Original Article

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Comparison of Obesity Related Index and Exercise Capacity Between Center-Based and Home-Based Cardiac Rehabilitation Programs

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Objective To compare a center-based cardiac rehabilitation (CR) program with a home-based CR program in terms of improving obesity related index and cardiopulmonary exercise capacity after the completing a phase II CR program.

Methods In this study, there were seventy-four patients with acute myocardial infarction after percutaneous coronary intervention who were analyzed. Patients with mild to moderate risk (ejection fraction >40%) were included in the group. The patients underwent an exercise tolerance test by measurement of the modified Bruce protocol at three assessment points. Those in the center-based CR group participated in a 4-week training program with electrocardiography monitoring of the patient's progress and results, while those patients who were in the home-based CR group underwent self-exercise training. We measured the obesity related indices such as body mass index, fat free mass index (FFMI), and cardiopulmonary exercise capacity including peak oxygen consumption (VO_{2max}), metabolic equivalents (METs), heart rate, resting systolic blood pressure and the diastolic blood pressure of the participants and noted the results.

Results Of the 74 patients, 25 and 49 participated in the center-based and home-based CR programs, respectively. Both groups showed significant improvement in VO_{2max} and METs at 1-month and 6-month follow-up. However, FFMI was significantly improved only in the center-based CR group after 1 month of the phase II CR.

Conclusion Both groups identified in the study showed significant improvement of VO_{2max} and METs at 1-month and 6-month follow-up. However, there was no significant difference in the intergroup analysis. A significant improvement of FFMI was seen only in the center-based CR group after phase II CR.

Keywords Rehabilitation, Myocardial infarction, Exercise tolerance, Obesity, Home care services

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INTRODUCTION

The prevailing discipline notes that cardiovascular disease is a major cause of death and disability and a global health concern. Although mortality associated with cardiovascular disease has decreased in recent decades, morbidity is also decreasing due to improved diagnosis and successful treatments that are offered to patients experiencing these conditions. Cardiac rehabilitation (CR) is offered to individuals after cardiac events to aid in the patient's recovery, and to help and assist the ability to reduce further cardiac illness. Additionally, it is noted that CR can improve the physical health and exercise capacity of patients with coronary heart disease [1-3]. In this context, CR is divided into three phases: in-hospital rehabilitation (phase I), training (phase II), and maintenance (phase III). Several studies have investigated effects of CR [4-11]. However, whether center-based or home-based CR program is better for patients with acute myocardial infarction (AMI) remains a controversial topic of review. In addition, sustaining long-term improvements in exercise capacity and obesity related index after completing a phase II CR program is challenging for many patients who are not used to working out or exercising on a daily basis. In general, if a patient stops exercising, benefits gained from phase II CR will return to baseline within a few weeks. Foreign studies about sustaining beneficial effects of exercise capacity have been published and verify these results [12-16]. In 2004, Smith et al. [12] evaluated long-term changes in exercise capacity of patients who underwent coronary artery bypass grafting and participated in a 6-month randomized controlled trial on center-based and home-based CR. Their results showed that improvements in exercise capacity declined in the center-based group at 12 months after discharge from CR. However, the home-based group maintained peak cardiopulmonary exercise capacity (VO_{2max}) [12]. Similarly, it is mentioned that Marchionni et al. [13] have reported that improvements in exercise capacity can be maintained over a long-term with a home-based CR program. In contrast, Oerkild et al. [14] have reported a decline in exercise capacity at 6- and 12-month follow-ups in both center-based and home-based CR groups.

In general, besides benefits of CR program for exercise capacity, CR program can improve body mass index (BMI) [17,18]. However, the effect of CR program on fat free mass index (FFMI) is currently unclear as seen in a literature review on this topic. Therefore, the objective of this study was to compare obesity related index and exercise capacity in patients who participated in a center-based CR with those who followed a home-based CR at baseline and at 1- and 6-month after initiating phase II CR, to determine which type of program in rehabilitation might be better for helping patients towards the goal of maintaining training benefits (i.e., improved cardiopulmonary exercise capacity, BMI and FFMI) in patients with AMI.

MATERIALS AND METHODS

Study design

This study was performed retrospectively by analyzing patient's medical records.

Participants

A total of 545 patients with AMI (ST elevation and non-ST elevation myocardial infarction) who were referred to our rehabilitation center in the Department of Physical and Rehabilitation Medicine after undergoing percutaneous coronary intervention (PCI) at the Department of Medicine between August 2011 and December 2013 were enrolled. The first exercise tolerance test (ETT) was performed on the participants at 3 weeks after the onset of myocardial infarction. Patients chose to participate in a home- or center-based CR program according to their decision and lifestyle needs. The patients underwent a follow-up ETT at 1 month and 6 months after the first ETT was completed. Patients who met the following two criteria were included: (1) underwent an ETT by the modified Bruce protocol before initiating phase II CR after completing 1-month of phase II CR and 6 months after initiating phase II CR; and (2) those with a mild to moderate risk (ejection fraction [EF] >40%). Patients with high risk factors on risk classification (i.e., left ventricular ejection fraction [LVEF] <40%) and unstable medical or musculoskeletal conditions were excluded from participating in the study. Finally, it is confirmed that 25 patients (22 males and 3 females) were included in the center-based CR group and 49 (42 males and 7 females) were included in the home-based CR group for final analysis. This study was approved by the Chonnam National University Hospital Institutional Review Board (No. CNUH-2015-186).

Intervention

All patients underwent a cardiac echocardiography before and after PCI. A symptom-limited ETT was performed using the modified Bruce protocol at baseline and at 1- and 6-month after initiating CR. In this case, it is noted that a treadmill (Med-Track ST 55; Quinton Instruments, Seattle, WA. USA) was used during the program. Peak oxygen consumption (VO_{2max}), metabolic equivalents (METs), blood pressure, heart rate, BMI, and FFMI were assessed for patients at every visit before performing ETT. All patients and their family members were educated about the various applicable cardiac risk factors including smoking, drinking, obesity, and the importance of maintaining a healthy diet. They were also informed about the necessity of lifestyle modification to achieve results.

The exercise intensity of heart rate reserve (HRR) was prescribed individually based on target heart rate calculated by Karvonen formula,

Target heart rate=[(maximal heart rate–resting heart rate)×%intensity+resting heart rate].

The target heart rate was calculated at 70% of the HRR during the periods. And it is noted that we prescribed exercise intensity at 70%–85% with low risk and 55%–70% with moderate risk patients.

Those in the both groups were recommended to participate in aerobic exercise for 4 weeks. And after 4 weeks, they were recommended resistive exercise three to four times per week, which was based on the results of the ETT. Those in the center-based CR group participated in regular aerobic exercise training with electrocardiography, heart rate, and blood pressure monitoring supervised by a medical doctor at the hospital. The exercise was performed for 4 weeks (one session/week) based on results of the initial ETT and after exercise, patients were educated according to their result. Each session consisted of a 10-minute warm-up, a 30-minute of prescribed aerobic exercise, and a 10-minute cool down. After exercise was performed at 4 weeks, the center-based CR group was educated on how to utilize resistive exercise, by utilizing a face to face meeting and consultation with a medical doctor. Those in the home-based CR group were instructed to participate in a community-based self-exercise program including stretching, walking, fast walking, bicycling, and jogging based on their initial ETT results, and the addition of resistive exercise was recommended to those group members as they were educated by a telephone consultation after 4 weeks. Those of the home-based CR group were monitored using exercise diaries, telephone messages, and questions in which the patient recalled whether they had exercised regularly at every visit, and this method was also applied to the center-based CR group after 4 weeks.

Outcomes

Study outcomes were estimated from ETT at baseline and at 1- and 6-month after initiating CR. We also considered 1 month as the finishing point for establishing the phase II CR. Thus, we regarded the 6-month follow-up as the outcome of maintenance phase.

Exercise capacity was determined by measuring VO_{2max} (in mL/kg/min) and FFMI reflecting masses of the skeletal muscle, organs, bone, and connective tissue of the participants. In this case, the FFMI considered is an indicator of the resting energy expenditure [19].

In the study, the resting heart rate (HR_{rest}), maximal heart rate (HR_{max}), resting systolic blood pressure (SBP), and resting diastolic blood pressure (DBP) were estimated using an automatic blood pressure and a pulse monitor. Also, a subjective measure of the participant's perceived exertion rate was recorded. The METs, maximal oxygen consumption (VO_{2max}), BMI, and FFMI were measured. VO_{2max} and METs of patients at baseline during ETT and after recovery were measured using an integrated metabolic measurement system (Trueone 2400 Metabolic System; Parvo-Medics, Sandy, UT, USA). Additionally, the BMI and FFMI were measured using an N20 Body Composition Analyzer (ubiquitous healthcare system; AIIA Communication Co., Seongnam, Korea).

Statistical analysis

Data were analyzed with IBM SPSS Statistics 22.0 software (IBM Corp., Armonk, NY, USA). Mann–Whitney U-test and chi-square test were used to compare categorical variables. The outcome of interest was difference between groups regarding improvement from baseline ETT to 1-month ETT, and sustainability from the baseline ETT to 6-month follow-up ETT. In terms of the overall changes within the groups, this information and measurements were examined using the Wilcoxon signed-rank test. A full analysis of the covariance was performed using previous ETT values as covariates to compare differences in changes between the two groups. A p-value less than 0.05

was considered statistically significant in the study as noted.

RESULTS

General subject characteristics

Baseline characteristics noted as variables in this study were seen including age, sex, BMI, FFMI, EF, VO_{2max}, METs, or other risk factors which were not significantly different between the two groups (Table 1). The mean age of subjects in the center-based CR group was 54.04 years and that in the home-based CR group was 56.33 years. In fact, the patients were predominantly male in both groups. In the study, the LVEF at the baseline was 59.49% in the center-based CR group and 58.47% in the home-based CR group. Also, the VO_{2max} at baseline was 26.01 mL/kg/min in the center-based CR group and 25.79 mL/kg/min in the home-based CR group. The noted BMI at the baseline was 25.26 kg/m^2 in the center-based CR group and 24.82 kg/m^2 in the home-based CR group. Finally, the FFMI at the baseline was 19.39 kg/m^2 in the center-based CR group and 19.19 kg/m^2 in the home-based CR group (Table 1).

Table 1. Comparison of demographic characteristics and baseline cardiopulmonary functions at 3 weeks after onset of acute myocardial infarction between center-based and home-based CR groups

	Center-based CR group (n=25)	Home-based CR group (n=49)	p-value[a)]
Age (yr)	54.04±8.72	56.33±10.50	0.377
Sex			0.589
Male	220	42	
Female	3	7	
BMI (kg/m^2)	25.26±2.93	24.82±2.97	0.908
FFMI (kg/m^2)	19.39±1.89	19.19±1.44	0.343
DM	4 (16.0)	8 (16.3)	0.971
HTN	9 (36.0)	20 (40.8)	0.688
Dyslipidemia	10 (40.0)	30 (61.2)	0.083
Smoking	14 (56.0)	25 (51.0)	0.685
Ejection fraction (%)	59.49±9.39	58.47±8.20	0.674
VO_{2max} at 1st ETT (mL/kg/min)	26.01±5.00	25.79±5.36	0.840

Values are presented as mean±standard deviation or number (%).
CR, cardiac rehabilitation; BMI, body mass index; FFMI, fat free mass index; DM, diabetes mellitus; HTN, hypertension; VO_{2max}, maximal oxygen consumption.
a)Mann-Whitney U-test except DM, HTN, and dyslipidemia which were compared with chi-square test.

Comparison of cardiopulmonary exercise capacity between center-based and home-based CR groups

Likewise, the mean baseline ETT results for the home-based CR group were shown at Table 2. Both groups showed significant improvement in the participant's cardiopulmonary exercise capacity (VO_{2max}) and METs after completing 1-month of phase II CR, and at 6-months after CR. In this case, the HR_{rest} was significantly decreased in both groups after 6-months. It was significantly decreased after 1-month of phase II CR only in the home-based group. It is noted especially that the SBP was significantly decreased after completing 1month of phase II CR in both groups. However, the SBP was only slightly showing a significant decreased in the center-based CR group at 6 months after completing CR.

Comparison of FFMI and BMI between center-based and home-based CR groups

In this study, the mean baseline FFMI and BMI values in the home-based and center-based CR groups were shown at Table 3. Unlike the results of the cardiopulmonary exercise capacity, only the center-based CR group showed significant improvement in FFMI (p=0.028) at 1 month after phase II CR. Therefore, the differences in change of FFMI between the two groups was significant (p=0.03). However, at 6 months after phase II CR, there was no significant difference in change of FFMI between the two groups.

DISCUSSION

The main purpose of this study was to compare a center-based CR program with a home-based CR program, in terms of improving cardiopulmonary exercise capacity after completing a phase II CR program. Similar to findings of other studies [12-16], participating in a CR program resulted in the significant improvement in exercise capacity (VO_{2max}), METs, and HR_{rest} in both center-based and home-based CR groups (all p<0.05) in the present study. In the meantime, the SBP showed consistent im-

Table 2. Comparison of cardiopulmonary exercise capacity between center-based and home-based CR groups

Variable	Center-based CR group (n=25)		Home-based CR group (n=49)		ANCOVA
	Mean±SD	p-value[a)]	Mean±SD	p-values	p-value[b)]
VO_{2max} (mL/kg/min)					
Baseline	26.01±5.00		25.79±5.36		
1 mo	28.59±7.49	0.017*	27.49±5.96	0.009*	0.456
6 mo	29.61±5.62	0.006*	29.24±6.92	0.001*	0.864
METs					
Baseline	7.43±1.43		7.37±1.53		
1 mo	8.17±2.14	0.017*	7.85±1.70	0.009*	0.456
6 mo	8.46±1.61	0.006*	8.35±1.98	0.001*	0.864
HR_{rest} (beats/min)					
Baseline	78.40±14.33		76.06±17.13		
1 mo	76.12±22.01	0.142	73.76±13.46	0.032*	0.440
6 mo	72.28±11.62	0.041*	72.24±10.84	0.019*	0.769
HR_{max} (beats/min)					
Baseline	134.64±16.97		132.43±19.33		
1 mo	135.56±20.85	0.829	134.55±19.70	0.746	0.130
6 mo	134.96±19.82	0.898	135.82±22.61	0.633	0.580
SBP					
Baseline	138.08±19.70		136.88±21.78		
1 mo	127.24±19.15	0.004*	130.24±21.72	0.036*	0.377
6 mo	125.96±18.41	0.021*	131.94±20.48	0.240	0.171
DBP					
Baseline	75.60±9.88		72.86±11.35		
1 mo	72.00±12.28	0.017*	71.24±9.80	0.324	0.773
6 mo	73.64±9.63	0.287	72.53±11.34	0.801	0.996

CR, cardiac rehabilitation; VO_{2max}, maximal oxygen consumption; METs, metabolic equivalents; HR_{rest}, resting heart rate; HR_{max}, maximal heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.
a)By Wilcoxon signed-rank test compared between baseline and 1 month or between baseline and 6 months.
b)By Analysis of Covariance (ANCOVA) compared between center and home-based CR groups.
*p<0.05.

provement in participants who participated in a center-based CR program at the 6-month follow-up whereas those in the home-based CR program showed decrease in SBP ($p<0.05$) only at the 1-month follow-up. There was no significant difference of SBP in intergroup analysis.

In general, it is noted that a center-based CR is more standardized in terms of exercise intensity, duration, frequency, and specificity than the use of a home-based CR. In center-based CR, patients can self-monitor during exercise more easily than patients in home-based CR. In addition, a physician and physical therapist educated the participants on the importance of exercise at every visit. This might have affected changes in exercise behaviors of those in the center-based CR group and the participation rate of the center-based CR group, and the affected the result of the intergroup analysis as identified in the study reviewing information noted between the two groups.

We also monitored patients in the home-based CR group who were noted as using an exercise diary and telephone interviews. But, there are many different guidelines about CR and each cardiac rehabilitation center may use different guidelines as the basis of their programs [20]. We believed that the exercise program of our center and other related factors such as applied to the patient social economic, regional variables may have affected our result. Additionally, it is shown that there

Table 3. Comparison of BMI and FFMI between center-based and home-based CR groups

Variable	Center-based CR group (n=25)		Home-based CR group (n=49)		ANCOVA
	Mean±SD	Changes p-value[a)]	Mean±SD	Changes p-value[a)]	p-value[b)]
BMI (kg/m^2)					
Baseline	25.27±2.98	-	24.82±2.97	-	-
1 mo	25.55±3.02	0.259	24.60±3.30	0.638	0.08
6 mo	25.68±3.05	0.264	24.62±2.98	0.935	0.157
FFMI (kg/m^2)					
Baseline	19.39±1.89	-	19.19±1.44	-	-
1 mo	19.63±1.71	0.028*	19.16±1.55	0.956	0.03*
6 mo	19.50±1.93	0.211	19.17±1.54	0.310	0.509

CR, cardiac rehabilitation; BMI, body mass index; FFMI, fat free mass index.
[a)]By Wilcoxon signed-rank test compared between baseline and 1 month or between baseline and 6 months.
[b)]By Analysis of Covariance (ANCOVA) compared between center and home-based CR groups.
*p<0.05.

are debates about the effects between home based rehabilitation and hospital based rehabilitation for some outcomes including exercise capacity and blood pressure and others [7,8]. Further study considering these factors is required.

The other purpose of this study was to compare a center-based CR program with a home-based CR program, in terms of improvement in an obesity related index after completing a phase II CR program. In 2013, Genton et al. [19] reported that a low FFMI was an independent risk factor for mortality by analyzing 203 healthy elderly people. In 2015, Narumi et al. [21] demonstrated an association between a decreased FFMI and an unfavorable cardiac prognosis in chronic heart failure patients. However, no study has evaluated the effect of FFMI in AMI patients. In our study, only the center-based CR group showed significant improvement in FFMI after one month of phase II CR. This might be attributable to the difference in performing exercise between using an exercise program in a center and at home. Those in the both groups in our study were recommended aerobic exercise for 4 weeks and after 4 weeks, and resistive exercise was also recommended. But when patients exercise under the supervision of both a physician and physical therapist in a hospital setting or environment, these patients may undergo training for both aerobic and resistive exercises. In contrast, the patients pursuing home exercise consisted mainly of performing aerobic exercise. Although not statistically significant, the observed improvement in FFMI was decreased at the 6-month follow-up. This might be due to the noted characteristics of the phase III CR program. In phase III CR, both programs used a home exercise program. Thus, there might be a lack of adherence to resistive exercise compared to that to that of aerobic exercise. In phase III CR, improved aerobic capacity can be maintained by the pursuit of aerobic exercise such as walking. This is not the case for muscle mass in response to resistive exercise. It would be beneficial to educate patients on both resistive and aerobic exercises, and include examples of both in a home exercise program.

In our study, BMI was not noted to have showed any significant improvement in either group. This result might have been because patients in our study were not actually noted to be obese, and most patients were noted at an acute stage after PCI relatively. In general, patients after PCI were recommended resistance training after 6 weeks of aerobic training. But some guidelines recommend an aerobic exercise program between 2 and 6 weeks if the patient is without complications prior to commencing a program of resistance training [20]. In our study, we think that a center-based CR group may participate in resistance training earlier than 6 weeks, because they can monitor their vital signs easily and frequently. This might have affected the amount of muscle mass and FFMI, but not the BMI of the participants. For example, this result might be due to the fact that FFMI better reflects muscle mass than BMI. Further study that includes the starting period of resistance exercise is needed to verify those conclusions of this result.

Some limitations of our study should be addressed.

First, it is noted that this was not a randomized study. Thus, our results for the study might have been affected by its non-randomized design. In this case, the participants were allowed to select the CR program. This might lead to selection bias on the part of the participants. Second, the sample size was small due to the incidence of a low adherence to the 6-month follow-up ETT and the lack of motivation of the participating patients. We included those patients in the study who had completed three times of the evaluation. This choice of inclusion may have worked to have reduced the sample size. Thus, a multi-center study is recommended and needed in the future. In addition, only the participants who had complete data of exercise capacity and FFMI at all assessment points were included in this study. Therefore, our subgroup might be more motivated to continue the study than those who did not attend the 6-month of follow-up ETT. Broadly speaking, the patterns of changes in exercise capacity might have been different in subjects who did not attend the 6-month follow-up assessment. Finally, other factors such as diet and use of medications might have also influenced the FFMI. However, we did not consider such factors in our analysis in this case. Further randomized controlled trials with a larger sample size and long-term follow-up considering variables such as the numbers of CR center visits and patient's socioeconomic class are needed to compare maintenance of exercise capacity, and other effects including health-related quality of life and reduced mortality and morbidity. However, this is the first research to study the effects of FFMI in AMI patients. Therefore, the results of this study can be used to analyze AMI related factors.

In conclusion, our results suggest that both center-based and home-based CR programs are effective in improving cardiopulmonary exercise capacity. However, center-based CR program seems to be more effective in improving FFMI after one month of phase II CR than the use of a home-based CR program. The center-based CR program was determined to be superior to the home-based CR program for improving FFMI at acute stage for patients with AMI suggesting that FFMI could be used as a prognostic factor of the CR program at an acute stage. Further study considering exercise capacity, diet, and other factors that can influence the muscle mass index is needed to confirm our results.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION

Conceptualization: Han JY. Methodology: Kim JH, Kim KH. Formal analysis: Park HK, Song MK. Funding acquisition: Han JY. Project administration: Han JY. Writing – original draft: Park HK, Kim JH. Writing – review and editing: Choi IS, Song MK, Han JY. Approval of final manuscript: all authors.

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