Original Article

Comparison of the Effect of Cardiac Rehabilitation on Functional Capacity of Diabetic and Nondiabetic Patients after CABG

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Abstract

Background: After a coronary artery bypass graft (CABG), diabetic patients deal with various hemodynamic disorders. This study aimed to compare the effect of cardiac rehabilitation (CR) on the functional capacity of diabetic and nondiabetic patients following CABG. **Methods:** This descriptive-analytical study was performed on 40 diabetic and nondiabetic patients attending a similar CR program following CABG. The subjects were selected by convenience sampling and were divided into two diabetes and nondiabetes groups. All patients attended 24 exercise sessions held 3 days a week. The functional capacity of patients was measured and recorded with the metabolic equivalent of Task criterion before and after the CR program. In addition, data analysis was performed in SPSS version 19. **Results:** In this study, the mean age of the diabetic and nondiabetic patients was 54.45 ± 5.82 and 56.85 ± 5.36 years, respectively. There was no significant difference between the research groups regarding the systolic and diastolic blood pressure ($P > 0.05$). The mean functional capacity in the diabetes and nondiabetes groups was 4.5 ± 0.79 and 5.2 ± 1.7 before the rehabilitation, respectively. However, the results of Mann–Whitney U-test were indicative of a lack of a significant difference in this respect ($P > 0.05$). After the CR program, the mean functional capacity in the diabetes and nondiabetes groups was 5.7 ± 1.31 and 6.3 ± 1.7, respectively, demonstrating an insignificant difference in this regard ($P > 0.05$). **Conclusions:** According to the results of the study, there was no significant difference between the diabetic and nondiabetic patients, who underwent CABG, after a CR program. However, replication of the study is warranted.

Keywords: *Cardiac rehabilitations, coronary artery bypass, diabetes mellitus, metabolic equivalent*

Introduction

Diabetes is a major risk factor for cardiovascular diseases that leads to increased mortality and disability and induced long-term complications in patients.[1] Studies show that diabetes can have negative impacts on general health, wellbeing, and quality of life.[2,3] Special attention is paid to patients with coronary artery disease and diabetes mellitus, and one of the important management tools for these patients is cardiac rehabilitation (CR) due to its ability to improve the overall status of patients.[1] CR encompasses an important part of the comprehensive secondary prevention program for cardiovascular diseases, which can reduce cardiovascular mortality by up to 50%.

The ultimate goal of CR is reviving and maintaining an optimal physiological, mental, social, and occupational status in individuals.[4,5] In fact, CR refers to a set of interactive measures taken to improve the physical, mental, and social states of individuals. In addition, the concept is used to reduce or even reverse the process of atherosclerosis and decrease mortality and morbidity of the disease.[6] In a research, Jamshidpour *et al*. compared the body mass index (BMI) of diabetic and nondiabetic patients after CR. According to the results, while BMI decreased in diabetic patients, it increased in nondiabetes patients after the CR program.[7] Exercise therapy in comprehensive CR programs increased the contraction strength of the subjects and improved their cardiac output, reported by Lavie *et al*.[8] The effect of CR on hemodynamic indexes, BMI, level of stress and anxiety, functional capacity, and risk factors for coronary artery disease (e.g., blood glucose level) has been assessed in various studies.[9,10]

Diabetes is one of the most important risk factors for some disorders such as

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nephropathy, retinopathy, neuropathy, cardiomyopathy, and other cardiovascular diseases.[11] Many studies have shown that diabetes reduces angiogenesis and the formation of cardiac collateral vessels. These factors decrease myocardial perfusion and blood supply while increasing mortality.[12] In general, individuals with diabetes have one- to sevenfold increased risk of cardiovascular diseases.[13] Cardiovascular diseases account for approximately 21% of mortality in diabetic people.[14] The beneficial impacts of weight loss and exercise on insulin resistance and other metabolic disorders accompanied by diabetes have made the need for a comprehensive CR program in this group of people clear.[15] Functional capacity is one of the most important determinants of cardiac status and ability. In addition, it is the best indicator of recovery and ability to return to normal life after myocardial infarction and surgery. Right ventricular function decreases after a coronary artery bypass graft (CABG), which is related to the functional capacity. As such, controlled exercises are recommended for the rehabilitation of these individuals.[16]

Muscle strength is essential for optimal performance, and muscle strength and subsequent functional or exercise capacity decrease in ischemic heart patients.[15,17] In addition, the decreased muscle mass of cardiac patients following a CABG has been reported, which is one of the factors for reduced muscle power, functional capacity, changed body composition, and life quality of patients.[18,19] Therefore, it seems that the cardiac functional capacity in diabetic patients is different from that of nondiabetic patients. In this regard, a question was raised on whether CR in diabetic patients can significantly affect their functional capacity or not. Given the numerous problems of diabetic patients (e.g., depression, stress, neuropathy, and muscle weakness due to high blood glucose), a different rehabilitation program is required for these individuals, compared to those with normal blood glucose levels. Literature review revealed a lack of study to compare the effect of CR on the functional capacity of diabetic and nondiabetic patients after CABG. With this background in mind, the present study aimed to compare the effect of a CR program on the functional capacity of diabetic and nondiabetic patients after CABG.

Methods

This descriptive-analytical study was performed on 40 diabetic and nondiabetic patients after CABG, who referred to Imam Reza Hospital in Mashhad, Iran to receive CR. The sample size was determined using G*Power software and previous studies. In total, 20 subjects were selected per group at a 95% confidence interval, 0.95% test power, and 0.8 effect size. Notably, the participants were selected by nonrandom sampling based on the inclusion criteria, followed by dividing them into two diabetes and nondiabetes groups. At first, informed consent was obtained from all participants. The inclusion criterion was undergoing CABG at least 4–5 weeks ago. Patients were categorized according to the risk of cardiac events during exercise as well as the control of the patients' medications (lipid-lowering agents and anticoagulants) by a trained physician for CR. It is worth mentioning that patients did not discontinue taking their medications during the rehabilitation process. The patients were divided into two groups based on their diabetes status. While the nondiabetes group included patients with FBS less than 110 mg/dL, the diabetes group involved subjects with a history of type 2 diabetes, who used glucose-lowering medications or insulin, and their FBS was more than or equal to 110 mg/dL in two consecutive tests before surgery. In addition, the HbA1c plasma of nondiabetic patients was below 5.7%, whereas it was ≥6.5% in the diabetic subjects.[20] Accordingly, the patients were classified into two diabetes and nondiabetes groups and underwent CABG.

All patients participated in 24 exercise sessions (three times a week). The treatment included walking on a treadmill for 5–20 min, riding a stationary bike for 5–20 min, and using an arm ergometer for 5–20 min. All patients performed the above exercises at each treatment session. In addition, stretching exercises were used for warm up and gradual cool down in each session. The exercise began with moderate intensity, meaning that 60% of patients' maximum heart rate was considered as the target heart rate during cardiac stress test in addition to assessing the patients' fatigue and heart symptoms. Moreover, cardiac status, blood pressure, and heart rate of patients were monitored and recorded continuously by the computer system during exercise. Recording of hemodynamic variables including systolic and diastolic blood pressure and heart rate was done before and after each session of CR by a digital wrist blood pressure and heart rate monitoring.

Participants were familiarized with the equipment, treatment environment, and how to do the exercises prior to the research. Furthermore, the functional capacity of patients was measured and recorded before and after the CR program. The functional capacity is expressed as metabolic equivalent (MET), which is indicative of utilizing 3.5 mL of O_2 per kg of body weight per minute. The functional capacity of patients was accurately estimated and recorded in MET using a treadmill. The process was performed twice (before and after the rehabilitation process [24 sessions]), data analysis was performed in SPSS version 19 using descriptive (frequency and percentage, mean, standard deviation) and inferential (analysis of covariance) statistics, and $P < 0.05$ was considered as statistically significant.

Results

The present study was performed on 20 diabetic and 20 nondiabetic patients, 29 of whom were male and the rest were female. In addition, the mean age of the diabetic and nondiabetic patients was 54.45 ± 5.82 and 56.85 ± 5.36 years, respectively. Moreover, the

Table 1: Demographic characteristics of patients in two diabetic and nondiabetic groups undergoing CABG surgery

Variable		Nondiabetic patients *n* (P)	Diabetic patients *n* (P)	*P*
Gender	Male	17 (85%)	12 (60%)	0.07
	Female	3 (15%)	8 (40%)	
Education	illiterate	0 (0%)	1 (5%)	0.18
	High school	14 (35%)	14 (35%)	
	Diploma	4 (20%)	3 (15%)	
	Associate Degree	1 (5%)	2 (10%)	
	Bachelor	1 (5%)	0 (0%)	
Cigarette smoking	Yes	8 (40%)	3 (15%)	0.07
	No	12 (60%)	17 (85%)	
Opioid usage	Yes	3 (15%)	3 (15%)	0.9
	No	17 (85%)	17 (85%)	
Age		Mean - standard deviation	Mean - standard deviation	
		54.45±5.82	0.99	

n=Number, P=Percent

Table 2: Comparison of mean blood pressure, heart rate, body mass index, and functional capacity in diabetic and nondiabetic groups before and after cardiac rehabilitation

Variable	Diabetics	Nondiabetics	*P*
systolic blood pressure (before)	129.45±12.27	123.6±17.50	0.155
Systolic blood pressure (after)	122.4±12.25	118.25±11.86	0.31
diastolic blood pressure (before)	77.83±18.81	83.1±14.07	0.43
diastolic blood pressure (after)	77.4±8.58	77.65±9.43	0.99
Heartbeat (before)	82.1±13.17	82.1±19.03	0.87
Heartbeat (after)	78.85±11.06	83.45±17.57	0.56
BMI (before)	26.65±2.67	24.78±3.27	0.05
BMI (after)	26.59±2.56	24.72±3.24	0.05
Functional capacity (before)	4.51±0.80	5.25±1.70	0.50
Functional capacity (after)	5.72±1.31	6.39±1.70	0.24

minimum and maximum age of the participants was 30 and 65 years, respectively. Other descriptive characteristics of the groups are shown in Table 1. As observed, the groups were homogeneous in terms of age, gender, level of education, smoking status, and narcotics use [Table 1].

According to the results, there was no significant difference between the research groups regarding the systolic and diastolic blood pressure, heart rate, BMI, and functional capacity before and after the CR program ($P > 0.05$) [Table 2].

The mean functional capacity in the diabetes and nondiabetes groups was 4.51 ± 0.79 and 5.25 ± 1.71 before the rehabilitation, respectively. However, the results of Mann–Whitney U-test were indicative of a lack of a significant difference in this respect ($P = 0.001$). After the CR program, the mean functional capacity in the diabetes and nondiabetes groups was 5.72 ± 1.31 and 6.39 ± 1.71, respectively, demonstrating an insignificant difference in this regard ($P > 0.05$). However, there was an increase in the functional capacity of all participants after the intervention, and Paired *t*-test showed a significant difference in this regard [Table 3].

Discussion

According to the results of the present study, the functional capacity of diabetic and nondiabetic patients equally increased after a CR program following CABG. Most studies performed in the field have only focused on the effect of CR on physiological and physical performance of patients after CABG, and a few studies have paid attention to diabetic patients in this regard. In addition, no comparison has been made between diabetic and nondiabetic patients in terms of functional capacity. The results showed a lack of a difference between the subjects in the diabetes and nondiabetes groups regarding their functional capacity before and after a CR program. In a retrospective pilot study, McPhee *et al*. (2015) evaluated early CR in functional capacity changes. According to the results, exercise training in patients with coronary artery disease improved physical capacity and running distance in maximal exercise test.[21] In this respect, our findings are in line with the results of the mentioned study since the functional capacity of both diabetic and nondiabetic patients improved after a round of CR. These changes are often the result of adjustments such as increased blood volume, increased ejection fraction, decreased vascular resistance, and increased cardiac muscle oxygenation capacity. However, the difference between our study and the research by McPhee *et al*. was a lack of comparison of the diabetes and nondiabetes groups in terms of cardiac function.

In another study, Pilannejad *et al*. assessed the effect of the first stage of CR on the quality of life and functional capacity of patients with cardiac failure, concluding that CR improved the mentioned variables in the participants.[22] In this context, our findings are congruent with the results of the aforementioned study, while the difference between the two studies was different sample sizes and using both diabetes and nondiabetes groups in the present research.

Table 3: Mean difference in functional capacity between diabetic and nondiabetic patients before and after cardiac rehabilitation

Variable	group	Mean (standard deviation)	*P*, Paired *t*-test
Functional capacity in diabetic patients	Before	4.51 (0.79)	0.0001
	After	5.72 (1.31)	
Functional capacity in nondiabetic patients	Before	5.25 (1.71)	0.0001
	After	6.39 (1.70)	

The present study showed that after CR patients' systolic and diastolic blood pressure and heart rate decreased. In this regard Saremi *et al*.'s study showed that 8 weeks of rehabilitation program can improve cardiac-metabolic risk factors such as decreased BMI, systolic and diastolic blood pressure, total cholesterol, and triglyceride in patients with coronary artery disease without changes in C-reactive protein.[23] Regulation of blood pressure may be due to improved autonomic function (increased parasympathetic activity compared to sympathetic) and enhanced endothelial function and vasodilation.[24] The results of the present study showed that after the rehabilitation program, functional capacity increased in both diabetic and nondiabetic patients, which indicates an improvement in patients' aerobic capacity. In this regard, McPhee *et al*. found that 2 months of exercise in patients with coronary artery disease improves exercise capacity and running distance in the maximum exercise test.[21] The study by Sigmund *et al*. showed that white race and higher functional capacity have a protective effect on readmission of patients with metabolic syndrome in the hospital. They suggested that new CR approaches are needed for patients with metabolic syndrome due to their unique traits.[25] The present study showed that the functional capacity of diabetic and nondiabetic patients increased equally with CR, which is not in line with the views of Sigmund *et al*. Due to the controversy, it is recommended that further studies evaluate different rehabilitation approaches in patients with metabolic syndrome.

Limitations and recommendations

To our knowledge, our study is the first to examine this concern and our results need to be confirmed in large randomized studies. One of the major drawbacks of the present research was its relatively small sample size, as well as the fact that participants were selected from a single center because of which the generalization of the results must be carried out with caution. In addition, the research data were limited to the period of 2018–2019, which was recognized as another limitation of the study.

Conclusions

According to the results of the present study, there was no significant difference between diabetic and nondiabetic patients regarding functional capacity after a CR program. In the present study, while the functional capacity of both groups improved after the CR program separately, there was no significant difference between the groups in this regard. However, given the small sample size of the current research, more extensive longitudinal studies and larger sample sizes are required to provide a more definitive conclusion regarding the effect of RC on cardiac functional capacity.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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