Maintenance of Exercise Capacity and Physical Activity Patterns 2 Years After Cardiac Rehabilitation

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■ BACKGROUND: The benefits of exercise training for post–myocardial infarction and post–coronary artery bypass surgery patients are well established, but little is known about the effects of rehabilitation in the months or years following the program. The purpose of this study was to assess exercise capacity, blood lipids, and physical activity patterns 2 years after completing a concentrated residential rehabilitation program in Switzerland.

■ METHODS: Seventy-eight patients (86% males, mean age = 56 ± 10, mean ejection fraction = 64% ± 12%) were referred to a residential rehabilitation program after a myocardial infarction or coronary artery bypass surgery between January 2001 and June 2001. Patients lived at the center for 1 month, during which time they underwent educational sessions, consumed a low-fat diet, and exercised 2 hours daily. Two years after completing the program, patients returned to the hospital and underwent a maximal exercise test, an assessment of recent and adulthood physical activity patterns, and evaluation of blood lipids.

■ RESULTS: During the 2-year follow-up period, there were 5 deaths, and 70 of the remaining 73 patients returned for repeat testing. Mean exercise capacity increased 27% during the rehabilitation program ($P < .01$). Gains in exercise capacity during rehabilitation were maintained after the follow-up period; mean exercise capacity after 2 years was 34% higher compared with that at baseline ($P < .01$). At the 2-year evaluation, patients were expending a mean of 3127 ± 1689 kcals/wk during recreational activities compared with 977 ± 842 kcals/wk during adulthood prior to their cardiac event ($P < .001$). Between the completion of rehabilitation and the 2-year follow-up, total cholesterol, total cholesterol/high-density lipoprotein ratio, and triglycerides increased significantly.

■ CONCLUSIONS: Two years after a cardiac event and participation in a concentrated residential rehabilitation program, patients maintained their exercise capacity and engaged in physical activities that exceed the levels recommended by guidelines for cardiovascular health. These observations suggest that a relatively intensive rehabilitation program provided a catalyst to maintain physical activity patterns and exercise tolerance in the 2 years following a cardiac event.

K E Y W O R D S

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exercise training

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physical activity

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The physiological and psychosocial benefits of exercise training after a myocardial infarction (MI) or coronary artery bypass surgery (CABS) have been demonstrated by an extensive body of literature spanning over 3 decades. These benefits include improved exercise capacity, lessening of symptoms, higher rate of return to work, and improved morbidity and mortality.[1-7] In regard to studies on morbidity and mortality, meta-analyses of the controlled exercise trials among post-MI patients have reported 20% to 25% reductions in both all-cause mortality and fatal reinfarction among participants in rehabilitation program compared with control subjects.[3,4,7] These findings were recently broadened to include patients with chronic heart failure studied during the 1990s; among 9 studies totaling 801 patients, a 35% reduction in mortality was observed among patients who engaged in an exercise program of at least 8 weeks' duration.[5] In these studies, it is not known whether the morbidity and mortality benefits were due to participation in the rehabilitation program per se, whether the program provided a stimulus to more generally enhanced participation in physical activity, or whether rehabilitation influenced other health-related lifestyle behaviors in subsequent years. Little is known about the longer-term effects a cardiac rehabilitation program has on physical activity patterns or lifestyle changes associated with better cardiovascular health.

As an extension of a previous study designed to assess training responses using self-regulation,[8] patients were contacted 2 years after completing a concentrated residential rehabilitation program in Switzerland. At the 2-year follow-up, patients returned to the hospital and underwent an exercise test, analysis of blood lipids, and an assessment of energy expenditure from physical activity during the period since the rehabilitation program was completed. The purpose was to determine the influence rehabilitation may have had on maintenance of exercise capacity and physical activity patterns 2 years after the program. The residential program included a relatively high-training stimulus and an emphasis on education, including efforts to encourage patients to maintain physical activity after discharge.

METHODS

Seventy-eight consecutive patients (86% males, mean age = 57 ± 11) referred to a residential rehabilitation center in Seewis, Switzerland, between January 2001 and June 2001 participated in the study. Of these, 5 died and 70 of the remaining 73 returned for repeat evaluation at the 2-year follow-up. The subjects were randomly divided into 3 groups for the purposes of comparing self-regulation of training intensity to standard training protocols for a previous study.[8] Clinical characteristics of the 3 groups are outlined in Table 1. Thirty-nine subjects (50%) had sustained an MI, 39 (50%) had undergone percutaneous transluminal coronary angioplasty, and 41 (52%) had undergone CABS. After the coronary event, patients were stabilized for approximately 2 weeks prior to beginning rehabilitation (mean number of days between hospital admission and beginning of the study were 15.5 ± 12). Medication regimens were stabilized such that all patients had stable symptoms at baseline. No subject had evidence of heart failure by clinical or echocardiographic criteria. All patients were limited by fatigue, dyspnea, or both on baseline exercise testing, and none had clinical evidence of pulmonary disease. After informed consent was obtained, baseline exercise testing was performed, and subjects were randomized into 1 of the 3 exercise groups.

Exercise Training

The rehabilitation center is located in an area isolated in the mountains at an elevation of 3500 ft. The center has its own staff of physicians, consisting of a medical director, 3 medical residents, and 3 exercise physiologists. Program components included education, exercise, and low-fat meals prepared daily by the center's cook. Details of the rehabilitation program have been described previously.[9]

Five indoor cycling sessions were performed weekly for a duration of 30 minutes, and all subjects walked outdoors for 45 minutes twice daily. Training duration was 1 month. For the purposes of a previous study designed to compare self-regulation of exercise intensity to standardized methods,[8] the subjects were randomly divided into 3 groups. For Group 1, exercise intensity was determined using a standard heart rate reserve method ([maximal heart rate-rest heart rate × 0.70] + rest heart rate).[10] During indoor cycling sessions, resistance was controlled using a heart rate feedback mechanism. A specific target heart rate was entered into the system, and resistance was adjusted at 10-second intervals to maintain a desired heart rate. During walking sessions, a Polar heart rate device (Woodbury, NJ) was used to monitor heart rate, and walking pace was adjusted such that heart rate was kept within ±5 beats/min of the target. Perceived exertion data were not acquired for this group. For Group 2, indoor and outdoor exercise intensity was determined using only the patient's perception of a Borg scale rating of 12 to 14 ("somewhat hard"),[11] irrespective of heart rate or work rate. For Group 3, exercise intensity was determined using both objective (heart rate reserve and work rate targeted at 60%–80% of maximal), and subjective (Borg 12–14 scale) responses, and work rate was adjusted (manually) accordingly. All indoor cycling sessions were supervised directly by a medical resident and outdoor walking sessions were supervised by exercise physiologists.

Exercise Testing

Maximal exercise testing was performed on an electrically braked cycle ergometer using an individualized ramp protocol,[12] which entailed choosing an individualized ramp

Table 1 • CLINICAL AND DEMOGRAPHIC CHARACTERISTICS AT BASELINE AND THE 2-YEAR FOLLOW-UP PERIOD FOR THE 3 GROUPS*

	Group 1		Group 2		Group 3	
	Baseline	Two Years	Baseline	Two Years	Baseline	Two Years
Demographics						
Number	24	22	27	23	27	25
Age†	54.3 ± 12	57.1 ± 13	60.9 ± 10	62.5 ± 10	55.4 ± 9	58.2 ± 8
Male, n (%)	21 (87)	19 (86)	23 (85)	19 (83)	23 (85)	23 (92)
Height, † cm	173.8 ± 7.8	…	172.6 ± 8.5	…	172.0 ± 8.0	…
Weight,† kg	83.5 ± 12.6	84.0 ± 12.6	77.9 ± 11.4	78.4 ± 11.1	79.2 ± 12.1	81.3 ± 12.2
Ejection fraction,† %	68.6 ± 12	…	60.8 ± 13	…	60.8 ± 14	…
Myocardial infarction	8 (33)	…	15 (55)	…	13 (48)	…
PTCA	12 (50)	…	15 (55)	…	12 (44)	…
Medications, n (%)						
β-Blocker	19 (79)	17 (77)	22 (81)	18 (78)	23 (85)	22 (88)
Nitrates	2 (8)	0	3 (11)	1 (5)	2 (7)	0
Calcium antagonist	2 (8)	0	4 (15)	2 (9)	4 (15)	2 (8)
Aspirin	22 (92)	19 (86)	27 (100)	23 (100)	24 (89)	21 (84)
Anticoagulant	2 (8)	2 (9)	3 (11)	0	11 (41)	2 (8)
ACE/AT II	5 (21)	10 (45)	6 (22)	10 (43)	7 (26)	11 (44)
Diuretics	8 (33)	1 (5)	11 (41)	2 (9)	11 (41)	2 (8)
Statins	22 (92)	17 (77)	26 (96)	21 (91)	24 (89)	21 (84)
Digoxin	0	0	0	0	0	0
Antiarrythmics	6 (24)	0	6 (22)	1 (4)	6 (22)	0

PTCA, percutaneous transluminal coronary angioplasty; ACE/AT II, ACE-inhibitor/angiotensin receptor blocker.
*None of the comparisons (baseline vs 2 years) were statistically different.
†Values are mean ± SD.

rate to yield a test duration of approximately 10 minutes. The ramp rate chosen was the same for a given patient on the pretraining and posttraining test as well as the 2-year follow-up test. A 12-lead electrocardiogram was monitored continuously, and blood pressure was measured manually every minute during exercise and throughout the recovery period. The patient's subjective level of exertion was quantified every minute using the Borg 6–20 scale.[11] All tests were continued to volitional fatigue/dyspnea.

Assessment of Physical Activity

The quantification of physical activity performed was assessed by a questionnaire modeled after the Harvard
[AQ2] Alumni studies of Paffenbarger and colleagues.[13] The questionnaire was self-administered, but was filled out in the presence of a staff member who ascertained completeness and clarity of the responses. The questionnaire responses were entered into a Microsoft ACCESS file, which computed metabolic costs of both occupational and recreational activities, and expressed the results as energy expenditure in kcals/wk. Energy costs of activities were estimated from the compendium of activities developed by Ainsworth et al.[14] Energy costs of stairs climbed per week were calculated using the estimation of Basset et al.[15] Energy expenditure was expressed in terms of lifetime adulthood recreational activity, and separately as energy expended during the year prior to the evaluation.

Blood Lipids

At the end of the rehabilitation period and 2 years later, standard blood lipids were analyzed, including total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides, in addition to glucose after all subjects fasted for 12 hours. Lipid values were calculated using a Cobas Integra absorbance photometry system (Roche Diagnostics, Rotkreuz, Switzerland).

Statistical Analysis

NCSS software (Kayesville, Utah) was used to perform multivariate ANOVA between exercise responses at baseline, after the rehabilitation program, and at the 2-year follow-up evaluation. ANOVA was also used to compare responses between patients randomized to the 3 training groups. Post hoc procedures were performed using the Bonferroni method.[16] Paired *t* tests were used to compare current energy expenditure with that during adulthood as well as to compare lipid values after rehabilitation with those at the 2-year follow-up. Data are presented as mean ± SD.

RESULTS

Of the 78 patients who completed the rehabilitation program, 70 returned for repeat evaluation after 2 years. Of the 8 who did not return, 4 had died from cardiovascular causes, 1 died from a noncardiovascular illness, 1 was too ill with cancer, 1 was recovering from noncardiovascular surgery, and 1 refused repeat testing.

No differences were observed between the 3 groups initially in clinical or demographic data, including age, height, weight, pulmonary function, or medication status. After the 2-year follow-up period, clinical and demographic data were similar to those at baseline (Table 1). No untoward events occurred during any of the exercise testing or training procedures. Assessing heart rate recordings retrospectively, the training intensities (expressed as heart rate reserve) were 65%, 64%, and 69% for groups 1, 2, and 3, respectively (NS). Mean heart rates during all exercise training sessions were also similar: 107 ± 13, 105 ±10, and 106 ± 8 beats/min for groups 1, 2, and 3, respectively. The mean perceived exertion during the training sessions in the self-regulated group (Group 2) was 12.8 ± 0.47, and the value for Group 3 was 12.6 ± 0.79.

Exercise testing responses before and after the rehabilitation period and 2 years later are presented in Table 2. For each evaluation, mean maximal perceived exertion levels were greater than 18 or 19, suggesting that maximal efforts were generally achieved. Training resulted in significant increases in maximal heart rate, maximal systolic blood pressure, work load achieved (27% increase in peak watts, equating to ≈2.5 METs), and exercise time. Submaximally, heart rate and peak watts achieved at a perceived exertion of 13 were higher after training ($P < .01$). However, heart rate at 5 minutes of exercise was not different from that at baseline.

At the 2-year follow-up evaluation, exercise capacity was maintained; peak watts achieved and exercise time were similar to those after rehabilitation, and remained significantly higher when compared with the values at baseline ($P < .01$). Resting and maximal exercise systolic and diastolic blood pressures and maximal rate-pressure product were higher at 2 years versus the postrehabilitation test. Resting heart rate was significantly lower at 2 years compared with values at both baseline and postrehabilitation.

Training responses according to the 3 exercise prescription groups are presented in Table 3. All 3 groups had similar responses to training, and exercise capacity at the 2-year follow-up was similar to that at the postrehabilitation evaluation for all 3 groups. The magnitude of the increase in exercise capacity at both the postrehabilitation and 2-year evaluation was not different between groups.

Energy expenditure values 2 years after completing the rehabilitation program and throughout adulthood are presented in Table 4. For the total group, the mean energy expenditure during recreational activity over the

Table 2 • EXERCISE TEST RESPONSES (MEAN ± SD) AT BASELINE, AFTER TRAINING, AND AFTER 2 YEARS

	Evaluation Point			
	Baseline	Postrehabilitation	Two Years	P*
Rest				
Heart rate, beats/min	77 ± 12	73 ± 13	65 ± 10†,‡	<.001
Systolic BP, mmHg	123 ± 15	124 ± 17	141 ± 17†,‡	<.001
Diastolic BP, mmHg	78 ± 9	79 ± 10	90 ± 10†,‡	<.001
Submaximal exercise				
Heart rate at PE 13	103 ± 16	112 ± 17†	112 ± 14†	<.001
Watts at PE 13	82.0 ± 33	114.6 ± 40†	114.3 ± 32†	<.001
Heart rate at 5′	101 ± 12	98 ± 14	102 ± 15	.18
Maximal exercise				
Heart rate, beats/min	122 ± 19	135 ± 20†	143 ± 18†	<.001
Systolic BP, mmHg	176 ± 28	188 ± 28§	208 ± 23†,‡	<.001
Diastolic BP, mmHg	89 ± 13	94 ± 13	104 ± 14§,‡	<.001
RPP (10^3)	21.6 ± 6.0	25.7 ± 6.4§	30.0 ± 5.9†,‡	<.001
Workload, W	127.7 ± 39	162.8 ± 4.5†	171.2 ± 46†	<.001
Perceived exertion	18.3 ± 0.94	19.0 ± 0.77†	19.2 ± 0.90†	<.001
Exercise time, min	8.3 ± 1.8	10.7 ± 2.0†	10.2 ± 1.7†	<.001

BP, blood pressure; PE, perceived exertion; RPP, rate pressure product.

*Represents P value from ANOVA between tests.

†$P < .01$ vs baseline.

‡$P < .01$ vs postrehabilitation test.

§$P < .05$.

Table 3 • EXERCISE TEST RESPONSES (MEAN ± SD) AT BASELINE, AFTER TRAINING, AND AT THE 2-YEAR FOLLOW-UP IN THE 3 EXERCISE PRESCRIPTION GROUPS

	Heart Rate Only			Self-regulation			Objective and Subjective			
	Baseline	Posttraining	Two Years	Baseline	Posttraining	Two Years	Baseline	Posttraining	Two Years	P^*
Rest										
Heart rate, beats/min	76.5 ± 11.1	75.9 ± 14.0	66.9 ± 11.3	77.6 ± 14.1	72.2 ± 14.9	64.8 ± 11.0†	76.1 ± 12.2	72.4 ± 11.7	64.5 ± 8.6	.10
Systolic BP, mmHg	126.1 ± 14.3	127.7 ± 19.1	141.6 ± 17.6	119.8 ± 15.3	119.4 ± 15.0	142.4 ± 16.9‡	122.3 ± 15.7	124.2 ± 17.3	138.6 ± 17.1†	.20
Diastolic BP, mmHg	81.4 ± 10.3	81.4 ± 10.8	90.7 ± 10.5	75.2 ± 8.3	74.8 ± 8.2	88.9 ± 10.6‡	79.0 ± 8.7	80.2 ± 10.1	89.0 ± 9.1†	.20
Submaximal exercise										
Heart rate. beats/min at PE 13	105.7 ± 16.7	116.8 ± 17.3	114.6 ± 15.4	102.7 ± 17.6	107.9 ± 19.2	112.4 ± 16.1	99.8 ± 12.8	111.6 ± 13.0	108.6 ± 10.5	.16
Watts at PE 13	84.4 ± 37.4	116.5 ± 41.6	114.8 ± 34.0	79.6 ± 32.1	106.6 ± 44.1	110.4 ± 31.8	82.1 ± 25.7	119.8 ± 34.7‡	117.4 ± 30.7†	.08
Heart rate, beats/min at 5′	103.7 ± 10.7	102.3 ± 11.6	104.3 ± 16.6	100.9 ± 13.6	93.7 ± 13.9	104.2 ± 17.1	99.2 ± 12.3	97.4 ± 14.1	97.1 ± 10.0	.33
Maximal exercise										
Heart rate, beats/min	125.9 ± 17.9	143.1 ± 19.5	150.9 ± 19.5‡	121.3 ± 22.2	132.0 ± 18.8	141.2 ± 18.2†	117.7 ± 14.7	130.8 ± 19.2	138.9 ± 15.6‡	.09
Systolic BP, mmHg	183.0 ± 25.7	198.0 ± 22.2	215.9 ± 17.4‡	175.7 ± 32.6	183.7 ± 26.4	201.7 ± 23.1†	168.8 ± 25.9	184.0 ± 33.4	207.2 ± 27.0‡	.13
Diastolic BP, mmHg	91.4 ± 14.0	97.3 ± 13.8	107.5 ± 11.9‡	87.0 ± 14.6	90.7 ± 13.9	100.7 ± 17.3†	89.4 ± 11.7	93.6 ± 12.3	102.8 ± 10.5†	.07
RPP (10^3)	23.2 ± 5.4	28.5 ± 6.2	32.7 ± 5.8‡	21.9 ± 7.7	24.5 ± 6.4	28.7 ± 5.8‡	19.9 ± 4.0	24.2 ± 6.2	28.9 ± 5.5‡	.15
Workload, W	129.9 ± 41.8	170.1 ± 43.4	177.2 ± 58.7†	124.2 ± 40.0	153.6 ± 44.6	157.7 ± 45.8	129.1 ± 33.0	164.9 ± 45.8	178.5 ± 43.5‡	.11
PE	18.2 ± 1.0	18.9 ± 0.8	19.3 ± 0.8‡	18.5 ± 0.9	19.3 ± 0.6	19.1 ± 1.1	18.4 ± 0.9	19.0 ± 0.8	19.3 ± 0.8†	.29
Exercise time, min	8.3 ± 1.6	11.0 ± 1.5‡	10.6 ± 1.3‡	8.5 ± 2.0	10.6 ± 1.9‡	9.5 ± 2.1	8.2 ± 1.8	10.6 ± 2.5‡	10.4 ± 1.7‡	.30

BP, blood pressure; PE, perceived exertion; RPP, rate pressure product.
*Represents P value between-group comparison.
$^\dagger P < .05$.
$^\ddagger P < .001$ vs baseline within group.

last year was 3127 ± 1689 kcals/wk, and was similar between each of the groups. This was contrasted by energy expenditure during adulthood prior to the cardiac event (977 ± 842), which was roughly one third of that expended during the period following rehabilitation ($P < .001$).

Blood lipid values after rehabilitation and at the 2-year follow-up are shown in Table 5. Total cholesterol ($P < .05$), triglycerides ($P < .01$), and the total cholesterol/HDL ratio ($P < .01$) were higher at the 2-year evaluation versus those at postrehabilitation.

DISCUSSION

While the benefits of rehabilitation in post-MI or post-CABS patients are well documented, few data are available regarding the longer-term effects once patients complete the program. The extent to which shorter-term improvements in exercise tolerance, education, and psychosocial counseling, as well as the cardiac event itself translate into health-related behavior changes over the months following rehabilitation are largely unknown. Because the present rehabilitation center generally receives referrals from the local region, contacting patients seemed reasonable, and it was likely that they would be amenable to returning for evaluation. Of the 73 patients alive at the time of the 2-year follow-up, 70 returned for evaluation; 2 were too ill to return, and only 1 refused. The rehabilitation program was typical of many programs in central Europe in that it was short, concentrated, and involved a comparatively high-training stimulus (twice daily exercise sessions). The fact that it was residential ensured virtually 100% compliance with the dietary and exercise components as well as a captive audience for educational sessions.

Present Results

During the rehabilitation program, patients demonstrated typical benefits in terms of exercise capacity, with an overall 27% improvement in work rate, a concomitant increase in exercise time, and increases in heart rate and work rate at a matched perceived exertion of 13. The salient finding was that the gains in exercise capacity achieved during rehabilitation were maintained after 2 years (Tables 2 and 3). In addition, physical activity patterns, expressed as energy expenditure during the last year, were surprisingly high, averaging more than 3000 kcals/wk. This volume of energy expenditure is comparatively high by most standards, but certainly exceeds the minimal recommendations made in the US Surgeon General's Report on Physical Activity and Health,[17] the Centers for Disease Control and Prevention/American College of Sports Medicine statement on activity and health,[18] and other consensus reports.[19,20] Based on the Harvard Alumni[13] (upon which our questionnaire was based), and other[21,22] follow-up studies, this level of activity, if performed throughout adulthood, would be associated with reductions in all-cause mortality, cardiac events, or both, in the order of 30% to 40%. Because there was no control group, only a comparison of energy expenditure with that during adulthood prior to entering rehabilitation could be made. The average energy expenditure 2 years after the rehabilitation program was considerably higher than the mean of 977 kcals/wk expended during adulthood prior to the cardiac event. The latter volume of activity would be considered typical for most adults, and would generally fall into a moderately active category, as shown in previous studies.[13,21,23] [AQ3]

The extent to which the activity patterns observed 2 years following rehabilitation were attributable directly to participation in the program is unknown. Ideally, knowledge and skills gained while living at the rehabilitation center would translate into sustained greater activity. Although the time spent exercising during the short rehabilitation period was relatively small, the supervision and encouragement patients received may have led to a more active lifestyle in the long term, and the overall volume of exercise is likely much larger than that directly provided during rehabilitation. It is not known whether the present results are applicable to more traditional, outpatient programs in the United States and elsewhere. The fact that our subjects lived at

Table 4 • ENERGY EXPENDITURE SINCE COMPLETING THE REHABILITATION PROGRAM AND DURING ADULTHOOD

	All Subjects (n = 70)	Heart Rate Reserve Group (n = 22)	Self-regulation Group (n = 23)	Objective/Subjective Group (n = 25)	*P*
Recreational activity, last year, kcal/wk	3127 ± 1689*	3155 ± 1608*	3023 ± 1449*	3171 ± 2019*	.95
Recreational activity, adulthood, kcal/wk	977 ± 842	724 ± 535	1162 ± 1127	1041 ± 765	.21
Current blocks walked, stairs climbed, kcal/wk	2442 ± 1843	2237 ± 1350	2134 ± 1559	2857 ± 2388	.35

*$P < .001$, energy expenditure last year versus adulthood.

Table 5 • BLOOD LIPID AND GLUCOSE VALUES (MEAN ± SD) AFTER REHABILITATION AND THE 2-YEAR FOLLOW-UP

	Postrehabilitation	Two Years
Total cholesterol, mg/dL	167 ± 30.2	180.0 ± 38.7*
HDL, mg/dL	41.0 ± 11.2	42.6 ± 12.4
LDL, mg/dL	99.5 ± 46.4	105.9 ± 31.3
Total/HDL ratio	3.45 ± 1.20	4.68 ± 1.60†
Triglycerides, mg/dL	124.0 ± 50.5	159.4 ± 70.8†
Glucose, mg/dL, fasting	96 ± 22	95 ± 19

HDL, high-density lipoprotein; LDL, low-density lipoprotein.
*$P < .05$.
†$P < .01$.

the rehabilitation center virtually ensured compliance with exercise, dietary intervention, and educational sessions, in addition to providing an environment of clinical, social, and peer group support. While these features likely contributed to the favorable observations after 2 years, studies assessing patients several years following more typical outpatient programs are needed.

Although not the focus of the current study, it is noteworthy that both the response to rehabilitation we reported in these subjects previously[8] and our observations 2 years later in the current analysis were similar between the groups randomized to self-regulated and heart rate-regulated intensity groups (Table 3). The purpose of classifying patients into the 3 groups was to compare responses to training between a self-regulated intensity group with groups using more traditional methods of exercise prescription, including one in which heart rate was tightly controlled via a heart rate-work rate feedback cycle ergometer. It has been previously reported that the response to the training program was similar between the 3 groups,[8] and in the current study, both exercise capacity and energy expenditure from weekly activity were similar among the 3 groups after the 2-year observation. This suggests that subjects taught to exercise on their own during rehabilitation, without heart rate monitoring or feedback, are able to maintain a physically active lifestyle after a cardiac event in a fashion similar to subjects whose training intensity was tightly controlled.

An additional notable observation was the increase in total cholesterol, triglycerides, and total cholesterol/ HDL ratio, along with a trend of an increase in LDL, at the 2-year follow-up compared with postrehabilitation (Table 5). Baseline lipid values (prerehabilitation) were not available with which to compare, but it is speculated that this was the result of comparatively low lipid levels following the period of rehabilitation. Programs of cardiac rehabilitation have generally been shown to result in small but statistically significant improvements in blood lipids.[24] The LDL, triglyceride, and total cholesterol values immediately after the rehabilitation period were likely inordinately low because of the careful control of diet and lifestyle while residing at the rehabilitation center.

Previous Studies

There are surprisingly few studies in the literature that have reevaluated patients some point after completing rehabilitation to assess maintenance of fitness, activity patterns, or both. The aforementioned meta-analyses, showing reductions in all-cause and cardiovascular mortality in the order of 25% among those participating in rehabilitation compared with controls,[3,4,7] have varied widely in terms of training duration and length of follow-up. While continued exercise is thought to be required to sustain most benefits of rehabilitation,[25] studies have reported that only 30% to 60% of those who complete a phase-II rehabilitation program are still physically active 3 to 6 months later.[26-28] Longer-term studies on exercise patterns following cardiac rehabilitation are sparse. Hage et al[29] assessed physical activity participation a mean of 4.4 years after a randomized rehabilitation program in elderly patients. Using a 6-level category scale, those in the intervention group showed slight but significantly higher physical activity scores over the follow-up period relative to controls. Stahl et al[30] assessed elderly post-MI patients 1 year after entering a rehabilitation program, 9 months after patients began a "voluntary" maintenance exercise program on their own. Self-reported activity in the exercise group was similar to that of controls at the 1-year evaluation.

In terms of survival, studies are mixed regarding the time course of the effects of rehabilitation. Perhaps the most germane study in the context of the present results was a follow-up of the National Exercise and Heart Disease Project (NEHDP), a large, randomized 3-year exercise trial among 651 post-MI patients whose outcomes were assessed 3, 5, 10, 15, and 19 years after the program.[31] Trends for mortality reductions were observed early in the follow-up period (<10 years), but these effects diminished as time since participation increased, suggesting that the protective mechanisms of rehabilitation may be short term. Conversely, other studies have observed mortality benefits only after more than 10 years.[32,33] However, the extent to which patients maintained participation in physical activity or other lifestyle behaviors over these time points is unknown.

LIMITATIONS

This study was limited by the absence of a control group. It is conceivable that subjects who came to the rehabilitation center, and agreed to return, represented a sample that was particularly motivated to make lifestyle changes after a cardiac event. It is also possible that the cardiac event alone may influence health-related behaviors without a rehabilitation program. As with any questionnaire approach, the results are dependent on patients' recollection and how judicious they may be in their responses. It should also be noted that more than half (54%) of this sample was retired, and therefore, likely had time available to engage in recreational activities after their cardiac event. Finally, although the mean energy expenditure 2 years after rehabilitation was high, there was also a rather high standard deviation, suggesting there was a great deal of variance in the patients' activity levels.

SUMMARY

Two years after a cardiac event and participation in a concentrated residential rehabilitation program that included exercise and educational sessions, patients maintained their exercise capacity, and engaged in physical activities that required energy expenditures exceeding those recommended by guidelines for cardiovascular health. These observations suggest that a relatively concentrated rehabilitation program provided a catalyst to maintain physical activity and exercise tolerance over the 2 years following a cardiac event. This may be a factor that has contributed to the widely recognized reduction in mortality associated with participation in cardiac rehabilitation.[3-5,7]

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AUTHOR QUERIES

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AQ1: Specify which affiliation is for which author.
AQ2: The use of word “quantification” does not seem appropriate. Modify as appropriate. Also, check whether the edits made in the sentence “The…colleagues” convey the intended meaning.
AQ3: Check whether the edited sentence “The latter...studies” conveys the intended meaning.
AQ4: Update, if possible.