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Effects of Interval Training on Post-coronary Artery Bypass Grafting Hemodynamic Indices

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Abstract

Objectives: There are conflicting reports on post-coronary artery bypass grafting (CABG) training programs that could have the most favorable impact on the hemodynamic state of patients. Therefore, the purpose of this study was to explore the effects of interval training on hemodynamic indices of patients following CABG.

Materials and Methods: In this prospective quasi-experimental study (over the 4 months leading to July 2019), 24 patients were randomly selected based on a similar study. Among these patients, 12 cases (the training group) referring to Shahid Madani hospital of Tabriz received twelve 20-minute sessions of interval training over a month and their hemodynamic indices were measured before and after the intervention. The indices were then analyzed using the Shapiro-Wilk test, correlated t-test, and independent *t* test and P values lower than 0.05 were considered statistically significant.

Results: The intergroup comparison of hemodynamic indices between training and control groups showed a significant difference ($P \leq 0.019$). In addition, the intragroup comparison of pre- and post-intervention results demonstrated significant improvements in all hemodynamic indices of the training group after the intervention ($P \leq 0.010$) while the changes were not significant in the control group ($P \leq 0.118$).

Conclusions: In general, the interval training program in the post-CABG period improved hemodynamic indices and patient rehabilitation.

Keywords: Interval training, CABG, Post-CABG, Hemodynamic indices

Introduction

Around 40% of mortalities in Iran have cardiovascular causes (1). The high prevalence of cardiovascular disease and related complications leads to the mortality and inability of a large part of the productive forces of the country, especially in their best years of job performance and ultimately to increased healthcare costs (2). Among cardiac diseases, coronary artery diseases (CADs) are the most common and coronary artery bypass grafting (CABG) is one of the main procedures for treating CAD (3).

CABG is performed in CA patients who suffer from CA clogging or atherosclerosis (4) and the procedure results in increased longevity and chest symptom relief (5). The functional capabilities of patients may reduce considerably because of surgery-caused complications and unwanted inactivity. That is why patients are advised to attend training and rehabilitation programs. Thus, cardiac recovery programs are designed with the purpose of secondary prevention including preventing later complications and reducing disease progression. From the onset of cardiovascular rehabilitation programs, training activities have been the major part of these programs. Through modifications in the muscular, cardiovascular, and neurohormonal system, regular training in cardiovascular patients improves functional capacity and enhances the quality of life, while it reduces surgery side-effects and surgery-caused mortality (6).

Post-CABG hemodynamic state has many changes and fluctuations in the first six months and sometimes, these instable changes become highly dangerous so that they can lead to mortality. The most common changes observed in the post-CABG period include changes in systolic and diastolic blood pressure, ejection fraction, heartbeat, oxygen consumption amount, and left ventricular size during systole and diastole (7).

Studies have shown that aerobic continuous training can reduce mortality factors including the cardiac ones. Nevertheless, it is still not completely clear which training exercise has the most favorable outcome for cardiac and coronary artery patients (8,9). On the other hand, an exercise in post-CABG rehabilitation has positive effects on life quality, life satisfaction, increased life expectancy, and increased health (4,10). Considering the provided results in the literature, there are unanswered questions regarding the effects of training exercises. Accordingly, the present study aimed to evaluate the effects of interval training on hemodynamic indices of patients following CABG.

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Materials and Methods

In this prospective quasi-experimental study (from 2019.07.05 to 2019.03.01), several variables were assessed in control and training groups using a pretest-posttest design. The research population included post-CABG patients who referred to Shahid Madani hospital of Tabriz University of Medical Sciences (the location of sampling, intervention, and analysis) and had undergone a surgery at least one month before their referral. The inclusion criteria were undergoing CABG surgery, showing consent for participation in the study, and having a doctor-prescribed need for the rehabilitation program. On the other hand, the exclusion criteria included non-sinus rhythm, inability to walk, orthopedic problems that prevent exercise, and contraindication to the training program. Following a recruitment announcement, 24 patients (sample size according to a similar study by Shafie et al) (11) were randomly selected using a random number table done by a statistics professor and equally divided into interval training and control groups. Prior to any tests, the subjects completed a demographic questionnaire including data on age, gender, weight, height, and body mass index and then underwent preliminary clinical examination by a specialist outside the research team for collecting data regarding medical history, cardiovascular disease history, clinical examinations, along with ECG diagnostic, and cardiac stress tests.

The tests comprised preliminary clinical assessments including height (SECA stadiometer with a 0.1 mm precision, Germany), weight (SECA scale with a 0.1 kg precision, Germany), blood pressure (digital blood pressure monitor by Medical Spacelabs, USA), heartbeat (Polar heart rate monitor CE 0537, N2965, Polar Beat T31, Finland), and cardiac rhythm through ECG (electrocardiogram device MHC 1200, USA). The echocardiography test (Vivid 3 model by the USA) was used to assess the structural factors of the heart. These tests were run with all training and control group patients one week before and one week after the intervention. To check reliability, all tests were run in a single place by specialists through a joint program. In addition, the modified Bruce test was used with the breath gas analysis device (Start 2000 MES, Cracow, Poland) to determine $VO2_{max}$ (12).

The assessment of the functional factors of the heart was achieved using the echocardiography device as follows.

The patient lay down on the bed of the device and then an echocardiography specialist used a transducer (a device to transmit ultrasound waves), placed it on the chest near the heart in order to transmit ultrasound waves to the heart. The reflections from different parts of the heart were recorded by a receiver and projected on a monitor. Using the images, the specialist then measured and recorded the indices for assessing the left ventricular function including left ventricular ejection fraction, left ventricular systolic diameter, and left ventricular diastolic diameter. All items were recorded for each patient using the pen and paper method.

Next, the participants received the rehabilitation program under the supervision of a physical medicine and rehabilitation specialist who was outside the research team. The intervention consisted of three 20-minute sessions per week over four weeks. Further, the training protocol was designed similar to the one by Wisloff et al and The American College of Sports Medicine (ACSM) standards, and according to the patient's baseline condition and exercise test results, the heart rate range, level, and intensity or velocity on the treadmill were recorded for each patient on the exercise control sheet. Training intensity was within 70%-85% of the maximum heart rate and lasted for 2-5 four-minute repetitions. Furthermore, the patients could rest 5-10 minutes after each repetition (13). On the other hand, the control group received no intervention.

All ethical considerations were adopted, including the ethics in research, informed consent, data confidentiality, examinations by a heart specialist, as well as free of charge examinations, tests, and rehabilitation exercise and voluntary participation. The data were imported to SPSS21 and analyzed using the Shapiro-Wilk test, correlated t-test, and an independent t-test with a 95% confidence interval.

Results

Of 35 patients who referred to Shahid Madani hospital of Tabriz, 24 cases were selected and none of them were excluded or withdrew from the study. Based on the results of the Shapiro-Wilk test, the mean and standard deviation of age, height, weight, and body mass index of the participants were 48.5 ± 07.20 (years), 172.33 ± 11.42 (cm), 79.25 ± 10.20 (kg), and 30.11 ± 05.25 (kg/m^2), respectively. There was no statistically significant difference between the two groups regarding these indices, demonstrating a normal distribution. Moreover, 17 patients were females (8 and 9 cases in the control and training groups, respectively). The results of the anthropic indices are provided in Table 1.

The results of the paired t-test showed that all hemodynamic indices of the training group patients improved significantly after the intervention compared to the control group ($P \leq 0.019$). Table 2 presents the results of the intergroup comparison of post-intervention hemodynamic indices.

On the other hand, the intragroup comparison of pre- and post-intervention scores based on the paired t-test results demonstrated significant changes in the training group. In other words, there were significant improvements in all hemodynamic indices of the training group after the intervention ($P \leq 0.010$) although the changes in the control group were not significant ($P \leq 0.118$). The intragroup results of hemodynamic indices are summarized in Table 3.

Table 1. The Pre-intervention Anthropic Indices

Variable	Training Group, Mean (SD)	Control Group, Mean (SD)	*P* Value[a]
Age	47.23±06.18	45.95±07.25	0.211
Height	175.18±12.42	171.11±09.54	0.109
Weight	80.03±06.52	79.45±06.36	0.149
BMI	30.01±05.63	30.45±04.11	0.409
EF	48.91±05.50	50.00±04.12	0.288
LVDd	48.39±05.45	49.01±05.01	0.306
LVSd	33.49±03.25	34.11±03.18	0.285
Heart rate	92.45±10.10	90.89±10.95	0.299
RSBP	139.55±10.21	140.15±10.40	0.153
RDBP	83.69±06.40	85.12±07.15	0.118
Number of participants	12	12	

Note. SD: Standard deviation; BMI: Body mass index; EF: Ejection fraction; LVDd: Left ventricular diastolic diameter; LVSd: Ventricular systolic diameter; RSBP: Systolic blood pressure; RDBP: Diastolic blood pressure.

[a] Shapiro-Wilk test.

Table 2. Comparison of Post-intervention Hemodynamic Indices

Variable	Training Group (n=12), Mean (SD)	Control Group (n=12), Mean (SD)	*P* Value[a]
EF	54.10±03.25	50.48±05.01	0.012*
LVDd	52.80±05.66	49.25±05.15	0.019*
LVSd	37.75±04.18	34.55±03.61	0.009*
Heart rate	88.20±09.45	90.49±11.55	0.017*
RSBP	124.30±09.14	138.48±10.32	0.008*
RDBP	80.70±06.12	85.52±08.89	0.009*

Note. SSD: Standard deviation; EF: Ejection fraction; LVDd: Left ventricular diastolic diameter; LVSd: Ventricular systolic diameter; RSBP: Systolic blood pressure; RDBP: Diastolic blood pressure.
[a] Paired *t* test; *Significant.

Table 3. Intragroup Comparison of Hemodynamic Indices

Variable	Group	Pre-intervention, Mean (SD)	Post-intervention, Mean (SD)	*P* Value[a]
EF	Training (n=12)	48.91±05.50	54.10±03.25	0.009*
	Control (n=12)	50.00±04.12	50.48±05.01	0.118
LVDd	Training (n=12)	48.39±05.45	52.80±05.66	0.007*
	Control (n=12)	49.01±05.01	49.25±05.15	0.745
LVSd	Training (n=12)	33.49±03.25	37.75±04.18	0.005*
	Control (n=12)	34.11±03.18	34.55±03.61	0.595
Heart rate	Training (n=12)	92.45±10.10	88.20±09.45	0.007*
	Control (n=12)	90.89±10.95	90.49±11.55	0.519
RSBP	Training (n=12)	139.55±10.21	124.30±09.14	0.006*
	Control (n=12)	140.15±10.40	138.48±10.32	0.319
RDBP	Training (n=12)	83.69±06.40	80.70±06.12	0.010*
	Control (n=12)	85.12±07.15	85.52±08.89	0.512

Note. SSD: Standard deviation; EF: Ejection fraction; LVDd: Left ventricular diastolic diameter; LVSd: Ventricular systolic diameter; RSBP: Systolic blood pressure; RDBP: Diastolic blood pressure.
[a] Paired *t* test; *Significant.

Discussion

The purpose of this study was to assess the impact of interval training programs on the post- CABG hemodynamic indices of patients. The findings revealed that the interval training during the post-CABG period could exert positive effects on the hemodynamic indices and improve the post-CABG cardiac state of the patients. In other words, interval training resulted in the cardiac rehabilitation of the patients. These findings are consistent with those of Kachur et al (14), Priscila et al (15), and Caruso et al (16). It seems that interval training could lead to increased total oxygen consumption and reduced ventilation and thus resulting in cardiovascular adaptations and improved hemodynamic indices. These processes occurred by increasing capillary density, reducing lateral artery resistance, increasing end-diastolic volume and stroke volume, heart rate, mitochondrial number and size, lactate uptake, and aerobic metabolism enzymes, and finally, by increasing muscular oxygen consumption and higher oxygen extraction from the blood. On the other hand, it was shown that simple exercise can improve the hemodynamic status and increase cardiac output by affecting the cardiac muscle and increasing blood supply to the heart tissue, as well as by increasing the level of oxygen to the heart tissue (17).

One of the most unfavorable outcomes following CABG operation in CAD patients is heart rate irregularity which is a symptom of left ventricular function disorder. Further, it may be accompanied by reduced left ventricular size during systole, diastole, or both. Rehabilitation programs can contribute to both cardiac contractility (identified by increased ejection fraction) and more normal and even better state of the heart by making structural changes to left ventricular dimensions and improving ventricular systolic diameter and left ventricular diastolic diameter, which was achieved in the present study. Thus, the measurement of the end-systolic dimensions of the left ventricle can be of great importance for identifying patients who are at high risk of premature death due to postoperative heart attack, and the implementation of programs that would improve this measurement can reduce the post-CABG mortality rate. In this study, interval training programs could make significant changes, which is consistent with the results of Fallahi et al (6) and Aghaei Bahmanbeglou et al (12).

There is little research on the structural changes of the heart and hemodynamic state of post-CABG patients following training exercises. Nevertheless, the existing body of research suggests the positive impact of training programs on the rehabilitation of the patient and the improvement of hemodynamic indices. In addition, decreasing changes in the left ventricular size and function, the heart rate, and other hemodynamic indices of the control group patients represent the unfavorable impact of not attending the rehabilitation program, suggesting the importance of these programs in the post-CABG period.

Limitations

Small sample size, varying reactions by patients of different ages to the training program, patients' lifestyle and nutrition exclusion, and blindness to their participation in the training program before the operations were the limitations of this study.

Suggestions

The authors recommend further research while aiming at overcoming the above-mentioned limitations. The integration of training programs into the post-CABG period protocol is also recommended for the patients.

Conclusions

Overall, interval training programs in the post-CABG period improved the hemodynamic indices of the patients and their rehabilitation.

Conflict of Interests

None.

Ethical Issues

The research project was approved by the Ethics Committee of Tabriz University of Medical Sciences (ethics no. IR.TBZMED.REC.1397.1059, IRCT No. IRCT20190325043107N2).

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