Improvement in Physiological Outcomes and Health-Related Quality of Life Following Cardiac Rehabilitation in Patients With Acute Myocardial Infarction

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Background  The present study examined the impact of an 8-week cardiac rehabilitation (CR) program on physiological outcomes and health-related quality of life (HRQOL) of patients with acute myocardial infarction (AMI).

Methods and Results  A total of 124 consecutive AMI patients were divided into a supervised outpatient CR group (n=82) and a non-CR group as a control (n=42). Peak oxygen uptake, handgrip strength, and knee extension muscular strength were used as physiological outcome measures. HRQOL outcomes were assessed by the Medical Outcome Study Short Form 36 (SF-36). CR group patients performed both aerobic exercise and moderate resistance training from 1 month (T1) to 3 months (T2) after AMI onset. Age, sex, body mass index, medications, and ejection fraction were similar in both groups. Significantly greater increases in overall physiological outcomes from T1 to T2 were measured in the CR group compared with those of the non-CR group. There were also significantly greater improvements in 4 of the 8 SF-36 health status subscales (physical functioning, role-physical, general health, and vitality) in the CR group compared with the non-CR group.

Conclusions  Eight weeks of exercise training have specific effects on improvement in HRQOL and physiological outcomes in Japanese patients. (Circ J 2004; 68: 315–320)

Key Words: Acute myocardial infarction; Cardiac rehabilitation; Health-related quality of life

Cardiac rehabilitation (CR) is an established form of treatment for patients with acute myocardial infarction (AMI) that is designed to provide a range of lifestyle and medical interventions to reduce cardiac mortality and morbidity through the promotion of a healthy lifestyle and reduction in coronary artery disease risk factors.

Another important objective of CR is improvement in health-related quality of life (HRQOL) and several studies have reported on the HRQOL of patients with coexisting AMI, cardiac surgery, and heart failure. Jette et al reported that cardiac disease is associated with a reduction in HRQOL. In examining the effect of intensive, interdisciplinary treatment programs of several weeks duration, non-controlled studies generally have reported improvements after rehabilitation in the areas of depression, anxiety, coronary risk factors, and HRQOL. Morin et al reported that CR patients who had completed baseline 3- and 6-month evaluations of coronary risk factors and HRQOL outcomes showed improvement at variable rates. Recently it was reported that participation in CR by patients with coronary artery bypass grafts (CABG) and AMI favorably improves not only physiological measurements but also psychological parameters in terms of HRQOL.

However, few of these studies have compared the HRQOL of patients following CR with that of patients who have not attended CR. In addition, no reports exist that discuss the effects of a combination of strength exercise and aerobic exercise on HRQOL in Japanese patients, who might have a different cultural background from that of Western populations. We hypothesized that CR patients who have had an AMI would have reproducible improvements in physiological measurements and HRQOL in comparison with those of control AMI patients. The purpose of the present study was to examine the impact of an 8-week CR program on physiological outcomes and HRQOL in patients with AMI.

Methods

Study Design and Subjects

This was a prospective observational study. Study patients were selected from 142 consecutive AMI patients who were admitted to St Marianna University School of Medicine Hospital for evaluation of AMI between November 2000 and October 2002. The diagnosis of AMI was made on the basis of chest pain persisting for at least 30 min, ST-segment elevation of at least 0.1 mV in at least 2 contiguous electrocardiogram (ECG) leads, and serum creatine kinase-myocardial band (CK-MB) elevation to more than twice the upper limit of normal.

Of the 142 patients, 133 who completed exercise testing
1 month after AMI onset and a routine 4-week acute phase CR program while hospitalized were included in this study. The remaining 9 patients were excluded from the study owing to failure to complete the exercise test because of cerebrovascular disease, orthopedic disorder, severe heart failure, or ST-segment changes, or because they had experienced uncontrolled arrhythmia during the 4-week CR program after the AMI. After the 4-week acute phase CR program, we then offered these 133 patients the chance to participate in an 8-week recovery phase CR program. The patients chose to either participate in this program or to only take tests measuring physiological and HRQOL parameters without undergoing exercise training. Of the 133 patients offered the recovery phase CR program, 48 declined to participate and chose to undergo testing only. The reasons for participation in the CR program were patient interest in the exercise training and/or that the patient lived near the hospital. In contrast, the reasons for nonparticipation were economic reasons, long distance from the patient’s house to the hospital, and lack of interest in exercise training. Therefore, these 133 patients were divided into either a supervised 8-week recovery phase CR program (CR group: n=85) or a nonparticipation CR program (non-CR group: n=48). In the CR group, 1 patient quit for reasons unrelated to the study. Because 2 responses to the SF-36 were incorrect, 2 other patients were excluded from the CR group. In the non-CR group, 3 patients were excluded because of incorrect responses to the SF-36. Three patients quit of their own accord for reasons unrelated to the study. Therefore, a total of 124 patients completed the study. Fig 1 summarizes the patient flow through the present study. We evaluated several patient characteristics, including age, sex, body mass index (BMI), education (<12 or ≥12 years of schooling), marital status, maximum CK-MB, location of AMI, and medication.

**Ethics**

The present study was approved by the St Marianna University School of Medicine Institutional Committee on Human Research. Informed consent was obtained from each patient at 1 month after the onset of AMI.

**Study Protocol**

**Exercise Capacity** Subjects underwent cardiopulmonary exercise testing (CPX) by a ramp treadmill protocol 1 month after the onset of AMI. Peak oxygen uptake (VO2) was measured as an index of exercise capacity. Measurements made from expired gases were used as indices of cardiovascular dynamics during exercise. CPX was performed again at 3 months after AMI onset.

**CPX** Symptom-limited exercise testing was performed on a MAT-2500 treadmill (Fukuda Denshi Co, Tokyo, Japan). Patients initially rested for 3 min on the treadmill. Exercise began with a 3-min warm-up (speed, 1.6 km/h; grade, 0%), which was followed by an increase in the load (speed or grade) every 60s. Throughout the test, the 12-lead ECG was monitored continuously, and heart rate (HR) was measured from the R-R interval of the ECG (ML-5000, Fukuda Denshi Co). Systolic blood pressure was measured by cuff via an automatic blood pressure monitor (Stress Test System, STBP-780, Colin Co, Aichi, Japan) at 1-min intervals. VO2, carbon dioxide production (VCO2), minute ventilation (VE), tidal volume (TV), end tidal CO2 (ETCO2), and the ventilatory equivalent for CO2 (V\textsubscript{E}/V\textsubscript{CO2}) were measured throughout the exercise period with an AE-300S aero monitor (Minato Ikagaku Co, Tokyo, Japan). The measurement system for CPX was carefully calibrated before the start of each individual test. Expired gas was sampled breath-by-breath. The end-point of exercise testing was determined according to the criteria of the American College of Sports Medicine. The appearance of a leveling-off of V\textsubscript{O2} (V\textsubscript{O2} plateau despite increasing exercise intensity) assisted in determining the exercise end-point. Ventilatory equivalents for O2 (VE/V\textsubscript{O2}) and CO2 (VE/V\textsubscript{CO2}), and the gas exchange ratio (GER) (V\textsubscript{CO2}/V\textsubscript{O2}) were calculated on a personal computer (Pentium 98 SE, EPSON Co, Nagano, Japan). The anaerobic threshold (AT) was determined by the original V-slope method as well as conventionally by determining the point at which VE/V\textsubscript{O2} increases after holding constant or decreases while VE/V\textsubscript{CO2} remains constant or decreases and by determining the period at which GER starts to increase steeply.

**Cardiac Catheterization**

One month after the onset of AMI, all subjects under-
went left ventriculography and selective coronary angiography using the Judkins technique. Ejection fraction was calculated via biplane left ventriculography. The luminal diameter of the stenosed coronary artery was evaluated by comparing the average diameter at the stenosis causing AMI with that of the nearest proximal normal segment.

**Handgrip Strength Measurement**

A standard adjustable-handle JAMAR dynamometer (Bissell Healthcare Co, MI, USA) was used for the measurement of handgrip strength as an index of upper limb muscle power and was set at the second grip position for all subjects. To measure grip strength, subjects were seated with their shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in the neutral position, and wrist between 0° and 30° of dorsiflexion and between 0° and 15° of ulnar deviation. Attention was paid to a possible Valsalva effect, and measurements were made 3 times each for both hands. We used the highest value measured as the index of handgrip strength.

**Knee Extension Muscular Strength Measurement**

The Biodex System 2 isokinetic dynamometer (Biodex Medical Systems, Inc, New York, NY, USA) was used for measurement of knee extension muscular strength as an index of lower limb muscular strength. The machine was calibrated at the initiation of the study. Patients were tested in the seated position with hip flexion at 80°, and stabilization straps were applied to the trunk, waist, and thighs. The resistance pad was placed at a level 10cm proximal to the medial malleolus. Range of motion during testing was set between 0° and 90° of knee flexion, and all limbs were calibrated at the initiation of the study. Patients were tested with their shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in the neutral position, and wrist between 0° and 30° of dorsiflexion and between 0° and 15° of ulnar deviation. Attention was paid to a possible Valsalva effect, and measurements were made 3 times each for both hands. We used the highest value measured as the index of knee extension muscular strength.

**HRQOL**

General HRQOL was measured with the Japanese version of the Medical Outcome Study 36-item Short Form Survey (SF-36). The SF-36 is a standardized, generic measurement instrument of HRQOL that has been validated in the general Japanese population. The SF-36 consists of 36 items representing 8 subscales that cover the domains of physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. Of the 8 subscales, 4 scales (physical functioning, role-physical, bodily pain, and general health) principally relate to physical health, and the other 4 scales (vitality, social functioning, role-emotional, and mental health) relate to mental health.

The 8 subscale scores range from 0 to 100, with lower scores indicating poorer levels of function and higher scores better levels of function. The SF-36 questionnaires were scanned by computer and scored by the Public Health Research Foundation (Tokyo, Japan) and the SF-36 subscale scores were converted into a deviation score adjusted for age- and sex-based scores from the general Japanese population. This was a mean score of 50 with a standard deviation of 10.

**Cardiac Rehabilitation Program**

The CR program involved an interdisciplinary team approach and included a cardiologist, nurse, physical therapist, dietitian, and pharmacist. Because the hospital does not have a psychologist on staff, we could not help individual patients with stress management. In the acute phase of CR, diet and medication instructions were given to each inpatient at discharge by a dietitian and pharmacist, respectively. In addition, inpatients received individual education at discharge by a nurse regarding cardiovascular risk factors and smoking cessation. Patient instruction was also performed in the outpatient setting.

At St Marianna University School of Medicine Hospital, physical therapists play a central role in the supervision of the muscle strength and aerobic exercise training in the exercise component of the acute and recovery phases of CR. Various members of staff took the patient’s history, conducted cardiovascular physical examinations, prescribed exercise and training, evaluated cardiovascular risk factors and laboratory data, and assessed the individual learning needs.

Exercise therapy in the recovery phase of CR was based on the results of the CPX and muscle strength testing, and on the rating of perceived exertion ascertained at the end of the acute phase of the inpatient CR program. After baseline testing, outpatients participated in a supervised combined aerobic and resistance exercise program that met twice weekly for 1 h. Exercise sessions were composed of a warm-up, aerobic exercise, resistance training, and cooldown period.

Exercise intensity during aerobic exercise was maintained at the AT heart rate attained during treadmill walking. For resistance training, 4 sets of a series of 2 upper-extremity exercises (shoulder flexion and abduction from anatomic position) were performed with an iron weight array at a resistance that allowed completion of 5 repetitions with a rating of perceived exertion of 11–13 (according to the Borg 6–20 scale). Four sets of a series of knee extensions and calf raises were performed for lower extremity exercises. Knee extension was performed with a weight strapped to the ankle and at a resistance that allowed completion of 5 repetitions with a 50% of 1 repetition maximum. Exercise intensity for calf raises was maintained at a rating of perceived exertion of 11–13. Each session was preceded and followed by series of stretches. Prescribed cardiac medications were continued on the day of the exercise test.

**Statistical Analysis**

All data are expressed as mean±SD. The [2 test and Student unpaired t-test were used to analyze differences in clinical factors. Data were analyzed using two-way repeated measures of analysis of variance (ANOVA) with Tukey post hoc tests. The between-group factor was type of CR program (CR group vs non-CR group) and the within-group factor was time period (1 and 3 months). Period by group interaction was analyzed. Post hoc testing was performed if a statistically significant main effect or interaction was detected. Statistical analyses were performed with SPSS 9.0J statistical software (SPSS Japan, Inc, Tokyo, Japan), and a p-value <0.05 was considered significant.

**Results**

**Subjects**

Mean age, sex, education, marital status, maximum CK-
MB, and location of AMI of the subjects were almost identical between the 2 groups (Table 1). Ejection fraction 1 month after AMI onset did not differ significantly between the CR (51.6±8.4%) and non-CR groups (51.7±5.4%). Oral dosages of drugs also did not differ significantly between the 2 groups. No changes in medications were made during the investigation period.

**Exercise Capacity**

The end-point of the exercise test for both groups was leg fatigue, shortness of breath, attainment of target HR, or GER \( \geq 1.20 \). No patient showed ischemic ST changes or experienced chest pain or serious arrhythmia during exercise testing. The effects of the CR program on peak \( V_O2 \) over the 2 time periods are presented in Table 2. Significant period by group interactions \( (F(1/122) =18.8, p=0.000) \) were detected, and post hoc analyses focused on the main effects of period \( (F(1/122) =25.8, p=0.000) \). Although there were no significant differences in peak \( V_O2 \) values between the groups before treatment, peak \( V_O2 \) at 3 months after AMI onset in the CR patients was significantly higher than that of the non-CR group (average increase, 24.5% in CR vs 4.1% in the non-CR group, \( p=0.000 \)).

**Muscle Strength**

The effects of the CR program on handgrip strength and knee extension strength over the 2 time periods are presented in Table 2. Handgrip strength and knee extension strength increased significantly only in the CR group. A significant interaction was detected in both handgrip strength and knee extension strength, with post hoc analyses showing a statistically significant difference between the 2 groups at 3 months [handgrip strength, \( F(1/122) =11.9, p=0.000 \]; knee extension strength, \( F(1/122) =22.6, p=0.000 \)]. Although there were no significant differences in either handgrip or knee extension strength between the groups before treatment, the CR patients scored significantly higher than the non-CR patients in handgrip strength (average increase, 9.1% in CR vs 1.4% in non-CR group) and knee extension strength (average increase, 26.6% in CR vs 6.6% in non-CR group) after treatment \( (p=0.000) \). No patient showed ischemic ST changes or experienced chest pain or serious arrhythmia during muscle strength testing.

**HRQOL**

The effects of the CR program on HRQOL over the 2 time periods are presented in Table 3. A statistically significant interaction was detected in the physical functioning \( [F(1/122) =21.5, p=0.000] \), role-physical \( [F(1/122) =18.7, p=0.000] \), general health \( [F(1/122) =4.5, p=0.03] \), and vitality \( [F(1/122) =4.6, p=0.03] \) subscale scores of the SF-36. Post hoc analysis indicated that the CR group at 3 months after AMI onset had significantly higher physical functioning, role-physical, general health, and vitality SF-36.
Effects of CR After AMI on Health-Related QOL

Table 3 Between-Group Comparison of SF-36 Subscales After Cardiac Rehabilitation (CR) Program

<table>
<thead>
<tr>
<th>SF-36 subscales</th>
<th>CR group (n=82)</th>
<th>Non-CR group (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 month</td>
<td>3 months</td>
</tr>
<tr>
<td>Physical functioning</td>
<td>47.7±6.3</td>
<td>52.5±5.9†</td>
</tr>
<tr>
<td>Role-physical</td>
<td>36.9±15.4</td>
<td>43.0±13.9†</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>46.3±14.1</td>
<td>53.6±7.7†</td>
</tr>
<tr>
<td>General health</td>
<td>46.1±9.2</td>
<td>48.7±8.3†</td>
</tr>
<tr>
<td>Vitality</td>
<td>47.4±9.1</td>
<td>52.6±7.4†</td>
</tr>
<tr>
<td>Social functioning</td>
<td>39.2±16.7</td>
<td>45.6±11.5†</td>
</tr>
<tr>
<td>Role-emotional</td>
<td>39.7±14.1</td>
<td>43.1±13.2†</td>
</tr>
<tr>
<td>Mental health</td>
<td>46.4±11.2</td>
<td>49.1±8.6†</td>
</tr>
</tbody>
</table>

*Time period by group interaction, p<0.05; †significantly different from initial values within group, p<0.05; ‡significantly different between groups, p<0.05.
Data are expressed as mean±SD.

Discussion

This is the first time, to our knowledge, that measurements of physiological and HRQOL outcomes have been evaluated in Japanese patients with AMI who have participated in CR, in relation to medium intensity resistance training and aerobic exercise training. The present study showed that positive effects could be attained with a relatively short-duration CR program.

We found that although the symptoms of the 2 groups of patients did not differ, patients who attended CR showed higher physiological outcome measurements than the patients who did not participate. With regard to physiological outcomes, we found that peak VO2 values in patients attending CR were significantly higher than those of patients not attending CR. Exercise capacity increased in the CR group, indicating considerably improved exercise capacity of a magnitude similar to that shown in another study of exercise training in coronary patients.

A previous study showed that resistance exercise training at a training intensity of 40-60% of 1 repetition maximum (RM) was physiologically safe for patients and resulted in moderate strength gains. Adams et al evaluated the effects and safety of an 8-week program of high-intensity muscle strength training combined with aerobic and resistance training in 61 phase II CR patients and found that a training intensity of 60-80% of 1 RM resulted in an increase in muscle strength of approximately 17% with no abnormal cardiac responses or orthopedic injuries. The results of our study are similar to the findings reported by Adams et al. Importantly, no cardiac or orthopedic complications occurred during aerobic and resistance exercise training in our study. These positive outcomes would indicate that the intensity of our CR program was sufficient. Positive improvement in physiological outcomes may enhance the ability of AMI patients to perform the activities of daily living, as well as occupational and recreational tasks.

We also found that although the characteristics of our 2 patient groups were not significantly different, those AMI patients who attended CR had higher SF-36 scores than those who did not attend. Significant improvement in HRQOL as assessed by the SF-36 subscales was shown by patients in the CR group, especially in the physical health-related scales, in comparison with those of the non-CR group. With regard to the bodily pain scale score, both groups showed improvement over the 2 time periods.

Previous research by Sledge et al has shown a positive change in HRQOL for cardiac patients (ie, those with AMI, CABG, or congestive heart failure) who participated in an intensive CR program in comparison with those who had received standard outpatient care only, suggesting that providing more intensive outpatient CR can improve scores in all SF-36 subscales more than can standard outpatient care. However, our current data showed no difference between CR and non-CR group patients with regard to scores in the bodily pain, social functioning, role emotional, and mental health subscales of the SF-36 at 3 months after AMI onset. This discrepancy may be related to differences in patient characteristics or to the type of CR program. Although the CR patients in our study mainly underwent an exercise training program, they also received healthy lifestyle counseling, spouse or partner support, and instructions in stress management. However, counseling and instruction in stress management were not given to individual patients by a psychologist, which may account for the difference in HRQOL-related findings between the present study and those of Sledge et al.

In the present study, of the four SF-36 subscales in which scores improved after CR, 3 were principally related to physical health (physical functioning, role-physical, general health). In addition, muscular strength and exercise capacity also improved during the present study’s CR program, and these improvements may have influenced the physical health-related scores. Thus the major benefit of the CR program may be the improvement of these scores. However, with regard to the SF-36 bodily pain subscale score, we felt that improvement in this score was unrelated to CR because neither group experienced chest pain during the study period. The possibility exists in the present study that although both peak VO2 values and muscular strength were improved, neither aerobics nor muscular strength training influenced the SF-36 bodily pain subscale score.

Beniamini et al studied 38 cardiac patients in whom a variety of HRQOL factors were assessed before and after completion of 12 weeks of either strength training or flexibility training that was added to their outpatient CR aerobic exercise program. The results of their study suggest that increases in muscle strength are associated with an improved HRQOL. We consider that the improvement in
HRQOL seen in our CR program was a general effect of both the aerobic and resistance training.

Oldridge et al also reported on disease-specific HRQOL after 8 weeks of CR exercise and counseling, and found the greatest change between baseline and 8 weeks, particularly in regard to emotional state, anxiety, disease-specific HRQOL, and exercise capacity. We believe that counseling and a stress management program are necessary parts of a successful CR program. Further studies are needed to evaluate how HRQOL is altered by different types of CR programs after AMI and also in different cardiac populations (ie, in CAGB or congestive heart failure patients).

**Study Limitations**

The present study group was comprised of a small number of subjects who were not randomized to a 1- vs 3-month intervention. Because the subjects chose participation in the CR program, selection factors could be responsible for treatment outcome differences. Also, it was not possible to determine differences between the groups for periods longer than 3 months. In future trials, supervised exercise training should continue for longer periods, and recreational or patient organizations should actively be encouraged to participate during the training sessions to stimulate patient recruitment in organized training outside the hospital.

A previous study suggested that changes in mood are mediated by self-efficacy rather than actual physical performance. Another study also suggested that increases in muscle strength are associated with enhanced self-efficacy and improved HRQOL. In the present study, these outcomes were not assessed specifically; thus, we could not determine whether self-efficacy was a factor in the improvement of HRQOL. The relation between improved HRQOL and exercise performance requires further study.

**Conclusions**

We found that a CR program combining resistance and aerobic exercise training for AMI patients during their recovery phase improved not only physiological outcomes but also HRQOL as assessed by the SF-36. The addition of resistance exercise to our CR aerobic exercise program may have resulted in significant improvements in HRQOL. Long-term follow-up is needed to evaluate whether these benefits will continue over time.

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**References**


