European Heart Journal (1987) **8** *(Supplement G)*, 33–38

Value of predischarge data for the prediction of exercise capacity after cardiac rehabilitation in patients with recent myocardial infarction

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KEY WORDS: cardiac rehabilitation, myocardial infarction, exercise training.

The aim of this study was to assess whether data related to predischarge clinical examinations, resting radionuclide ventriculography and symptom-limited bicycle ergometry can predict the achievement of a normal exercise capacity after a rehabilitation program in patients with a recent myocardial infarction. The study population consists of 141 consecutive patients who completed a 3-month training program. Patients with heart failure and/or severe angina were excluded. The rehabilitation program included two training sessions weekly during the 3 months. Working capacity (WC) increased from 79 ± 17% at hospital discharge to 105 ± 21% of normal values after rehabilitation (P < 0·001), by 33% on average. Ninety-five patients achieved a normal WC. Conventional predischarge clinical evaluation, resting left ventricular ejection fraction, exercise induced angina, or ST segment depression were not predictive of normal WC after rehabilitation. Predischarge WC was the single best predictor of a normal WC after rehabilitation compared to those with a persistently low WC (84 ± 15% in patients with normal WC vs 69 ± 14% in those with persistently low WC, P < 0·001). Nevertheless, 49% of patients with a baseline WC of less than 80% achieved a normal WC after rehabilitation. No correlation was found between the change of WC after rehabilitation and predischarge WC or ejection fraction. Therefore, the selection of patients for cardiac rehabilitation after a myocardial infarction should be based primarily on clinical grounds. Exclusion based on exercise induced angina, ST segment depression or low resting ejection fraction at hospital discharge or at entry in the rehabilitation program is not justified.

Introduction

The aim of rehabilitation after myocardial infarction is to improve the quality of life with respect to physical, psychological and social sequelae of the cardiac event[1]. Although there is uncertainty about the overall beneficial effect of rehabilitation in the long term[2,3], there is little doubt that exercise training improves functional capacity in most patients[4]. Nevertheless, it would be highly desirable to be able to predict which patients would benefit most from cardiac rehabilitation programs in order to develop an efficient referral policy, as has recently been underscored by Hammond *et al.*[5]. Accordingly in this study we addressed the following questions. (1) What is the extent of improvement of working capacity after cardiac rehabilitation in patients with recent myocardial infarction? (2) Are clinical descriptors, resting radionuclide ventriculography and symptom-limited bicycle ergometry at hospital discharge able to predict the achievement of a normal exercise capacity after the cardiac rehabilitation program?

Methods

From March 1981 to December 1983, 706 patients were admitted at the coronary care unit of the Thoraxcenter with the diagnosis of acute myocardial infarction. Of these patients, 104 died during their hospital stay. Of the 602 hospital survivors, symptom-limited bicycle ergometry was performed at discharge in 407 patients, on average 2 weeks after the infarction. As previously described[5], stress test was performed with stepwise increments of 10 W min^{-1}, with continuous monitoring of three Frank ECG leads. Cuff blood pressure was

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0195–668X/87/08G033 + 06 $02.00/0

obtained at 2-minute intervals during exercise and in the recovery phase. Clinically prescribed medication, which included beta-blockers in 52% of the patients and digitalis in 16%, was not discontinued before the test.

One hundred seventy-one of these patients who underwent predischarge bicycle ergometry were referred for cardiac rehabilitation. Inclusion criteria were the absence of persistent symptoms or signs of heart failure or angina resistant to medical treatment, and other obvious non-cardiac limitations, such as intermittent claudication and chronic obstructive lung disease. Psychological inclusion criteria which included anxiety reaction, diminished self esteem and a positive motivation were also taken into acount[2].

Besides bicycle ergometry, a resting radionuclide ventriculography was performed at hospital discharge in 158 patients of the study group[6,7]. Some baseline characteristics of patients who were referred for cardiac rehabilitation are reported in Table 1 and are compared to those of 236 patients eligible for predischarge stress testing but who were not referred for cardiac rehabilitation.

EXERCISE TRAINING

The Rotterdam rehabilitation program is performed on an outpatient basis organized in a similar way to the CAPRI program in Seattle[8]. As previously described[3,9], two training sessions take place weekly in large sport centres. Each session lasts 90 minutes and consists of a warming-up period (10–15 minutes), jogging (10–15 minutes at a target heartrate of 60–70% of the maximal heart rate of baseline stress test), calisthenics (10–15 minutes), sports such as volleyball, soccer, badminton, hockey or basketball (30 minutes) and relaxation exercises (10–15 minutes). Jogging and calisthenics are graded in 10 levels of intensity and prescribed on the basis of the baseline stress testing and later on the progress during the program. During training there is no telemetric control of heart rate. At the end of different phases of the program, the participants record and note their own heart rate.

Table 1 Baseline characteristics of patients who underwent a predischarge exercise test and were referred or not referred for cardiac rehabilitation

	Referred for rehabilitation	Not referred for rehabilitation	*P* value
Number	171	236	—
Clinical data			
age (years)	51 ± 10	57 ± 5	0·005
males (%)	90	79	0·01
previous MI (%)	20	29	0·05
anterior MI (%)	41	32	0·02
late heart failure (%)	11	14	NS
post MI angina (%)	19	20	NS
late VT/VF (%)	2	4	NS
Radionuclide angiography			
LV ejection fraction (%)	47 ± 14 ($n = 158$)	47 ± 25 ($n = 224$)	NS
Bicycle ergometry			
Working cap. (%)	78 ± 17	78 ± 17	NS
angina (%)	15	24	0·02
max. heart rate (bpm)	135 ± 24	127 ± 21	0·001
max. SBP (mmHg)	162 ± 29	161 ± 28	NS
ST segment depr. (%)*	45	49	NS
ventric. arrhythmias (%)	18	26	0·05

Abbreviations: MI = myocardial infarction, VT = sustained ventricular tachycardia, VF = ventricular fibrillation, SBP = systolic blood pressure.
Data are expressed by mean ± standard deviation, unless otherwise specified.
*Horizontal or downsloping, ⩾ 1 mm.

During the training a physician, a nurse, two physiotherapists and a social worker are present to supervise 30 to 40 patients. Facilities for cardiopulmonary resuscitation are available. Rehabilitation starts on average one month after hospital discharge and the average period of training is 3 months. At the end of the 3-month period a symptom limited exercise test is performed with stepwise workload increments of 20 Watt min^{-1}.

Statistical analysis was performed with Student's *t*-test, chi square test, Fisher's exact test, and linear regression analysis, when appropriate.

Table 2 Results of bicycle ergometry at discharge and after cardiac rehabilitation in 141 patients

	Predischarge	After rehabilitation	*P* value
max. workload (W)	122 ± 30	165 ± 41	0·001
work capacity (%)	79 ± 17	105 ± 21	0·001
rest HR (bpm)	82 ± 15	72 ± 13	0·03
peak HR (bpm)	136 ± 24	141 ± 23	NS
rest SBP (mmHg)	119 ± 15	133 ± 17	0·05
peak SBP (mmHg)	163 ± 28	175 ± 27	0·05
angina (*n*)	22	21	NS

Abbreviations: HR = heart rate, SBP = systolic blood pressure.

Results

Of the 171 patients referred for cardiac rehabilitation, 141 patients completed the program. Results of exercise testing are reported in Table 2. Percent working capacity increased on average by 33% after rehabilitation while resting heart rate decreased by 12%, from 82 to 72 bpm. The number of patients on beta-blockers (76) was unchanged during the two tests.

At the end of the rehabilitation program patients were divided into two groups, 95 patients who had a normal working capacity (mean 117%, range 100–160%) and 46 patients with a reduced working

Table 3 Prediction of a normal working capacity after rehabilitation from predischarge data

	Normal working capacity	Low working capacity	*P* value
Number	95	46	—
Clinical data			
age (years)	53 ± 9	48 ± 9	0·005
males (%)	88	93	NS
previous MI (%)	16	26	NS
anterior MI (%)	37	50	NS
late heart failure (%)	7	10	NS
post MI angina (%)	16	23	NS
late VT/VF (%)	1	4	NS
CTR > 50% (%)	16	15	NS
Radionuclide ventriculography			
LV ejection fraction (%)	50 ± 13 (*n* = 86)	46 ± 15 (*n* = 43)	NS
Bicycle ergometry			
work capacity (%)	84 ± 15	69 ± 14	0·0005
peak HR (bpm)	136 ± 24	135 ± 24	NS
peak SBP (mmHg)	167 ± 29	156 ± 23	0·02
angina (%)	15	17	NS
ST depression (%)	45	41	NS
ST elevation (%)	50	50	NS
ventr. arrhythmias (%)	17	15	NS

Abbreviations: CTR = cardiothoracic ratio from predischarge chest X-ray, HR = heart rate. For the other abbreviations see table 1.

capacity (mean 83%, range 30–90%), expressed as percentage of that of normal subjects with comparable sex, age and height.

The baseline data at hospital discharge of those patients with a normal working capacity after rehabilitation and those with a reduced working capacity are reported in Table 3. Of the clinical data, only age was significantly higher in patients with poor working capacity, while the other clinical variables were not associated with working capacity. Left ventricular ejection fraction, although slightly lower in patients with low working capacity, was not significantly different in the two groups. There was also no correlation between the extent of increase in working capacity and baseline ejection fraction (Fig. 1).

Of the data obtained from bicycle ergometry, working capacity at the entry of the rehabilitation program was the best predictor of a normal working capacity after rehabilitation, as it was 18% lower in patients who had a low working capacity after rehabilitation. As with ejection fraction, the increment in working capacity was not correlated to baseline working capacity (Fig. 2).

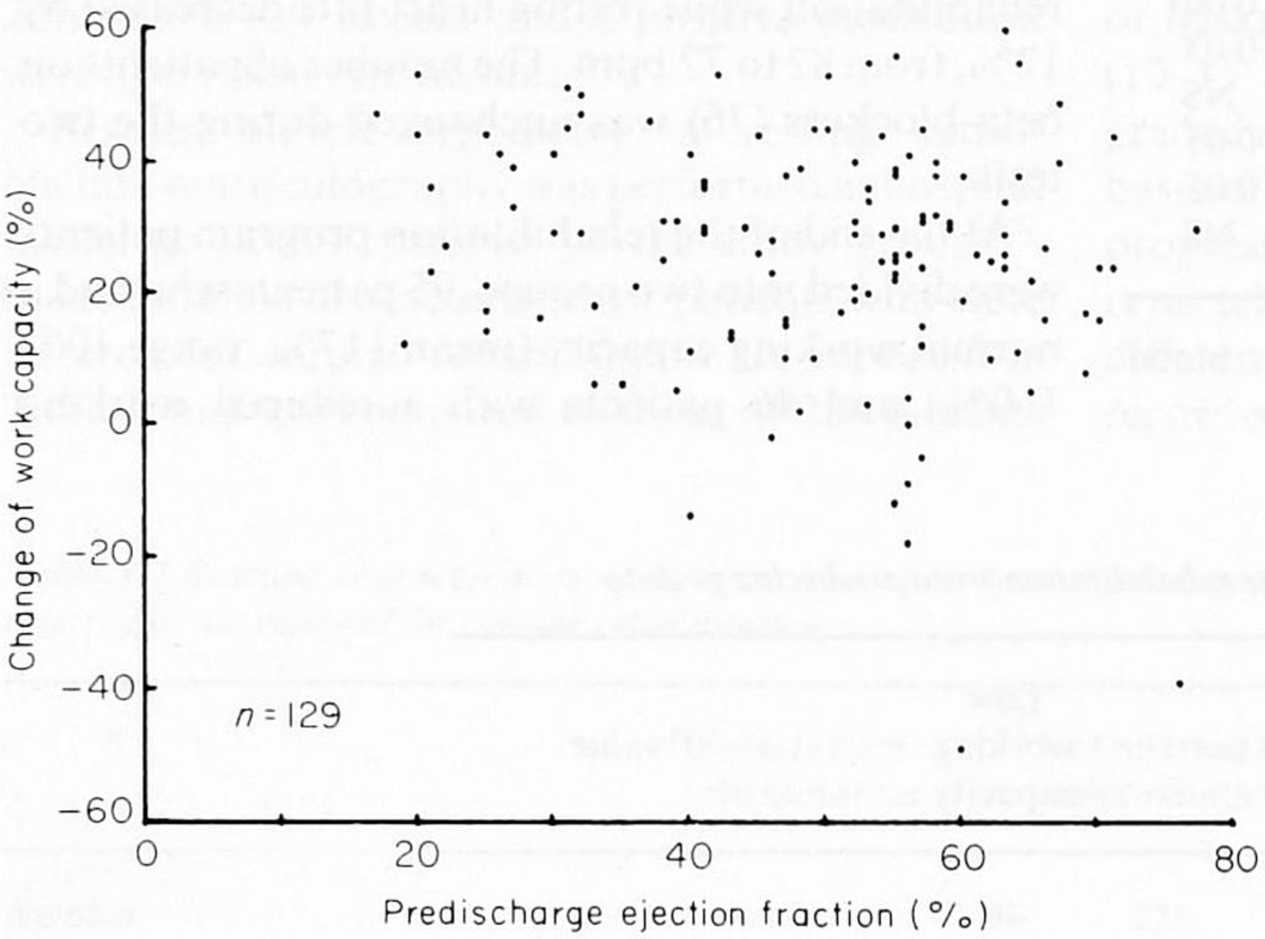

Figure 1 Scattegram of the change of working capacity after rehabilitation versus baseline left ventricular ejection fraction. There is no correlation between the two variables.

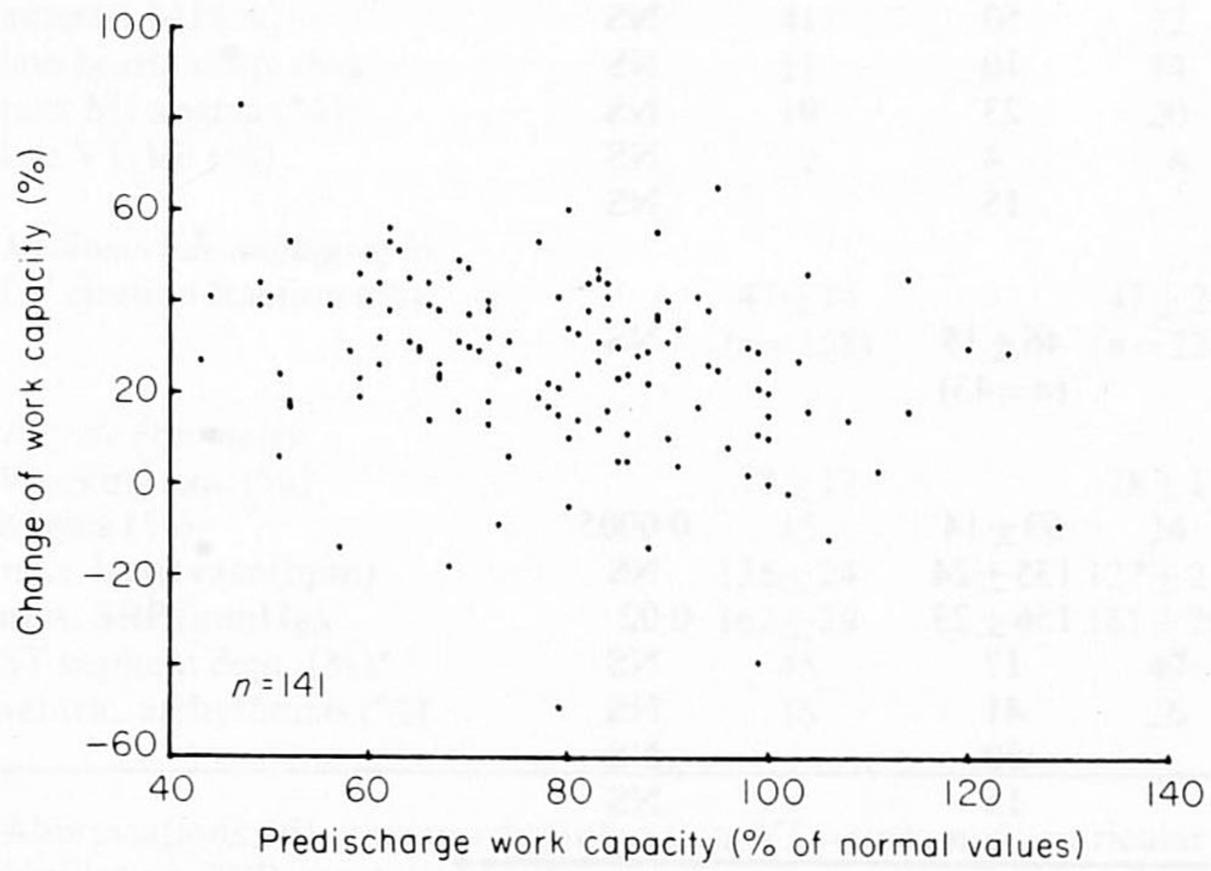

Figure 2 There is no correlation between the change of working capacity after rehabilitation and baseline working capacity.

Discussion

One of the aims of cardiac rehabilitation is to improve functional capacity. In the present study, based on 141 consecutive postinfarction patients who completed a 3-month exercise training program, working capacity increased by 33% on average. At the end of the training program, 67% of patients had a normal working capacity. Baseline clinical data (with the exception of age) as well as radionuclide left ventricular ejection fraction at rest were not predictive of working capacity after rehabilitation (Table 3). Of the baseline exercise stress test results the best predictor was an adequate working capacity (Fig. 3).

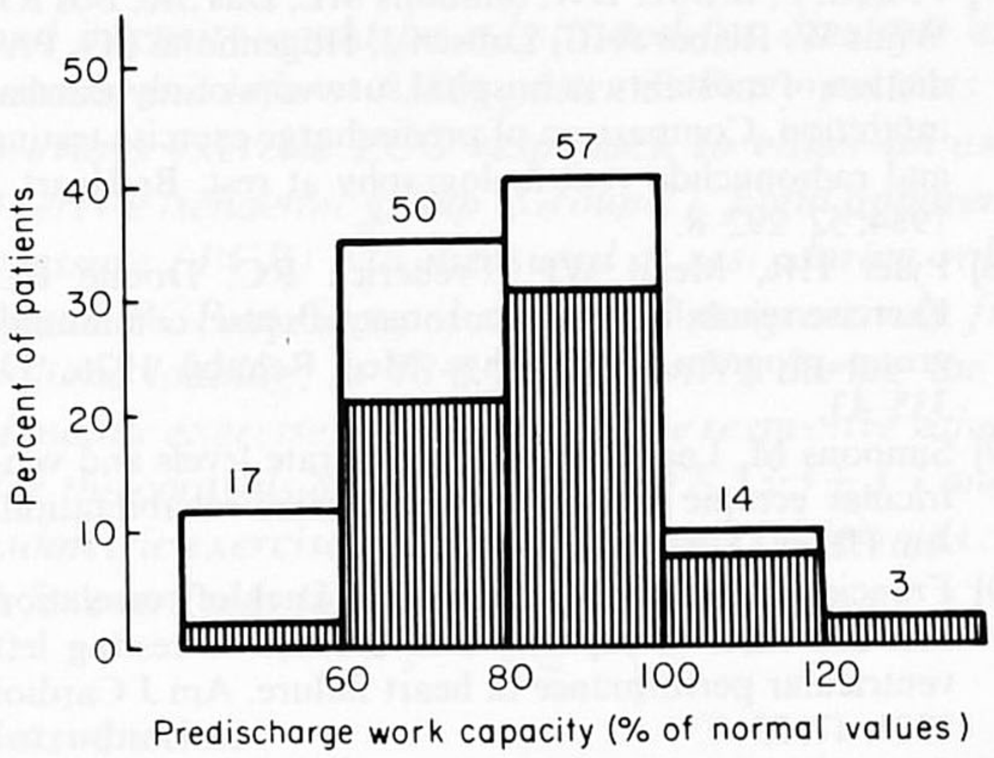

Figure 3 Frequency distribution of baseline working capacity (WC) in patients with normal (▥, $n=95$) and low (□, $n=46$) WC after rehabilitation. The majority of patients with a baseline WC greater than 80%, but also 49% of patients with a lower baseline WC, had a normal WC after rehabilitation.

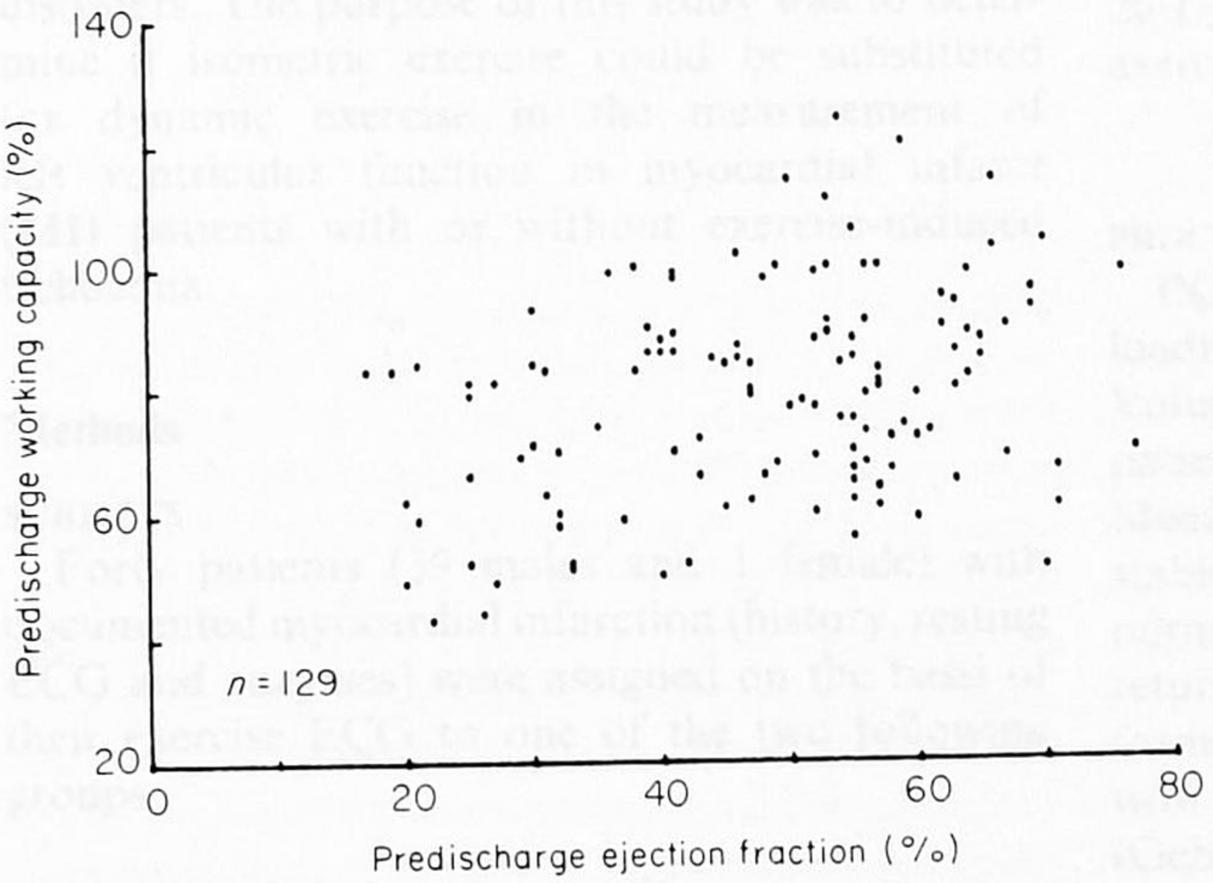

Figure 4 The scattegram of predischarge working capacity versus left ventricular ejection fraction shows a large dispersion of data.

Several factors have to be taken into account to explain these results. Firstly, although a substantial percentage of the patients referred for cardiac rehabilitation had signs or symptoms of heart failure and/or angina in the late hospital phase (Table 1), patients with the most severe symptoms were excluded. Secondly, it is known from previous studies that there is a poor correlation between exercise capacity and indices of resting left ventricular performance[10]. Thirdly, a remarkable improvement of exercise tolerance has also been reported after physical conditioning in patients with severely depressed left ventricular function[11]. In the present study we confirmed all these findings, since we found a lack of correlation between baseline ejection function and working capacity (Fig. 4) and we did not observe any relationship between the improvement of working capacity and baseline ejection fraction (Fig. 1). In other words a similar improvement of functional capacity was found in patient with poor or normal ejection fraction.

In contrast to previous static measurements, dynamic measurements, and particularly baseline working capacity provide useful information about functional capacity after rehabilitation, although the gain of functional capacity was similar in patients with low or high baseline working capacity (Fig. 2). Most patients with borderline decreased baseline functional capacity achieved a normal functional capacity after rehabilitation. However, a substantial fraction of patients with a definite

limitation of working capacity, also normalized after training. (Fig. 3).

In summary, working capacity after rehabilitation increased by 33% on average compared to predischarge values in postinfarction patients without angina and/or symptomatic heart failure. Predischarge rest radionuclide ejection fraction and exercise induced angina and/or ST segment depression are not useful for predicting a normal exercise capacity after rehabilitation. Working capacity has some predictive value. A low predischarge maximal working capacity, however, does not preclude a normal maximal working capacity after rehabilitation in about 50% of the patients. Therefore, the selection of patients for cardiac rehabilitation after myocardial infarction should be based primarily on clinical grounds. Exclusion based on predischarge exercise induced angina, ST segment depression or resting ejection fraction is not justified.

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