-effective, multifaceted interventions designed to optimize clinical outcomes in cardiac patients. They focus on exercise, medication management, nutritional counseling, risk factor management, and psychosocial counseling (8-10). In this study, the aim was to investigate the use of a 6-Minute Walk Test (6-MWT) which is a simple and non-invasive test to evaluate the functional capacity of patients with ACS who underwent cardiac rehabilitation programs.

Materials and Methods

In this longitudinal study, 44 patients with acute coronary syndromes underwent Percutaneous Coronary Intervention (PCI) or Coronary Artery Bypass Graft (CABG) three months before the study and were referred to the CR clinic in Rasht, Iran. Patients who had contraindications of CR or those who could not continue CR for any reasons such as rehospitalization, myocardial infarction, or recurrent revascularization, were excluded from this study. First, demographic information on the participants, including age, sex, smoking status, family history of cardiovascular disease, history of diabetes, and hypertension was collected. The number of vessels involved based on the report of angiography, anthropometric parameters including weight, Body Mass Index (BMI), Waist Circumference (WC), and laboratory parameters (FBS, LDL, HDL, AST, ALT, and TG) were collected from patients' files. Then, a 6-MWT to evaluate the submaximal level of functional capacity of an individual while walking on a flat, hard surface for 6 *min*, and echocardiography (to determine ejection fraction) were performed for all participants. In the next step, CR was performed

for all subjects.

The inclusion criteria for the CR program included having stable ischemic heart disease, stable heart failure, Patent Ductus Arteriosus (PDA), or patients who had undergone heart valve replacement. Twelve cardiac rehabilitation sessions (twice a week for six consecutive weeks) were performed on all participants. It is noteworthy that none of our participants had contraindications to CR. Contraindications to CR include cardiac rehabilitation exercises, nutrition counseling, home physical activities, encouragement of smoking cessation tips, and emotional support.

At the start of each session, the participant's vital signs were assessed. Then, the Heart Rate (HR) of the patients after CR was estimated according to their age and sex. And during aerobic exercises, the estimated heart rate was managed to be maintained. In the next step, an individual CR program was planned. The patients exercised for 60-90 *min* per session. Ten minutes of warm-up, 20 to 40 *min* of aerobic exercise, followed by 10 *min* of recovery. During the CR program, an Electrocardiogram (ECG), blood pressure, heart rate, and percent oxygen saturation are monitored. Lipid & hepatic profile & blood sugar was assessed before and after CR sessions. In addition, one session a week was held for patients and families during the CR program to inform them about managing psychological factors such as stress, anxiety and depression, quitting smoking, and maintaining a healthy diet; while also sending them motivational messages for modified lifestyles through social media. The patient's psychological status was assessed using the Patient Health Questionnaire-4 (PHQ-4) and the Cognitive Stress Scale 4 (PSS-4). It is noteworthy that artificial intelligence was not used in the production of the submitted work.

Patient health questionnaire-4

PHQ-4 is an extremely concise tool for detecting both depression and anxiety disorders, including the first two elements of each measure PHQ-9 and GAD-7. Thus, PHQ-4 includes two sub-categories of 2 categories-one for depression (PHQ-2) and Generalized Anxiety Disorder-2 (GAD-2) for anxiety. Each item is rated on a 4-point Likert scale ranging from 0 (not at all) to 3 (almost every day). The total PHQ-4 score ranges from 0 to 12, and the

total PHQ-2 and GAD-2 scores can range from 0 to 6. A higher score indicates higher levels of depression and anxiety (11).

Perceived Stress Scale 4 (PSS-4)

Perceived Stress Scale is one of the most widely used methods of assessing psychological stress. This self-report scale generates an overall stress score based on general questions rather than specific experiences. This scale can be useful for comparing perceptions of stress in different countries. With this scale, the respondents rated the month before the self-assessment time. The PSS was originally a 14-item scale, although the scale was reduced to 10 items when 4 underperforming items were identified and eliminated. In addition, this has been further reduced to 4 items for use in situations where rapid measurements are required. The PSS-4 scale has a clear advantage in terms of production time and ease of use. The total score is determined by adding the score for each of the four items. Questions 2 and 3 are coded in reverse order. Questions 1 and 4: 0=Never; 1=Almost never; 2=Sometimes; 3=Quite often; 4=Very common Questions 2 and 3: 4=Never; 3=Almost never; 2=Sometimes; 1=Quite often; 0=Very often. The score of PSS-4 ranges from 0 to 16 and a score of 6 and higher indicates higher stress (12).

One day after the last session, 6-MWT, echocardiography, checking laboratory parameters, measuring weight, Body Mass Index (BMI), Waist Circumference (WC), and psychological assessment were performed for a second time. The predicted distance in 6-MWT was calculated by using the following formula for each person at the beginning and end of the study:

Males: $(7.57 \times \text{height in cm}) - (5.02 \times \text{age}) - (1.76 \times \text{weight in kg}) - 309$

Females: $(2.11 \times \text{height in cm}) - (5.78 \times \text{age}) - (2.29 \times \text{weight in kg}) + 667$.

Statistical analysis

In terms of the normality of the data, the Kolmogorov-Smirnov test was used to check. Quantitative data were expressed as mean and standard deviation and qualitative data as frequency and percentage. Paired t-test was used to compare quantitative data before and after the study. IBM SPSS Statistics software

Table 1. Clinical characteristics of participants

| Variables | Total |
|----------------------------|-----------|
| | N=44 |
| Diabetes (n.%) | 21(47.7%) |
| Hypertension (n.%) | 26(59.1%) |
| Smoking (n.%) | 3(6.8%) |
| Family history (n.%) | 14(31.8%) |
| Coronary angiography (n.%) | |
| SVD | 10(22.7%) |
| 2VD | 12(27.3%) |
| 3VD | 22(50%) |

(version 24, IBM Corporation, Armonk, NY, USA) was used for all statistical analyses at a level of statistical significance of $p < 0.05$.

Results

In this study, 44 patients with a mean age of 61.34 ± 6.89 -year-old were enrolled in the study. Most of (68.2%) our participants were male. Table 1 shows the clinical characteristics of the participants.

Table 2 compares laboratory and anthropometric factors in the studied patients before and after cardiac rehabilitation.

According to the information in table 2, the mean LDL and TG levels significantly decreased during the CR program. The mean values of weight, WC, and BMI did not change much throughout 12 sessions of cardiac rehabilitation.

Table 3 compares functional and echocardiographic parameters before and after the CR program.

As table 3 shows, statistically significant improvement was found between all of the functional and ECG characteristics except blood pressure on the peak of endurance before and after the 12 sessions of the cardiac rehabilitation program.

The distance walked in the 6-MWT statistically significantly increased by 66.11 m. The distance and duration walked on the treadmill without cardiac symptoms and new ST-T changes improved statistically significantly from 350 m to 717 and from 5.93 min to 11.25, respectively. The speed of walking on the treadmill improved significantly in the final session of the CR ($p = 0.001$). The percent

Table 2. Comparison of laboratory and anthropometric factors in the studied patients before and after cardiac rehabilitation

| | Baseline N (%) | Final N (%) | p-value |
|------------|-------------------|----------------|---------|
| FBS | 119.4(42.1) | 117.6(25.4) | 0.800 |
| LDL | 85.4(26.2) | 68.3(21.4) | 0.002 |
| HDL | 41.7(10.2) | 42(12.5) | 0.900 |
| AST | 28.5(11.4) | 29.1(10.2) | 0.300 |
| ALT | 31.6(9.8) | 32.1(6.9) | 0.500 |
| TG | 197.5(10.8) | 148.2(71.5) | 0.001 |
| Weight(kg) | 78.28(16.57) | 76.40(16.1) | 0.500 |
| WC(cm) | 105.27(12.81) | 104.8(12.5) | 0.300 |
| BMI | 29.12(5.61) | 28.19(5.48) | 0.400 |

Body Mass Index (BMI), Waist Circumference (WC).

Table 3. Comparison of functional and echocardiographic characteristics of the study patients before and after cardiac rehabilitation program

| Variables | Baseline (Mean±SD) | Final (Mean±SD) | Difference | p-value |
|--------------------------------------|-----------------------|--------------------|-------------|---------|
| EF(%) | 49.31±6.15 | 51.81±5.1 | 2.5±1.8 | 0.001 |
| 6-MWT(m) | 349.25±89.44 | 420.69±81.9 | 66.11±51-80 | 0.001 |
| % Predicted 6-MWT distance | 69.6±17.02 | 82.9±17.01 | 13.2±9 | 0.001 |
| Distance walked without symptom(m) | 350.86±168.55 | 717.44±264.77 | 366.5±226.5 | 0.001 |
| Duration walked without symptom(min) | 5.93±1.66 | 11.25±1.92 | 5.32±2 | 0.001 |
| Max speed of walked | 2.61±0.7 | 6.35±1.11 | 3.74±1.14 | 0.001 |
| Max Mets | 2.53±0.5 | 5.47±0.6 | 2.94±0.76 | 0.010 |
| % Max HR | 60.27±8.91 | 79.52±11.84 | 19.25±1.3 | 0.010 |
| HR on the peak of endurance | 93.59±11.75 | 128.21±14.8 | 34.62±1.6 | 0.010 |
| BP on the peak of endurance | 136.81±14.22 | 137.38±11.98 | 0.56±0.1 | 0.700 |

EF: Ejection Fraction, SD: Standard Deviation, 6-MWT: 6-minute walk test, *m*: Meter, HR: Heart Rate, BP: Blood Pressure.

Table 4. Comparison of psychological factors at baseline and end of the study

| | Baseline (mean±SD) | Final (mean±SD) | Difference | p-value |
|-------|-----------------------|--------------------|------------|---------|
| PSS-4 | 5.50±2.88 | 3.27±2.19 | 2.23±0.96 | 0.001 |
| PHQ-4 | 4.25±3 | 3.11±2.3 | 1.14±0.90 | 0.001 |

PSS-4: Perceived stress scale-4; PHQ-4: Patient health Questionnaire-4; SD: Standard deviation.

of maximum heart rate on the endurance of exercise increased significantly to 79% without symptoms ($p=0.010$).

In addition, we compared the mean of anxiety and stress of participants at baseline and end of study which is shown in table 4.

As can be seen in table 3, the anxiety and stress of participants reduced statistically after 12 sessions of cardiac rehabilitation.

Discussion

ACS is a type of cardiovascular disease that is characterized by a sudden reduction in blood supply to the heart and includes ST-segment Elevation Myocardial Infarction (STEMI), non-STEMI (NSTEMI), and unstable angina and it is responsible for more than 1 million hospitalizations annually (13). In recent years, the diagnosis and treatment of ACS have improved significantly which can lead to an increase in the survival of affected patients (14). CR as secondary prevention is aimed at optimizing the psychological and physical conditions of patients with ACS (15). In this study, factors of functional capacity and psychological status of participants before and after CR were compared.

An important determinant of functional capacity that was studied in our study was the mean distance walked in a 6-MWT. Although the exercise test can evaluate the functional capacity, the 6-MWT is a more cost-effective test and it can be performed with simpler equipment compared to the exercise test.

According to results of this study, the mean distance of the 6-MWT increased from 349.25 m before CR to 420.69 m after CR ($p=0.001$). This result is in line with the results of the study of Bianchi *et al* (6) in which the distance covered during the 6-MWT improved from 474.7 at the beginning to 590 meters after CR ($p<0.001$). The baseline 6-MWT distance in the study of Galal *et al* (16) was 317.60 ± 64.45 meters which increased to 395.75 ± 49.24 meters after the CR program ($p<0.001$).

In the present study, other functional characteristics of participants such as the percent of predicted 6-MWT distance, the mean distance walked without symptoms, the duration of distance walked without symptoms, and the maximum speed of walking distance improved significantly ($p<0.001$). A significant increase in functional capacity after cardiac rehabilitation was shown in the studies of Mohammed HG *et al* (16) and Grochulska *et al* (17) which confirmed the findings of the present study.

Another factor of functional capacity found in present study was heart rate. The percentage of maximum

heart rate increased from 60.27 ± 8.91 in the baseline to 79.52 ± 11.84 at the end of the CR program and none of our patients showed any cardiac symptoms. McMahon *et al* (18) acclaimed in their study that submaximal exercise heart rate improved following CR, confirming the present study's findings.

In the present study, the mean Ejection Fraction (EF) of patients improved significantly after 12 sessions of CR program (49.31 vs. 51.81%). Improvement of EF after the CR program is a controversial issue that can result from revascularization in patients after PCI (with or without the CR program), can be a result of improvement of primary stunning after MI with or without CR or it can be because of different echocardiography machines or even different operators. However, previous studies showed that more sessions of CR can elevate the EF. The results of the present study is in accordance with the studies of Soleimannejad *et al* (19) and Bianchi *et al* (20) in which EF increased significantly after PCI. No significant correlation was found in the study of Peretti *et al* (21).

It should be considered that although Left Ventricular Ejection Fraction (LVEF) is commonly used to assess myocardial contractility, it is not solely determined by this factor. LVEF is also affected by various hemodynamic factors, including heart rate, preload, and notably, afterload. Specifically, arterial elastance significantly influences changes in LVEF, with an inverse relationship (22).

Another important determinant that was investigated in the present study, was psychological status particularly anxiety and stress of patients after the CR program which showed a significant reduction in both factors following the CR ($p=0.001$). This was consistent with the results of the previous studies (23,24) in which anxiety or depression decreased significantly after the CR program. However, the results of Olsen *et al*'s study (25) were different. The researchers stated in the results of this study that anxiety and depression are common among patients who undergo PCI, and CR has no effect on their anxiety and depression. They also stated that anxiety is more common among young and female patients, and depression is common among older patients and is associated with cardiac morbidity.

Improvement in lipid profile and WC is not solely

related to CR program; high dose statins which are prescribed after ACS have a significant role in this process.

Based on the results of the present study, the mean anthropometric indices, including weight, WC, and BMI, did not change significantly over the 12 sessions of CR ($p>0.01$). Changes in patients' anthropometric indices require them to follow a standard diet and generally modify and improve their lifestyle. CR alone in 12 sessions is not sufficient to reduce weight, WC, and BMI in patients.

Laboratory parameters, aside from LDL and triglycerides, also did not show significant changes. This could be because the present study's patients only underwent 12 sessions of CR. To improve laboratory parameters, patients need to change their lifestyle, which involves many factors. CR alone cannot induce changes in patients' laboratory parameters. It is also possible that the number of rehabilitation sessions was too few, and 12 sessions were not enough to

bring about changes in laboratory parameters.

Conclusion

In conclusion, the present study highlights the pivotal role of CR in enhancing both the functional capacity and psychological characteristics of patients with ACS. More importantly, the results of the present study showed that 6-MWT can be a helpful and more economical test for evaluating of functional capacity.

Acknowledgement

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Conflict of Interest

There was no conflict of interest in this manuscript.

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