

EFFECTS OF LONG-TERM AND SHORT-TERM CARDIAC REHABILITATION PROGRAMS ON CARDIOVASCULAR RISK FACTORS AND PHYSICAL FITNESS AFTER PERCUTANEOUS CORONARY INTERVENTION

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ABSTRACT

Background

Cardiac rehabilitation programs reduce the likelihood of relapse and cardiac arrest in patients with coronary artery disease. The goal of this study was to compare and analyze changes in cardiovascular risk factors and physical fitness in patients who participated in short-term (ST) and long-term (LT) cardiac rehabilitation programs following coronary artery percutaneous coronary intervention (PCI).

Methods

This study included 193 men aged ≥ 45 years who received PCI for coronary artery occlusive disease. The participants were divided into ST program participants (3 months, 108 participants; ST group) and LT program participants (12 months, 85 participants; LT group). Blood lipids analysis, body composition, and physical fitness tests were performed to assess cardiovascular risk factors and physical fitness. Paired *t*-test and two-way ANOVA with repeated measures were used to investigate the effect of the intervention.

Results

Both groups had significant improvements after cardiac rehabilitation in body fat, high-density lipoprotein cholesterol, exercise duration, heart rate (HR) at rest, double product peak, VO_2 peak, 6-min walking, and sit-to-stand, compared to baseline. The LT group also had significant improvements after cardiac rehabilitation in waist circumference (WC), total cholesterol (TC), triglyceride (TG), and HR peak. LT group had significantly improved effect than ST group in WC, TC, TG, exercise time, HR peak, and 6-min walking.

Keywords: *cardiac rehabilitation; risk factor; fitness; percutaneous coronary intervention*

INTRODUCTION

Coronary artery disease has a high incidence and mortality worldwide (1). In patients with coronary artery disease, plaque grows within the arteries, causing narrowing of the arteries and often leading to occlusion if the plaque ruptures (2). The main treatment methods for coronary artery disease include percutaneous coronary intervention (PCI) and coronary artery bypass graft, in addition to drug therapy (3). In recent years, PCI has been used with increasing frequency due to its advantages over other treatments, such as nonincision, shorter hospital stays, lower cost, and lower recurrence rates. However, due to the nature of coronary artery disease, systemic care and lifestyle modification therapy are emphasized because of the frequent relapse or cardiac arrest after treatment.

Systematic care, such as exercise, diet, and lifestyle modification therapy following procedures for patients with coronary artery disease, is called cardiac rehabilitation (CR). The purpose of CR is to help maintain physical and mental health by modifying factors that can be improved mainly by diet and exercise, such as obesity, dyslipidemia, hypertension, diabetes, and quality of life (4, 5). CR can reduce mortality and cardiac arrest in patients with cardiac disease by 20–25% (6). In addition, regular exercise and diet can help reduce weight and blood pressure (BP), improve insulin sensitivity, and positively affect blood lipid components and cardiorespiratory fitness (7, 8).

Although positive effects of CR and exercise have been reported, CR research has some difficulties. Firstly, there is a limitation in verifying the effectiveness of the intervention due to the high withdrawal rate. A CR drop-out-related study reported that

47.5% of people did not complete a CR program (9). Secondly, it is difficult for patients to start CR at the same time after discharge, and the participation period is highly diverse due to the high drop out. Therefore, the purpose of this study was to compare and analyze changes in cardiovascular risk factors and physical fitness in patients who participated in short-term [ST] and long-term [LT] CR programs following coronary artery PCI. We collected data for patients who participated in CR programs after coronary artery PCI treatment at 3 and 12 months. And, they were retrospectively compared and analyzed for differences between variables considered as cardiovascular risk factors, separating the patients into the ST group and the LT group after the termination of CR.

MATERIALS AND METHODS

Participants and procedure

A total of 352 men aged ≥ 45 years who received PCI for coronary artery occlusive disease joined the CR program within 1 month of PCI. Those who did not complete all of the tests associated with this study, did not participate in CR programs for more than 3 months, or whose cardiac problems were detected before the age of 40 were excluded. There were 159 patients who did not meet the eligibility criteria; only 193 patients were ultimately included. The researcher explained the purpose, background, and progress of the study to the patients, and used data only from those patients who agreed to participate in the study. For the analysis, the group was divided into an ST group of 3 months and an LT of 12 months using the record. Participants visited the hospital within 1 month after receiving PCI

TABLE 1 General Characteristics of Participants

Variables	ST group (n = 108)	LT group (n = 85)	P
Age, years	60.1 ± 7.8	59.0 ± 8.8	0.328
Height, cm	166.7 ± 6.7	165.5 ± 7.3	0.220
Weight, kg	70.7 ± 10.7	69.1 ± 9.5	0.240
BMI, kg/m ²	25.1 ± 2.6	25.2 ± 2.6	0.783

Data are presented as mean ± standard deviation; test by analysis of independent *t*-test was performed; BMI, body mass index; ST, short-term; LT, long-term.

and underwent specialist treatment and blood collection. Table 1 shows the general characteristics of the participants. The study was approved by the Institutional Review Board of AMC (2015-0594).

Cardiac rehabilitation programs

The ST CR program lasted for 3 months while the LT lasted for 12 months. The CR program consisted of nutritional counseling, exercise prescription, and nursing care. CR exercise programs were prescribed based on the results of the cardiac exercise stress test, medical tests, and cardiologists' opinions, and the patients were trained to perform home-based CR exercises. The exercise program was based on the American College of Sports Medicine (ACSM) guidelines (10) and recommended that the participants perform aerobic exercises at least 3 days a week for ≥30 min. Exercise intensity was set using the heart rate (HR) reserve of 40–70%, which was based on cardiac exercise stress test results. The participants were trained by clinical dietitians on how to create low-fat, low-cholesterol, calorie-balanced, and nutrient-balanced diets. Nurses educated patients on how to complete self-care through symptom management, knowledge of diseases, and stress counseling (11).

Blood lipids analysis

Participants were required to fast for 8 hours prior to blood collection for an accurate assessment. Triglyceride (TG), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol

(LDLC), and total cholesterol (TC) corresponding to dyslipidemia were measured.

Exercise stress test

Oxygen uptake was measured by an exercise stress test to assess cardiovascular endurance. The exercise stress test used Vmax29 exercise stress testing equipment (SensorMedics Co., Yorba Linda, CA, USA) and was performed under the supervision of medical professionals to check for the presence of cardiac diseases using electrocardiography (ECG) (10). Patients were required to refrain from excessive physical activity prior to the test. Abnormalities in BP, HR, and ECG were checked every minute during the test, and the rate of perceived exertion and chest pain scale were measured every 3 min. The highest oxygen uptake (VO₂ peak, mL/min/kg) was measured by analyzing the exhaled gas using a gas analyzer with the breath-by-breath method. Heart rate (HR) and BP were measured at rest and during exercise, and the double product (DP) was calculated. The degree of recovery was calculated from HR and the HR recovery rate in 1 min of recovery ($[(\text{peak-recovery 1 min})/\text{resting}] \times 100$). HR at rest, HR during exercise, BP, DP, and HR recovery were analyzed to examine the hemodynamic response during exercise.

Body composition and physical fitness test

Body composition

We used impedance to measure muscle mass and body fat using the Inbody 770 (Inbody Co., Seoul, Korea) and then performed exercise stress tests and physical fitness tests.

Six-minute walking

Participants walked the designated track as fast as possible for 6 min. The investigator informed the subject of the elapsed time in 1-min intervals and measured the total distance after 6 min (12).

Handgrip strength

Handgrip strength was measured using a digital handgrip dynamometer (TKK-5401; TAKEI

Scientific Instruments Co., Ltd., Tokyo, Japan). Participants were asked to stand and assume a neutral position of the arm and wrist. Measurements were performed twice in both hands, and the mean value was reported for each side (13).

Flexibility

Flexibility was measured using a digital sit-and-reach measuring instrument (TKK-5403; TAKEI Scientific Instruments Co., Ltd.) during a sit-and-reach test. Participants were asked to assume a sitting position, straighten their legs and arms, lean forward, and maintain this position for at least 3 s. The sit-and-reach test was performed twice, and the best result was recorded (10).

Sit-to-stand

Muscular endurance of the lower body was measured using the sit-to-stand method. Participants sit with their hands crossed over their shoulders, stand up with their knees straightened for 30 s, and then return to a seated position. The test recorded the repetition number (14).

Statistical analysis

SPSS 25.0 software (IBM SPSS Inc., Armonk, NY, USA) was used for data analysis. Continuous variables were expressed as mean and standard deviation. An independent *t*-test was conducted to assess significant differences between the ST group and the LT group. Paired *t*-test was conducted to evaluate the intervention effect within the two groups. Two-way ANOVA with repeated measures was used to investigate the effect of the group and time. The two main factors were time (pretest and posttest) and group (ST vs. LT). Statistical significance was set at $P < 0.05$ for all analyses.

RESULTS

Risk factors for cardiovascular disease

Table 2 presents the differences between the ST group and the LT group with regard to risk factors for cardiovascular disease. There was significant improvement in body fat and HDLC in the ST group, compared to baseline. There was also significant improvement in body fat, waist

TABLE 2 Risk Factors of Cardiovascular Disease in the Short-term and the Long-term Group

Variables	ST group (n = 108)		LT group (n = 85)		P
	Pretest	Posttest	Pretest	Posttest	
BMI, kg/m ²	25.1 ± 2.6	25.1 ± 2.5	25.2 ± 2.6	25.1 ± 2.6	0.667
Body fat, %	26.2 ± 19.1	23.8 ± 5.8 ^a	25.8 ± 5.6	23.8 ± 5.4 ^a	0.235
Muscle, %	36.9 ± 8.7	38.9 ± 6.5	37.9 ± 3.7	38.5 ± 7.0	0.142
Waist C, cm	90.5 ± 7.8	90.2 ± 6.4	90.0 ± 6.6	88.3 ± 6.2 ^{a,b}	0.039 ^c
Hip C, cm	95.6 ± 5.1	95.6 ± 6.1	95.5 ± 4.9	93.1 ± 8.5	0.756
WHR	0.95 ± 0.05	0.94 ± 0.05	0.96 ± 0.18	0.94 ± 0.04	0.874
TC, mL/dL	140.5 ± 30.1	140.9 ± 31.9	143.0 ± 32.8	130.7 ± 33.0 ^{a,b}	0.025 ^c
HDLC, mL/dL	46.0 ± 11.5	48.2 ± 13.1 ^a	46.3 ± 9.0	50.7 ± 11.8 ^a	0.132
LDLC, mL/dL	82.0 ± 26.3	79.3 ± 26.5	83.0 ± 28.9	78.9 ± 25.3	0.487
TG, mL/dL	128.5 ± 69.4	130.7 ± 85.4	128.2 ± 60.1	119.7 ± 57.4 ^{a,b}	0.040 ^c

Data are presented as mean ± standard deviation; test by analysis of paired *t*-test, independent *t*-test, and repeated two-way ANOVA were performed; $P < 0.05$; a, Pre versus Post within group; b, ST versus LT; c, Group × Time; BMI, body mass index; Waist C, waist circumference; Hip C, hip circumference; WHR, waist-hip ratio; TC, total cholesterol; HDLC, high-density lipoprotein cholesterol; LDLC, low-density lipoprotein cholesterol; TG, triglyceride; ST, short-term; LT, long-term.

circumference (WC), TC, HDLC, and TG in the LT group, compared to baseline. Also, the LT group showed a greater improvement in WC ($P = 0.039$), TC ($P = 0.025$), and TG ($P = 0.040$) than the ST group.

Exercise stress test

Table 3 shows the effects of ST and LT CR in exercise stress tests. In the ST group, exercise time, HR rest, and DP peak were significantly improved, and in the LT group, HR rest, HR peak, and DP peak were significantly changed. The LT group showed a significant difference according to the group and exercise duration ($P = 0.043$) and HR peak ($P = 0.038$), compared to the ST group.

Physical fitness

Table 4 shows the fitness changes in the ST and LT groups after CR. Both groups showed significant

improvements in VO_2 peak, 6-min walking, and sit-to-stand. The LT group had a significant change in the 6-min walking than the ST group ($P = 0.029$).

DISCUSSION

CR programs reduce the likelihood of relapse, complications, and cardiac arrests in patients with coronary artery disease, besides improving their quality of life (15, 16). CR programs also have a positive impact on risk factors by modifying health behaviors such as nutrition, smoking, alcohol consumption, and stress management. In particular, exercise-based CR programs have been reported to be highly effective in reducing obesity, blood glucose, BP, and dyslipidemia (7, 17). General aerobic exercise has been reported to improve blood lipid levels (18), and exercise-based rehabilitation programs have been reported to be effective in

TABLE 3 Exercise Stress Test between the Short-term and the Long-term Group

Variables	ST group (n = 108)		LT group (n = 85)		P Time × group
	Pretest	Posttest	Pretest	Posttest	
Exercise duration, min	7.3 ± 2.4	8.0 ± 2.1 ^a	7.3 ± 2.4	10.2 ± 2.4 ^{a,b}	0.043 ^c
Rest					
HR rest, beat/min	69.0 ± 13.6	66.3 ± 12.5 ^a	68.4 ± 15.1	66.5 ± 19.1 ^a	0.481
SBP rest, mmHg	123.2 ± 16.7	122.9 ± 17.1	122.0 ± 15.2	120.0 ± 15.1	0.846
DBP rest, mmHg	74.5 ± 9.9	74.6 ± 10.2	75.4 ± 9.2	75.8 ± 10.1	0.953
DP rest	8481 ± 2022	8156 ± 1953	8250 ± 2259	7936 ± 2081	0.741
Exercise					
HR peak, beat/min	132.6 ± 20.8	128.2 ± 23.5	133.5 ± 23.4	122.1 ± 22.2 ^a	0.038 ^c
SBP peak, mmHg	186.1 ± 27.3	179.9 ± 28.7	180.4 ± 27.7	176.8 ± 28.0	0.164
DBP peak, mmHg	82.0 ± 14.0	81.1 ± 14.9	83.8 ± 17.6	81.3 ± 15.9	0.483
DP, peak	24,897 ± 5926	23,301 ± 6662 ^a	23,933 ± 6261	23,173 ± 6012 ^a	0.088
Recovery 1 min					
HR, mmHg	110.8 ± 19.9	107.5 ± 20.4	110.6 ± 20.9	108.8 ± 19.7	0.781
HR recovery rate, %	32.3 ± 22.1	32.0 ± 21.4	34.1 ± 18.9	33.6 ± 20.2	0.621

Data are presented as mean ± standard deviation; test by analysis of paired t-test, independent t-test, and repeated two-way ANOVA were performed; $P < 0.05$; $T \times G$, time × group; a, Pre versus Post within group; b, ST versus LT; c, Time × Group; ST, short-term; LT, long-term; HR, heart rate; SBP, systolic BP; DBP, diastolic BP; DP, double product; HR recovery rate formula, [(peak-recovery 1 min) / rest] *100.

Table 4. Physical Fitness between the Short-term group and the Long-term Group

Variables	ST group (n = 108)		LT group (n = 85)		P
	Pretest	Posttest	Pretest	Posttest	
VO ₂ peak, ml/kg/min	31.5 ± 8.3	33.8 ± 8.3 ^a	30.9 ± 7.6	35.1 ± 9.4 ^a	0.135
6-min walking, m	546.1 ± 80.3	568.7 ± 75.1 ^a	549.6 ± 67.8	580.8 ± 66.6 ^{a,b}	0.029 ^c
Hand grip strength, kg	35.6 ± 5.4	36.2 ± 6.0	35.7 ± 7.3	37.4 ± 6.8	0.068
Flexibility, cm	-1.2 ± 8.9	-0.7 ± 9.3	0.5 ± 7.2	1.5 ± 8.7	0.141
Sit-to-stand, repetition	13.5 ± 2.6	14.4 ± 3.2 ^a	13.8 ± 2.4	14.6 ± 3.1 ^a	0.511

Data are presented as mean ± standard deviation; test by analysis of paired t-test, independent t-test, and repeated two-way ANOVA were performed; $P < 0.05$; $T \times G$, time × group; a, Pre versus Post within group; b, ST versus LT; c, Group × Time. ST, short term; LT, long term.

affecting blood lipid levels (TC -5%, TG -15%, LDL -2%, and HDL +6%), body composition (body mass index, BMI -1.5%), and physical fitness (cardiovascular endurance +35%) for patients with cardiac disease (19). A previous study with a 14-year follow-up examined 4451 men who participated in CR programs (20) and found a decrease of 7 mg/dL in cholesterol, an increase of 1 mg/dL in HDLC, decreased alcohol consumption, and increased smoking cessation rates, compared to men who did not participate in CR programs. Therefore, CR programs are effective interventions that allow LT management of cardiovascular risk factors.

This study found that the LT program was more effective in reducing risk factors of cardiovascular disease than the ST program. The ST group had significant effects only in body fat and HDLC, whereas positive effects in body fat, WC, TC, HDLC, and TG were seen in the LT group. This trend is similar to those in other studies comparing the LT and ST effects of CR programs.

A previous study (21) showed no significant changes in body composition and lipid components after 3 months, but patients who used the program for more than a year had significant improvements in almost all risk factors. The study also showed significant differences in BP, HDLC, and TG in some patients after 3 months but no significant differences in TC or LDLC were found. However, there were significant changes in TC and LDLC after 6 months. Furthermore,

those who participate in a CR program for more than 6 months experience significant improvements in weight, body fat, HDL, TC, and TG (22).

However, patients may experience difficulties with regard to participating in LT CR. Patients may find it difficult to actively participate in exercise due to the after effects and psychological fears after cardiac treatments such as PCI or Coronary Artery Bypass Graft (CABG). Previous study has also reported that up to 20% of patients with acute coronary syndrome experience high levels of anxiety (23). In addition to these psychological reasons, there may be economic reasons. It has been reported that people with high economic status and frequent screenings have a low incidence of metabolic syndrome (24).

This study showed no improvement in LDLC in either the ST group or the LT group. These results are in line with those of Gordon et al. (18), who reported a 4.5% reduction in LDLC with resistance training; aerobic-centered exercises did not improve LDLC in their study. Therefore, the lack of improvement in LDLC in our study may be because the CR programs in our study consisted mainly of aerobic exercises.

One of the main objectives of exercise-based CR is improvement in hemodynamic response, such as BP and HR. DP functions as an index for myocardial oxygen consumption (25). HR and BP are indirect measurements of DP, and lower the values at the same exercise intensity, the better the patient's

fitness. Exercise generally decreases the HR and BP in the resting state (26). However, in a previous study, the CR exercise program improved exercise capacity by 26.4%, but DP had a nonsignificant change of only 1.25% (27). We also found that the VO_2 peak had improved in both groups, with no significant difference in DP at rest. These results are likely attributable to medication commonly taken by patients with coronary artery disease. Beta-blockers and BP medications commonly prescribed for people with coronary artery disease cause reductions in HR and BP. Therefore, the decrease in DP observed in the general public as a result of exercise cannot be expected in patients with coronary artery disease. We did observe significant improvements in the DP peak during exercise, duration of exercise, and cardiovascular endurance, as well as a reduction in HR and DP, in the LT group. This indirectly confirms an improved heart function in the sense that lower myocardial oxygen consumption is needed even at higher exercise intensities.

Cardiorespiratory endurance is the aerobic capacity to deliver oxygen to the muscles through the action of the lungs, heart, and blood vessels, and is used as a major predictor of death for people both with and without cardiovascular disease (28). A decline in cardiorespiratory endurance is known to increase the prevalence of cardiovascular disease and the risk of metabolic syndromes, such as obesity, insulin resistance, hyperlipidemia, and elevated BP (29). Many studies have already reported improvement in cardiorespiratory endurance because of exercise-based CR (19, 27, 30). In this study, both the ST group and the LT group showed improvements in variables related to cardiorespiratory endurance, compared to baseline. However, there was no difference in cardiorespiratory endurance between the two groups, indicating that CR provided no additional benefit to muscular endurance after 3 months. This is in line with the results of a previous study showing that changes stalled after 6 months (31).

This study has some limitations. Firstly, no investigation was conducted with regard to dietary

habits that may affect cardiovascular risk factors. Secondly, variables for drug effects were not adjusted. Thirdly, this study only included men. Therefore, the results have to be interpreted with caution. Further studies will be required to complement these weaknesses and verify the effectiveness of CR programs. In addition, previous studies indicated that CR was associated with metabolic syndrome, which is a cardiovascular risk factor associated with variables such as thigh circumference, appendicular muscle mass, and waist–height ratio (32–33). Future studies will need to analyze these variables as an effect of CR. In conclusion, patients who participated in the ST CR program showed improved cardiovascular risk factors and physical fitness, but the LT program was more effective. Future studies should consider our findings when preparing CR programs for patients undergoing PCI.

CONCLUSION

The CR program led to improved cardiovascular risk factors and physical fitness. CR decreased body fat, improved HDLC, and exercise capacity. In addition, LT program participants had more improvement in WC, TC, triglyceride, exercise duration, and 6-min walking than those in the ST program.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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