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Effect of Hospital-based Cardiac Rehabilitation on Quality of Life and Physical Capacity in Acute Myocardial Infarction Patients: 2 Years Follow Up

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Abstract

Objective: The aim of this study was to investigate the effect of hospital-based cardiac rehabilitation (CR) on quality of life (QOL) and physical functions in patients with acute myocardial infarction (AMI) during 2 years of follow-up.

Methods: All AMI patients referred to the Cardiac Health and Rehabilitation Center (CHRC) were informed about CR and followed for 2 years on an outpatient basis from July 2010 to December 2015. Patients who were divided into a CR group and non-CR group. All patients took home-based self-exercise as CR programs of CHRC and in addition, the CR group received hospital-based supervised exercise training three times a week for 2 months. Both groups were evaluated for physical capacity and QOL at baseline, after 2 months of exercise training, and at 6 months, 1 year, and 2 years of follow-up.

Results: The CR group showed significant improvements in physical functioning (PF), physical role functioning, bodily pain, vitality (VT), social role functioning, emotional role functioning, mental health, physical component summary (PCS), and mental component summary at all-time points compared to baseline. At 1 year of follow-up, the CR group displayed significantly greater PF, general health perceptions, VT, and PCS values than the non-CR group. Regarding physical capacity, the CR group exhibited significantly lower resting heart rate and significantly greater maximal oxygen consumption and metabolic equivalents than the non-CR group at 6 months of follow-up.

Conclusion: Hospital-based CR was effective in promoting QOL and early improvement in exercise capacity in patients with AMI. Further, the improvement in QOL was maintained for up to 2 years.

Keywords: Acute myocardial infarction; Quality of life; Hospital-based cardiac rehabilitation; Home-based exercise; Physical capacity; Long-term efficacy; Physical function

Introduction

Cardiovascular diseases (CVD), including acute myocardial infarction (AMI), are a major global health problem. AMI is an event of cell death of cardiac myocytes that are caused by an unstable ischemic syndrome [1]. The prevalence of AMI is increasing, and it is the leading cause of morbidity and mortality worldwide [2]. Although the rate of mortality declines with the development of treatment and management strategies for AMI [3], there is growing interest in CVD prevention and management following AMI. Likewise, the importance of cardiac rehabilitation (CR) in the management and prevention of CVD has been highlighted and is being implemented in many countries [4,5].

CR is an integrated program that focuses on not only exercise programs, but also risk factors such as nutrition education, smoking cessation education, weight management, blood pressure, diabetes management, and stress management [6,7]. CR consists of four phases: phase 1 is an inpatient program, phase 2 includes hospital-based CR for 8 weeks, and phases 3 and 4 are community-based CR. Benefits from the application of CR after AMI or heart failure have already been identified in meta-analyses and Cochrane reviews [8-10]. CR continues to improve patient symptoms, reduce mortality from heart problems, and improve physical abilities and quality of life (QOL) [10-12].

Although AMI is the consequence of progressive arteriosclerosis, sudden heart attack leads to unexpected shock to both patients and their families, causing fear and despair. It is also important to manage the patient's QOL based on the nature of the disease; this is not a cure, but patient QOL requires continuous management [13].

The goal of comprehensive CR programs after myocardial infarction (MI) is to assist patients in resuming normal activities of daily living in the community. Additionally, these programs help patients to reach and maintain health-related QOL, as well as establish a cardio-

protective lifestyle and remain physically active. As such, the long-term effects of CR should be evaluated. In previous studies, the effect of CR on patients with AMI was analyzed at 3 months, 6 months, and 12 months [14,15], and also focused on physical improvements [16,17].

The aim of the current study was to investigate the effect of phase 2 hospital-based CR on QOL and physical functions in patients with AMI during 2 years of follow-up.

Materials and Methods

Study subjects

This retrospective study was performed in the Department of Rehabilitation at Kyungpook University Hospital in Deagu. The patients were diagnosed with AMI and were referred to the Cardiac Health and Rehabilitation Center (CHRC) following percutaneous coronary intervention (PCI). Patients who were followed up for 2 years from July 2010 to December 2015 were eligible.

Patient inclusion criteria were as follows:

- After 2 weeks (± 3 days) of PCI and
- Cognitive functional ability to follow a CR program and fill out a questionnaire.

The exclusion criteria were as follows:

- Hemodynamic instability (a decrease in continuous systolic blood pressure greater than 10 mmHg or an increase in continuous systolic blood pressure to more than 250 mmHg during exercise),
- Life-threatening arrhythmia,
- Congestive heart failure,
- Musculoskeletal dysfunction,
- Active inflammatory disease, or
- Psychiatric problems precluding adequate cooperation.

All patients were offered participation in a hospital-based CR program. Based on the CR program of phase 2, the patients were divided into two groups: the CR group, which underwent hospital-based exercise for 8 weeks, and the non-CR group, which received educational home-based CR. Both groups regularly visited the outpatient clinic to assess cardiac function, and educational intervention, dietary advice, and psychological support were provided. All patients underwent medical evaluation, which included medical history and physical examination.

Experimental design

All patients underwent a cardiopulmonary exercise test (CPET) before exercise training (baseline), at the end of exercise training (2 months), and at 6 months, 1 year, and 2 years of follow-up. In addition, QOL questionnaires were completed following each CPET. All patients with baseline assessments were informed about the CR program and were asked to independently decide whether to proceed with the hospital-based CR at phase 2. Both groups were educated on the intensity and proper method of the home-based exercises according to the baseline CPET results. All patients were educated on their target heart rate, which was calculated to correspond to 40%-80% of their maximal oxygen consumption. Patients were trained in how to reach the target heart rate during exercise at home. The non-CR group performed self-monitored home-based exercise, and the CR group participated in hospital-based CR for 8 weeks. Both groups completed a CPET, QOL questionnaire, and received feedback on generic instructions and appropriate exercise at 8 weeks, 6 months, 1 year, and 2 years. The study was approved by the Institutional Review Board of Kyungpook National University.

CR programs

Comprehensive education was provided by CR physiatrist, dietitians, and nurses in the CHRC during phase 1 CR. The educational sessions included basic disease knowledge; risk factors, benefits, and goals of rehabilitation; and consequences of negative lifestyle habits. These professionals informed the patients of their lifestyle and behavior modification program, which allowed the patients to control their own risk factors.

All patients underwent symptom-limited CPET 2 weeks after PCI. Patients in the CR group underwent 8 weeks of exercise training three times per week. Training sessions lasted at least 60 min and included kinesiotherapy and psychological intervention and education, and were monitored by physiotherapists and cardiac specialists. Each session was preceded by 10 min of warm-up exercises and was followed by a 5 min cool-down session. Patients had continuous electrocardiogram monitoring during exercise. The primary exercise time of 45 min was divided into 15 min segments (one exercise session consisted of three segments). One minute before the start of the new segment, the patient's blood pressure (BP), heart rate (HR), and Borg rating of perceived exertion (RPE) [18] were checked and the exercise intensity of the next segment was determined. The intensity of exercise was determined using the Karvonen formula [19]:

HR reserve (HRR)=HRmax–HRrest

Target HR (THR)=HRR × (40%-80%)+HRrest

Exercise training was completed using a treadmill, and the intensity of exercise started at 40% of HRR and aimed to reach 60% of HRR during the first 4 weeks and then eventually reach 80% of HRR during the last 4 weeks.

CPET

Symptom-limited, treadmill-based CPET with respiratory gas exchange analysis was performed in all patients. The modified Bruce protocol was used; the protocol is divided into successive 3 min stages with each stage requiring the patient to walk faster and at a steeper slope [20]. A 12-lead electrocardiogram was continuously monitored during the test, and BP was manually recorded every 3 min. Metabolic gas exchange was measured via a laboratory metabolic cart (TrueOne® 2400; Parvo Medics, Salt Lake City, UT, USA). After completing the CPET, the patient was asked why they stopped the test. During CPET, physical function of each patient was evaluated by measuring resting HR (RHR), maximal HR (HRmax), maximal oxygen consumption (VO_2max), metabolic equivalents of the task (MET), maximal exercise time (ETmax), maximal RPE (RPEmax), stage 3 RPE (3RPE), stage 3 rate pressure product (3RPP), maximal RPP (RPPmax), and respiratory exchange ratio (RER). CPET was performed five times at baseline, after 8 weeks (end of exercise training), and after 6 months, 1 year, and 2 years of follow-up in both groups.

QOL assessment

The second version of the 36 item Short-Form Health Survey (SF-36) [21,22] was used to evaluate the QOL of the CR group and non-CR group. The SF-36 is a generic questionnaire measuring eight

domains of health, including physical functioning (PF), physical role functioning (RP), bodily pain (BP), general health perception (GH), vitality (VT), social role functioning (SF), emotional role functioning (RE), and mental health (MH), with a standard score of 0 (poor health) to 100 (good health). Two summary measures were further calculated from the item scores using the procedures recommended by the developers. The summary measures were physical component summary (PCS) and mental component summary (MCS) [23].

Statistical analysis

SPSS version 22.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Descriptive statistics are presented as mean ± standard deviation. Comparisons between the groups were conducted using independent t-tests. A repeated measures analysis of variance was performed to determine the changes within and between the groups over time. Statistical significance was set at an alpha level of $p<0.05$ for all analyses.

Results

Patient characteristics

From June 2010 to December 2015, 390 patients were referred to the CHRC for AMI. Of these, 245 patients underwent baseline CPET, and 72 patients were followed up for 2 years. Of these 72 patients, 35 were in the CR group (received hospital-based CR for 8 weeks in phase 2), and 38 were in the non-CR group (participated in home-based educational CR) (Figure 1).

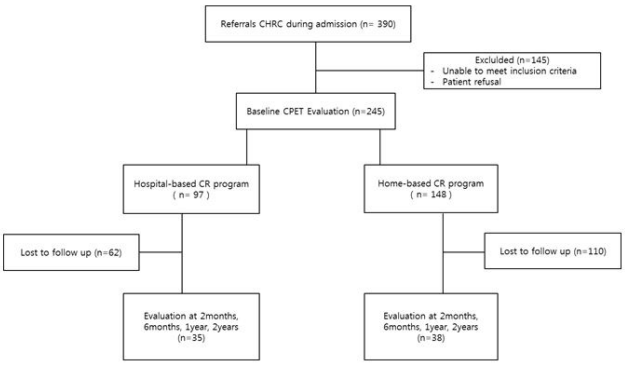

Figure 1: Patient flow throughout the study; CHRC: Cardiac Health and Rehabilitation Center; CPET: Cardiopulmonary Exercise Test; CR: Cardiac Rehabilitation.

General characteristics and baseline CPET of the study group are shown in Table 1. There were no significant differences between the groups for age, sex, weight, body mass index, and RHR. For baseline CPET, there were also no significant differences for physical capacity and exercise tolerance between the groups.

Variable	CR(n=35)	Non-CR(n=38)	P value
Age	52.4 ± 8.0	53.4 ± 9.0	0.627
Sex, Male, number (%)	33 (97.1%)	36 (94.7%)	0.235
Weight	69.5 ± 8.4	71.8 ± 9.0	0.283
BMI	25.0 ± 2.8	25.4 ± 2.8	0.411
RHR	67.3 ± 11.8	72.0 ± 10.9	0.08
HRmax	150.3 ± 15.5	148.7 ± 18.2	0.679
VO_2max	28.2 ± 5.4	27.2 ± 5.0	0.395
MET	8.1 ± 1.5	7.8 ± 1.4	0.396
RER	1.2 ± 0.1	1.1 ± 0.2	0.466

Table 1: Baseline characteristic of subjects (n=72); Values are presented as mean ± standard deviation if not otherwise stated; CR: Cardiac Rehabilitation; RHR: Resting Heart Rate; VO_2max: Maximal Oxygen consumption; MET: Metabolic Equivalent of Task; RER: Respiratory Exchange Ratio.

QOL changes between the groups

All patients were evaluated for QOL using the SF-36 at baseline, after 8 weeks of exercise training, and after 6 months, 1 year, and 2 years of follow-up. There was no significant difference between the groups in any baseline QOL measures. In the CR group, all item and summary measures significantly increased from baseline to all post-exercise time points, with the exception of GH; GH significantly increased from baseline up to 1 year. In the non-CR group, there was a significant increase in the BP item between baseline and 8 weeks and baseline and 2 years. Additionally, there was a significant increase between baseline and 2 years in the RE item, and baseline and 8 weeks, 1 year, and 2 years in the MCS summary measure (Table 2).

Parameter	Group	Baseline	After 8 weeks	After 6 months	After 1 year	After 2 years
PF	CR	88.4 ± 15.5	92.8 ± 5.4†	95.1 ± 6.0†	95.3 ± 3.9*†	95.0 ± 5.8†
	non-CR	90.9 ± 7.3	92.5 ± 9.2	93.0 ± 8.6	91.8 ± 7.9	92.6 ± 8.6
RP	CR	56.6 ± 33.9	75.7 ± 34.0†	82.4 ± 27.2†	93.5 ± 15.8†	92.2 ± 17.3†
	non-CR	65.2 ± 42.7	76.8 ± 31.9	78.6 ± 36.5	79.0 ± 35.1	79.6 ± 34.0
BP	CR	76.2 ± 18.1	84.2 ± 15.5†	87.8 ± 12.4†	91.2 ± 12.4†	87.8 ± 15.4†
	non-CR	84.1 ± 16.0	90.0 ± 15.3†	89.5 ± 15.0	87.9 ± 13.2	92.2 ± 11.2†
GH	CR	58.9 ± 14.2	63.9 ± 15.8†	64.2 ± 14.7†	68.7 ± 16.8*†	62.3 ± 16.8
	non-CR	59.5 ± 18.9	61.6 ± 19.3	59.0 ± 22.5	56.8 ± 22.9	59.6 ± 20.5
VT	CR	59.1 ± 16.8	65.4 ± 16.3†	68.6 ± 12.8†	72.8 ± 15.3*†	67.7 ± 16.9†
	non-CR	60.0 ± 15.2	62.0 ± 14.4	62.7 ± 18.7	65.0 ± 16.2	64.6 ± 16.8
SF	CR	79.0 ± 17.6	88.2 ± 15.1†	84.2 ± 17.5	85.9 ± 20.6	89.5 ± 15.9†

	non-CR	79.5 ± 21.8	84.8 ± 19.9	84.8 ± 18.4	79.5 ± 18.4	86.1 ± 14.8
RE	CR	52.0 ± 45.8	72.5 ± 41.4†	87.3 ± 24.6†	87.1 ± 30.6†	92.7 ± 22.0†
	non-CR	58.3 ± 45.0	75.0 ± 38.1	76.2 ± 38.3	81.3 ± 37.4	81.5 ± 31.1†
MH	CR	64.9 ± 15.6	71.4 ± 17.2†	69.8 ± 17.5	75.9 ± 19.1†	74.6 ± 18.1†
	non-CR	66.6 ± 15.2	72.7 ± 16.8	72.9 ± 19.2	72.3 ± 17.6	74.5 ± 16.5
PCS	CR	48.4 ± 5.8	51.7 ± 4.5†	52.5 ± 4.3†	53.3 ± 3.9*†	52.6 ± 4.2†
	non-CR	51.1 ± 5.4	51.9 ± 5.9	51.7 ± 6.3	50.8 ± 5.7	51.6 ± 5.7
MCS	CR	39.1 ± 11.0	44.4 ± 9.9†	45.1 ± 5.6†	46.5 ± 10.7†	47.7 ± 8.5†
	non-CR	40.0 ± 9.6	44.1 ± 9.7†	44.3 ± 10.9	46.2 ± 9.0†	45.8 ± 8.4†

Table 2: Comparative analysis of SF-36 quality of life in CR group and non-CR group; Values are presented as mean ± standard deviation; *: between group difference; †: within group difference<0.05 compared to baseline; PF: Physical Functioning; RP: Physical Role Functioning; BP: Bodily Pain; GH: General Health Perception; VT: Vitality; SF: Social role Functioning; RE: Emotional Role Functioning; MH: Mental Health; PCS: Physical Component Score; MCS: Mental Component Score.

Further, there was a significant group by time interaction for PF, GH, VT, and PCS ($p<0.05$). Post hoc analyses revealed that the CR group had significantly greater values for PF, GH, VT, and PCS than the non-CR group after 1 year ($p<0.05$ for all) (Table 2 and Figure 2).

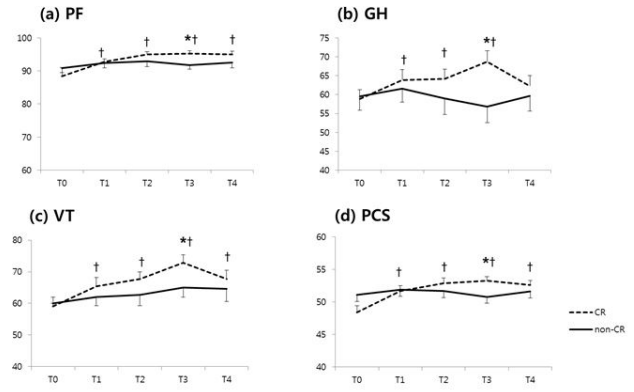

Figure 2: Comparative analysis of SF-36 quality of life scores between two groups; values are presented as mean ± standard error; *: between group difference $p<0.05$; †: within group difference<0.05 compared to baseline; T0: baseline; T1: after 8weeks; T2: after 6 months; T3: after 1 year; T4: after 2 years; PF: Physical Functioning; GH: General Health perception; VT: Vitality; PCS: Physical Component Score.

Physical capacity changes between groups

In both groups, there was a significant difference from baseline for RHR at 8 weeks and 1 year, HRmax at 1 and 2 years, 3RPE at 8 weeks, 6 months and 1 year, RPEmax at 8 weeks and 6 months, 3RPP at 8 weeks, and RPPmax at 1 year and 2 years. VO_2max, METs and ET significantly different from baseline to all follow-up time points (Table 3). There was a no significant group difference by time interaction.

parameter	Group	Baseline	After 8 weeks	After 6 months	After 1 years	After 2 years
RHR	CR	67.3 ± 11.8	63.8 ± 10.8*†	65.2 ± 10.0*	72.3 ± 12.4†	69.8 ± 10.1
	non-CR	72.0 ± 10.9	71.7 ± 11.7†	70.1 ± 10.8	73.0 ± 10.5†	74.1 ± 11.0
HR max	CR	150.3 ± 15.5	151.9 ± 15.0	154.4 ± 18.2	157.2 ± 16.2†	157.3 ± 14.7†
	non-CR	148.7 ± 18.2	151.2 ± 18.1	153.2 ± 16.0	156.0 ± 15.8†	156.7 ± 16.8†
VO_2max	CR	28.2 ± 5.4	32.1 ± 5.9*†	32.1 ± 5.9*†	32.3 ± 6.7†	31.9 ± 5.9†
	non-CR	27.2 ± 5.0	29.0 ± 4.8†	28.9 ± 4.5†	30.9 ± 5.9†	31.4 ± 5.6†
MET	CR	8.1 ± 1.5	9.2 ± 1.7*†	9.2 ± 1.7*†	9.2 ± 1.9†	9.1 ± 1.7†
	non-CR	7.8 ± 1.4	8.3 ± 1.4†	8.3 ± 1.3†	8.8 ± 1.7†	9.0 ± 1.6†
ET	CR	894.0 ± 148.5	973.9 ± 120.7†	986.1 ± 115.0†	982.4 ± 110.5†	999.9 ± 122.2†
	non-CR	885.5 ± 102.7	949.3 ± 104.1†	957.1 ± 105.2†	971.9 ± 83.8†	984.5 ± 104.0†
3RPE	CR	10.5 ± 2.0	8.8 ± 2.2†	9.3 ± 2.2†	9.6 ± 2.3†	9.8 ± 1.8
	non-CR	10.9 ± 2.4	9.7 ± 2.0†	10.1 ± 2.3†	10.6 ± 2.0†	10.0 ± 2.1
RPE max	CR	16.8 ± 1.4	16.0 ± 1.5*†	16.3 ± 1.5*†	16.6 ± 1.4	16.9 ± 1.4

	non-CR	16.7 ± 1.2	16.7 ± 1.1†	17.0 ± 0.8†	16.9 ± 1.2	16.9 ± 0.9
3RPP	CR	12605.7 ± 2358.6	10935.4 ± 2440.5*†	11952.5 ± 2568.4	12592.6 ± 2323.3	12535.1 ± 2385.0*
	non-CR	13433.6 ± 2621.8	12869.0 ± 2611.3†	12766.3 ± 2462.4	13171.0 ± 2887.2	13961.1 ± 3268.5
RPPmax	CR	23334.4 ± 4130.2	24016.7 ± 5043.7	24800.9 ± 5072.1	25969.5 ± 4806.4†	26558.6 ± 4740.4†
	non-CR	22889.8 ± 4762.1	24064.5 ± 5207.5	25316.0 ± 5565.9	25661.7 ± 5720.8†	28140.4 ± 5742.7†
RER	CR	1.2 ± 0.1	1.1 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1
	non-CR	1.2 ± 0.2	1.2 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	1.1 ± 0.1

Table 3: Comparative analysis of cardiopulmonary parameters in CR group and non-CR group; Values are presented as mean ± standard deviation; *: between group difference $p<0.05$; †: within group difference $p<0.05$ compared to baseline; RHR: Resting Heart Rate; VO_2max: maximal oxygen consumption; MET: Metabolic Equivalent of Task; ETmax: Maximal Exercise Time; RPEmax: maximal Borg Rating of Perceived Exertion; 3RPP: stage 3 Rate Pressure Product; RER: Respiratory Exchange Ratio.

When the two groups were compared at each time point, there were significant differences after 8 weeks and 6 months. At 8 weeks, RHR, RPEmax, and 3RPP were significantly lower and VO_2max and METs were significantly greater in the CR group compared to the non-CR group. The same findings were observed at 6 months of follow-up with the exception of 3RPP (no between group difference). Further, there was no significant difference between the groups for the CPET performed after 1 year, and after 2 years, only 3RPP was significantly lower in the CR group than the non-CR group (Table 3).

Discussion

This retrospective study investigated the long-term effects of hospital-based CR on physical capacity and QOL in patients with AMI over a 2-year period. Exercise training comprising 24 sessions over 8 weeks resulted in significant improvements in QOL after phase 2 CR, which was not observed in the non-CR group. For QOL (assessed via the SF-36), the CR group displayed significantly higher QOL from baseline to after phase 2 CR, and this improvement was sustained throughout the 2-year study period. In contrast, only BP, RE, and MCS significantly improved from baseline to 2 years of follow-up in the non-CR group.

A Cochrane review of exercise-based rehabilitation for coronary heart disease showed improvement in QOL, but the evaluation and analysis of QOL were heterogeneous and limited [24]. Aude et al. [25] revealed that CR helped participants feel better and they perceived their health improvement; however, the duration of hospital-based CR for patients with AMI varied, and was had a relatively short-term follow-up [26-28]. Therefore, we are unable to pool the data to quantify the effect. As reported in previous studies [15,29], patients with AMI initially felt hopelessness and fear, and psychological interventions played an important role in the success of CR. Improving the mental component of QOL is very important, because psychological anxiety of the patient is closely related to motivation and compliance of treatment and eventually affects prognosis [30]. Therefore, it is very meaningful that the present study's 8-week hospital-based CR program promoted QOL, which was maintained for 2 years. Among the subscales, PF, GH, VT, and PCS were significantly greater in the CR group than in the non-CR group at the 1-year follow-up. This suggests that the patients in the CR group were more emotionally supported and were able to escape fear of repeated heart attack compared to the patients in the non-CR group.

With regards to physical capacity, there were significant differences between the groups for RHR, VO_2max, METs, and RPEmax after 6 months, but not at 1 year and 2 years of follow-up. This shows that the effect of hospital-based CR was maintained for up to 6 months, which indicates that it led to early improvement in physical capacity. Hospital-based CR programs receive continuous emotional support during phase 2, and patients receive feedback on the intensity and method of exercise in real time, thus enabling more effective exercise training. This can further be explained through hospital-based CR promoting efficient ventricular remodeling and autonomic tone. Aerobic exercise reduces blood demand at the same exercise intensity, and decreases BP and myocardial VO_2. In addition, VO_2max increases as the VO_2 of peripheral tissues increases efficiently [31]. Moreover, after phase 2 is completed, patients in the CR group will typically adopt continuous exercise habits. However, at the 1-year follow-up, there was no difference between the CR group and the non-CR group for physical capacity. This finding shows that there was an increase in physical capacity that was also prevalent in the non-CR group. A potential explanation for this occurrence is that the difference between the groups decreased as the patients became more aware of the nature of their illness and the need for rehabilitation with regular outpatient visits.

Mortality and recurrence rates after AMI are highest within 1 year of the heart attack and then decline thereafter [32-34]. Early recurrent infarction has a clear effect on survival; therefore, it is very important to efficiently improve QOL, including the mental component, and improve physical capacity as soon as possible through a hospital-based CR program after PCI is performed.

This study had some limitations. First, we did not consider all of the individual differences that affect the QOL of patients. Therefore, further studies need to include more patients and observe a longer follow-up period. Second, the present study had a retrospective design. There was a selection bias for the patients who were trained in the outpatient department of rehabilitation for 2 years. These patients may be a select group with no major comorbidities, which might have resulted in an overestimation of the actual effects of a hospital-based CR program. Although randomized approach would have been ideal, it was not used in this study. Third, patients were included without considering the severity of AMI disease, and analysis of the two groups without considering the severity was a limitation.

In conclusion, hospital-based CR was effective in promoting QOL and early improvement in exercise capacity in patients with AMI, and the benefits of QOL were maintained over a long-term period through the adoption of regular exercise habits.

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