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CAN HIGH-RISK PATIENTS AFTER MYOCARDIAL INFARCTION PARTICIPATE IN COMPREHENSIVE CARDIAC REHABILITATION?

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ABSTRACT. Patients with large transmural infarctions (MI) and signs of congestive heart failure (CHF) are often excluded from physical training, because of the risk of malignant arrhythmia or cardiac overloading. From a non-selected MI population <65 years we enrolled 37 high-risk patients in a two-year comprehensive cardiac rehabilitation programme, including health education, follow-up at a post-MI clinic, and physical training in outpatient groups. The feasibility, effectiveness and safety of the physical training were evaluated: Twenty-one patients joined the physical training and participated with excellent compliance, reaching the preset levels of training. No adverse effects occurred during the 921 training sessions. The high-risk patients were compared with the remaining 228 patients and a subgroup of 86 low-risk patients with regard to mortality, morbidity, medication, effect on risk factors, exercise test performance and rate of return to work. The high-risk group showed a higher mortality (27.0 vs. 10.4%, $p<0.05$), a lower maximal work capacity at the exercise test 4 months after MI (126 W vs. 140 W, $p<0.05$), and a lower rate of early return to work (22.6 vs. 50% $p<0.01$) when compare with the low risk group. However, they showed a similar improvement in exercise test parameters. At the end of the programme a remarkable 63% had returned to work vs. 48.2% of the remaining patients. The reduction in smoking and the effect on blood pressure were equal in both groups. It is concluded that high-risk patients may well benefit from regular physical training in outpatient groups, if adequate medical supervision is available.

Key words: myocardial infarction, cardiac rehabilitation, physical training, congestive heart failure.

The aims of a cardiac rehabilitation programme after myocardial infarction (MI) are to modify the risk factors for coronary artery disease and to improve physical fitness and psychological wellbeing. Physical training as a part of comprehensive cardiac rehabilitation improves physical work capacity, decreases the heart rate at submaximal workloads and raises the angina threshold (1). It has a beneficial effect on blood lipids (2) and improves the psychological status (3, 4).

Patients with large transmural infarctions and signs of congestive heart failure constitute a high-risk group (5) and are usually excluded from participation in physical training because of an increased risk of sudden death due to malignant arrhythmias and of cardiac overloading during exercise. Yet they are physically and mentally more handicapped than other MI survivors (6), and should therefore be offered all possible rehabilitation.

We decided to include high-risk patients because the cardiac rehabilitation programme at the Oskarshamn district hospital offered individually-adapted training in outpatient groups under the direct supervision of a physician of the rehabilitation team. There are few reports on physical training of high-risk patients, and those there are based upon selected or referred patient populations with varying delays between the MI and the start of the training programme (7–9).

The aims of our study were: (i) To evaluate the feasibility of, patient compliance with, and the safety of a physical training programme, starting 6–8 weeks post-MI, offered to high-risk patients in a non selected MI patient population. (ii) To compare the effects on mortality, morbidity, risk factor modification, medication, exercise testing performance and return to work in these patients with those in the MI patients not fulfilling the criteria for the high-risk patients.

MATERIAL AND METHODS

The study population consisted of all MI patients <65 years who were admitted to the coronary care unit (CCU) of the Oskarshamn district hospital during August 1977 – December 1984. After discharge the surviving 265 patients were invited to enrol in a comprehensive cardiac rehabilitation

programme consisting of health education, follow-up at a post-MI clinic and physical training in out-patient groups. The design of the programme and the effects on mortality, morbidity, risk factors, medication and return to work have recently been published (10, 11).

We excluded 11 patients because of unstable angina pectoris, malignant arrhythmia, or heart failure (NYHA grades III–IV) and 29 patients because of other diseases (orthopedic complaints, psychiatric disorders etc). Two hundred and twenty-five patients were invited to the training programme: 41 patients declined due to poor motivation or transport problems.

During the first three months (period I) training consisted of 40 min interval training in groups of 7–8 patients twice weekly, led by a physiotherapist under supervision of a physician from the rehabilitation team. Individual training schemes were based on the results of the exercise testing. Home training programmes were provided.

Period II, the remainder of the first year post-MI included continued home training but less frequent group-training.

Period III, the second year post-MI involved monthly group training.

All data from the post-MI clinic, including exercise testing at 6 weeks, 4 months and 12 months and from the training programme were prospectively collected in a MI-register. From this register a study group of high-risk patients was obtained. We defined high risk as the presence of all four of the following: (i) basal rales during the CCU stay, (ii) pulmonary venous congestion and/or signs of lung oedema on the CCU chest X-ray, (iii) an aspartate aminotransferase level >3 μkat/l, and (iv) the need for further diuretic therapy after discharge from the hospital.

Thus a study group of 37 MI patients was collected, all of whom had major transmural infarctions with clinical signs of congestive heart failure. Five patients died within two months post-MI: reinfarctions (2), sudden death (2), stroke (1). Two patients were excluded from physical training because of schizophrenia (both died within six months), 1 because of depressive neurosis and 3 because of NYHA grade IV CHF (two died within two years, but 1 underwent subacute valve replacement and joined the training later). Five of the remaining 26 patients declined to participate in the training. Therefore 21 patients entered physical training in outpatient groups.

The adherence to the training and the occurrence of adverse effects (cardiovascular or orthopedic complications) were studied. Feasibility was evaluated by comparing the average maximum heart rate during exercise with the preset maximum heart rate based upon the results from exercise testing. Compliance was analysed by comparing the scheduled number of training sessions with the number actually attended.

The exercise tests were performed on an electrically braked bicycle ergometer (Siemens-Elema, Sweden). A 12-lead ECG was recorded in supine position before, 1, 4 and 10 min after exercise, or until provoked ST-T changes had disappeared. A 6-lead precordial ECG was recorded continuously during exercise.

The two-year results of the programme with respect to mortality, morbidity, smoking, blood pressure, cholesterol, exercise testing, medication and return to work have been compared between the high-risk group (Group I, $n=37$) and all the remaining MI patients in the programme (Group II, $n=228$). The results have also been compared with those in a subgroup of group II: a low-risk group (Group III, $n=86$), consisting of all patients not fulfilling any of the criteria of the high-risk group. Tables I and II show the pre-MI and acute MI data in the three groups.

Table I. *PRE-MI data*

All percentages between brackets

	Group I	Group II	Group III
n	37	228	86
Age, years	56.5	57.3	57.8
Males	26 (70.3)	200 (87.7)	76 (88.4)
Hypertensives	10 (27.0)	59 (25.9)	13 (15.1)
Smokers	17 (45.9)	119 (52.2)	34 (39.5)
CHD-heredity	5 (13.5)	65 (28.5)	29 (33.7)
Previous MI	2 (5.4)	23 (10.1)	8 (9.3)
Diabetes Mellitus	5 (13.5)	25 (11.0)	5 (5.8)
Rate of employment	30 (81.1)	175 (76.7)	72 (79.1)

Significantly fewer males in Group I ($p<0.05$), all other differences not statistically significant.

There were no dropouts during the follow-up. All data on mortality, morbidity, coronary bypass grafting and return to work were available. Patients who left the district were included in the statistical analysis. For the definitions of acute MI, total cardiac events, hypertension, smoking, IHD heredity, and arrhythmia we refer to our previous studies (10, 11).

Statistical methods

We have used Student's t-tests and the X^2-test according to Pearson, with Yates correction when appropriate. Two-tailed tests were used throughout (12).

RESULTS

Feasibility, compliance and safety

On average the patients started physical training 6–8 weeks after MI. The maximum heart rate during training was higher in the study group and paralleled the higher maximum heart rate during exercise testing. However, the high-risk patients succeeded as well as the other participants in reaching the preset heart rate during cycling, jogging and supine exercise (actual heart rate: 92.0–98.3% of the preset heart rate).

In the study group 67.7% started physical training compared with 68.8% among the remaining patients and 78.6% in the low-risk group (NS). These percentages remained constant throughout the training programme. There were no dropouts in the high-risk group during the first year: in period I they attended 94% of all training sessions, in period II 93%. During

Table II. *Acute MI data*

All percentages between brackets. CCU = coronary care unit, ASAT = aspartate aminotransferase, BSA = body surface area, NTG = nitroglycerine

	Group I	Group II	Group III
Anterior infarction	29 (78.4)	109 (47.8)	39 (45.3)
Basal rales/signs of cardiac failure on CCU chest X-ray	37	40 (17.7)	0
Arrhythmia	6 (16.2)	31 (13.6)	5 (5.8)
ASAT, mean level, μkat/l	6.6	2.9	1.6
Heart size, ml BSA	543	505	473
Medication at discharge			
Digitalis	29 (78.4)	75 (32.9)	12 (13.9)
Betablockers	8 (21.6)	80 (35.1)	34 (39.5)
Diuretics	37	81 (35.5)	0
Long acting NTG	2 (5.4)	12 (5.3)	6 (7.0)
Sedatives	2 (5.4)	11 (4.8)	5 (5.8)

the second year there was a lower rate of attendance: 63.0%.

No cardiovascular complications (e.g. symptomatic cardiac overloading or clinically relevant arrhythmias) occurred during the 921 patient training sessions in the high-risk group. No other adverse effects (e.g. orthopedic injuries) were observed.

Mortality and morbidity (Table III)

Compared with the low risk group, the high risk patients had, as expected, a higher rate of cardiac deaths and total cardiac events during the two years after MI ($p<0.05$), mainly due to a higher mortality within the first months after discharge. No patients in the study group underwent coronary bypass surgery. The number of readmissions during the first year post-MI was significantly higher in the study group than in the low-risk group.

Heart size on chest X-ray

The mean heart size on chest X-ray decreased moderately during the first year (543 ml → 516 ml/body surface area), but at one year post-MI the patients in the study group still had a significantly larger volume than the patients in the low-risk group (516 ml vs. 464 ml, $p<0.05$).

Risk factor modification, lipoproteins (Table IV)

There were no statistically significant differences in the numbers of hypertensive patients (defined as blood pressure >160/95 mmHg) between the groups at 4, 8, 12 and 24 months post-MI. The reduction in the number of smokers after MI was equal in the three groups, i.e. 79%, 76% and 79%, respectively (Tables I and VI). After the MI the percentage of smokers remained constant. The total cholesterol levels at 6 weeks post-MI tended to be higher in the study group.

Table III. *Mortality and morbidity*

	Group I	Group II	Group III
Cardiac death/2 yrs	10 (27.0)	29 (12.7)	9 (10.4)*
Non fatal reinfarction	0	17 (7.4)	0
Total cardiac events	10 (27.0)	46 (20.2)	9 (10.4)*
Coronary artery bypass grafting	0	13 (5.7)	7 (8.1)
Number of readmissions/pat. First year post-MI	1.8	1.9	1.5*
Average duration (days) of readmission	12.3	14.3	8.0

Comparison vs. Group I: *$p<0.05$.

Table IV. *Risk factors*

Percentages of the surviving population between brackets

	Group I	Group II	Group III
Smokers			
Pre-MI	17 (45.9)	119 (52.2)	34 (39.5)
12 m	2 (7.1)	28 (13.7)	7 (9.0)
24 m	1 (3.7)	26 (13.5)	6 (8.0)
Hypertensives			
Pre-MI	10 (27.0)	59 (25.9)	13 (15.1)
12 m	2 (7.1)	20 (9.8)	5 (6.4)
24 m	1 (3.7)	17 (8.7)	6 (8.0)
Bloodpressure, mmHg			
12 m	133/82	139/83	138/81
24 m	137/82	141/83	142/81
Mean cholesterol levels, mmol/l	7.2	6.7	6.7

No statistically significant differences between the groups.

Medication (Table V)

At one year post-MI significantly more high-risk patients were on treatment with digitalis and diuretics, and significantly fewer were on betablocking agents. There were no differences in the use of long-acting nitroglycerine or sedatives.

Results of exercise testing (Table VI)

The data from the exercise tests have been calculated as in Table VI. The test at six weeks had a heart rate limit of 130 beats/min (110 for betablockade). The tests at 4 and 12 months were symptom-limited. Therefore only the results of the second and third tests could be compared, both within and between the groups. No hazardous arrhythmias (ventricular tachycardia or fibrillation, AV block grade III) occurred during exercise testing.

The 140 participants in physical training in group II who survived the first year after MI showed significant increases in maximal workload, maximal heart rate, peak systolic blood pressure and double product between the exercise tests at 4 and 12 months. We found similar tendencies in the study group and in the low-risk group. As might be expected, the patients in the study group showed higher maximal heart rates, lower peak systolic blood pressure and a tendency to a lower maximal work load. Even a larger ST-segment depression was observed, but the large amount of patients on treatment with digitalis must be taken into account.

Return to work (Table VII)

At 4 months post-MI a lower percentage in the study group had returned to active employment compared with the low-risk group: 22.6% vs. 50.0%, $p<0.01$. This difference disappeared after 8 months. Indeed, after two years the percentage return to work was slightly higher in group I (63%) than in group II (48.2%) or group III (58.7%).

Table V. *Medication one year post MI*

Percentages of the surviving population between brackets

	Group I	Group II	Group III
Digitalis	21 (75.0)	73 (35.6)***	10 (12.8)***
Betablockers	11 (39.3)	128 (62.4)*	57 (73.1)**
Diuretics	25 (89.3)	76 (37.1)***	9 (11.5)***
Long-acting NTG	1 (3.7)	15 (7.3)	6 (7.7)
Sedatives	4 (14.3)	22 (10.7)	8 (10.3)

Comparison vs. Group I: *$p<0.05$, **$p<0.01$, ***$p<0.001$.

Table VI. *Results of exercise testing*

Double product: Max heart rate × peak syst. blood pressure/10^3

	Group I	Group II		Group III
Max workload (Watt)				
6 weeks	89.0	99.6		105.5
4 months	126.1	132.8	$p<0.05$	139.7*
12 months	132.5	140.7		144.3
Max heart rate				
6 weeks	129.7	118.0		117.0
4 months	136.4	120.9***	$p<0.05$	122.2***
12 months	139.1	126.5**		125.8**
Peak systolic bloodpressure				
6 weeks	158.3	166.1		174.0
4 months	160.0	171.2	$p<0.05$	179.8*
12 months	167.1	178.0		184.5**
Double product				
6 weeks	20.3	19.6		20.4
4 months	21.8	20.8	$p<0.01$	22.0
12 months	23.1	22.6		23.3
Max. ST-segment depression, mm				
6 weeks	0.9	0.7		0.7
4 months	1.6	0.9**		0.9*
12 months	1.5	1.0		1.1

Comparison vs. Group I: *$p<0.05$, **$p<0.01$, ***$p<0.001$.

DISCUSSION

The decision to exclude high-risk MI patients from physical training may have serious psychological consequences. Therefore the physician has to face the dilemma: Are the risks of physical training (i.e. cardiac overloading and arrhythmia) outweighed by the physiological and psychological benefits of cardiac rehabilitation?

A combination of clinical parameters indicating severe myocardial damage was used in order to define the study group of high-risk patients. When the programme started in 1977 no echocardiographic equipment was available, thus measurements of left ventricular size and function have not been used in this study. A beneficial effect of physical training in patients with severe left ventricular dysfunction has been reported in recent studies (7–9, 13–17). In these studies the increase in physical work capacity was entirely due to peripheral adaptation. It was not correlated with the resting left ventricular ejection fraction (LVEF). These reports were based upon referred patient groups with varying delays between discharge from hospital and the start of the training programme. Our study, on the other hand, represents a non-selected MI population starting physical training 6–8 weeks after MI. However, in spite of these differences we found a similar beneficial effect of exercise training of work capacity during exercise testing.

Squire et al. (7) reported a 56% return-to-work rate in a group of 20 referred MI patients with severe left ventricular dysfunction participating in physical training. In our study 63% had returned to work at 2 years, slightly better than the percentage in group II and group III, a remarkable finding. Due to the sample size no extended analysis of this finding has been performed, but there were no differences in blue and white collar jobs between the groups. The feasibility and safety of outpatient group training reported in previous studies could be confirmed, as no adverse effects occurred.

Table VII. *Return to work*

Percentages of the surviving population between brackets

	Group I	Group II	Group III
4 months	7 (22.6)	82 (36.6)	42 (50.0)**
8 months	14 (46.7)	99 (46.0)	47 (57.3)
12 months	16 (57.1)	98 (47.8)	45 (57.7)
24 months	17 (63.0)	93 (48.2)	44 (58.7)

** Comparison vs. Group I, $p<0.01$.

In conclusion, we suggest that a considerable number of high-risk MI patients, with clinical signs of serious myocardial involvement and left ventricular dysfunction, can participate in and benefit from cardiac rehabilitation, if the necessary medical supervision is available and all the safety precautions have been taken.

Contrary to the earlier general opinion these patients might have the relatively greatest benefit from a cardiac rehabilitation programme, especially regarding return to work. Thus they should be given priority in a hospital based programme.

Even if no improvement in resting LVEF can be expected, the peripheral adaptation may lead to an increase in physical work capacity comparable with that seen in other MI patients. Participation may also contribute to successful vocational rehabilitation, thus improving the quality of life of these patients.

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