

## Review Article

# Cardiac rehabilitation

H. Gohlke\* and C. Gohlke-Bärwolf†

\*Rehabilitationsklinik Sinnighofen, Bad Krozingen; †Herz-Zentrum, Bad Krozingen, Germany

## Introduction

The definition of cardiac rehabilitation whether it be by the WHO or the European Society of Cardiology is very complex and includes not only the field of cardiology but also psychological and social interventions (Fig. 1). However, the practice of cardiac rehabilitation in Europe differs greatly from country to country. Cardiac rehabilitation in phase II varies from residential rehabilitation which includes cardiological management, stress management, exercise training, dietary instructions and intense risk factor modification as practiced in Germany, Austria and partially Switzerland and France in structured outpatient rehabilitation programmes with daily sessions, to once-a-week exercise training programmes without risk factor intervention in countries with less well-developed systems.

Therefore, cardiac rehabilitation, as practiced in European countries, is difficult to define and to evaluate. Different components of cardiac rehabilitation, however, can be evaluated with respect to their effects on cardiac events or survival. Risk-factor intervention in patients with cardiac disease is of great importance because the event rate in patients with established coronary disease is five to seven times the event rate of patients with similar risk factors but with no evidence of cardiac disease<sup>[1]</sup>.

The following components of a multifactorial rehabilitation programme will be addressed:

1. Smoking cessation
2. Dietary modification
3. Cholesterol lowering
4. Individualized physical exercise training programmes

5. Stress-modification and relaxation
6. Vocational rehabilitation
7. Costs

## Smoking cessation

Smoking cessation is the single most effective measure in smokers with coronary disease. It reduces angiographic progression of pre-existing and new lesions<sup>[2,3]</sup>. Cardiac event rates are reduced by at least 50% in patients after angiography, myocardial infarction, bypass surgery or after PTCA. The improvement in survival after smoking cessation is comparable to that achieved by bypass surgery<sup>[4–6]</sup>. Activation of the clotting system is probably of major importance: smokers suffering sudden death were more likely than non-smokers to have acute thrombosis without plaque rupture in the coronary system<sup>[7]</sup>. Smoking-induced activation of platelets cannot be inhibited by acetylsalicylic acid<sup>[8]</sup>.

Individual counselling and support of the patient by the physician is the most successful approach. Sessions in a series, group therapy, behaviour modification techniques, advice pamphlets and nicotine replacement therapy are of additional help in achieving abstinence<sup>[9]</sup>. These components can also be applied successfully during a cardiac rehabilitation programme<sup>[10]</sup>.

## Dietary modification

Dietary counselling and modification of dietary habits have an important role in cardiac rehabilitation and

The sum of interventions required to ensure the best possible physical, psychological and social conditions so that patients with chronic or post acute cardiac disease may, by their own efforts, preserve or resume their proper place in society.

Submitted for publication 3 February 1998, and accepted 4 February 1998.

**Key Words:** Cardiac rehabilitation, smoking cessation, diet in coronary disease, cholesterol lowering, exercise training, stress management, vocational rehabilitation, cost efficiency.

*Correspondence:* Prof. Dr Helmut Gohlke, FESC, FACC, Rehabilitationsklinik Sinnighofen, Herbert-Hellmann-Allee 44, D-79189 Bad Krozingen, Germany.

**Figure 1** Definition of cardiac rehabilitation by the Task Force of the Working Group on Cardiac Rehabilitation of the European Society of Cardiology<sup>[120]</sup>.

secondary prevention. Populations with a diet low in saturated fat and cholesterol but high in fibre and fish consumption have a low cardiovascular event rate. Diets high in saturated fat not only increase serum cholesterol but also increase the activity of clotting factor VII which correlates with cardiovascular event rates<sup>[11–18]</sup>. The percentage of saturated fat in the diet, particularly the long chain saturated fatty acids (18:0) and trans fatty acids (t-18:1) palmitinic-, stearinic-, palitoleinic- and elaidinic acid, correlate with progression of coronary atherosclerosis<sup>[19–21]</sup> and angiographic progression of coronary disease, independent of cholesterol levels<sup>[22]</sup>.

In the Heidelberg Study — a study of diet plus exercise — the lowest levels of LDL-cholesterol in combination with physical activity were associated with regression<sup>[23]</sup>. Low LDL-levels are also associated with low levels of haemostatic risk factors<sup>[24]</sup>. Fruit and vegetables have a favourable effect on coronary risk, possibly mediated by fibres, unsaturated fatty acids and antioxidants<sup>[25,26]</sup>.

These epidemiological relationships and angiographic results have been applied in secondary prevention trials. Total mortality can be reduced by a diet low in fat and calories, but high in carbohydrates, fruit and vegetables<sup>[27,28]</sup>.

A diet with a high composition of bread, fruit, green vegetables and canola-based margarine, instead of butter, cream and red meat can lead to a more than 50% reduction in cardiovascular deaths and non-fatal myocardial infarction, compared to the usual diet, possibly as a result of the higher dietary content of alpha linolenic acid, which is transformed in the body into omega-3-fatty acid<sup>[29,30]</sup>. Omega-3-fatty acids may, in addition to antithrombotic activity, also have anti-arrhythmic properties<sup>[31]</sup>. A reduction in sudden death was seen during the DART Study<sup>[27]</sup> which encouraged the consumption of fish.

It is not yet firmly established which nutrients or substances convey beneficial dietary effects. Replacing saturated fats by unsaturated fats, and trans-unsaturated fat by unhydrogenated, unsaturated fats probably has a substantial influence on cardiac events<sup>[18,32]</sup>. Therefore, a modification in the diet with an emphasis on a low proportion of saturated animal fat, avoidance of trans-unsaturated fats, an adequate supply of mono- and polyunsaturated fats, with a moderate amount of low fat dairy products, at least two fish meals per week, a high fibre content and plenty of fruit and vegetables is desirable for all patients with coronary disease, independent of the cholesterol level reached. This type of diet also has favourable effects on hypertension, bone loss, hip fractures and is also likely to decrease the risk of cancer<sup>[18,33,34]</sup>.

## Cholesterol lowering

Cholesterol levels are of considerable importance for clinical event rate and angiographic progression<sup>[35–38]</sup>.

Lowering of LDL-cholesterol not only decreases coronary events by 30–40% and slows progression of angiographically defined coronary disease<sup>[39–42]</sup> but also decreases total mortality up to 34% in patients with coronary disease. The difference in event rates and survival increases up to 6 years after initiation of treatment; thus a further benefit can be assumed to occur beyond 6 years. Treatment leads to a 2% reduction in the annual event rate, i.e. 50 patients need to be treated for one year to prevent one cardiovascular event and 154 patients need to be treated to prevent one death<sup>[35]</sup>. Cholesterol lowering is also important for coronary patients with average cholesterol levels<sup>[37]</sup>.

Aggressive lipid lowering after bypass surgery with target LDL levels below 95 mg . dl<sup>-1</sup> slowed bypass graft disease progression and prevented graft occlusion more effectively than moderate lowering with target levels of <135 mg . dl<sup>-1</sup><sup>[38]</sup>. Lipid lowering resulting in stabilization of atherosclerotic plaques, a decrease in thrombotic tendency and improvement of endothelial function probably contributes to an improved prognosis<sup>[43–47]</sup>. In addition, functional improvement of the coronary artery system, with an increase in dilatory capacity and a decrease in arteriolar resistance can be expected in virtually all patients with increased or average cholesterol levels. This effect takes place within weeks of cholesterol lowering<sup>[48–50]</sup>. In patients with exercise-induced ischaemia, lipid lowering can decrease the extent of exercise-induced ischaemia within 3 months. This effect was reversible after discontinuation of lipid lowering treatment<sup>[51]</sup>.

Pharmacological treatment, in combination with dietary modification, has prognostic effects similar to bypass surgery and should be used in all patients with coronary artery disease and hypercholesterolaemia, unless contraindications are present. The treatment is particularly beneficial in patients above 60 years, in women and in patients with an ejection fraction of 25–40%<sup>[37]</sup>. LDL-cholesterol should be lowered to 100 mg . dl<sup>-1</sup> (2.5 mmol . l<sup>-1</sup>) or less, or should be lowered at least 30–40% after a phase of dietary modification<sup>[52,53]</sup>. The treatment is cost effective for patients with established coronary disease. The costs for a life year saved varies from \$4200 to \$27 000 depending on the total risk. \$27 000 are well within or below the range accepted for other commonly used treatment modalities, e.g. treatment of hypertension<sup>[54,55]</sup>.

However, acceptance of pharmacological treatment for elevated LDL-cholesterol is low. In the EuroAspire study, less than 50% of patients received appropriate lipid lowering therapy after a cardiac event<sup>[56,57]</sup>. Under non-study conditions, this percentage is probably even lower. A cardiac rehabilitation programme should educate the patient about the importance of lipid lowering to avoid progression of disease, as regards prognosis and the possibility of functional improvement, as well as possible side effects and interactions with other medications. Because lipid lowering is a long-term therapy, a therapeutic regimen without biochemical or symptomatic side effects should be

established. Usually the treatment goal of  $100 \text{ mg} \cdot \text{dl}^{-1}$  ( $2.5 \text{ mmol} \cdot \text{l}^{-1}$ ) can only be reached by a combination of dietary modification and pharmacological therapy.

### Individualized physical exercise training programmes

Regular physical activity and better exercise performance are associated with better long-term survival in persons without heart disease<sup>[58–63]</sup>. In patients with documented coronary artery disease<sup>[64–66]</sup>, an increase in physical activity level and an improvement in cardiorespiratory fitness are associated with better survival<sup>[64–68]</sup>.

Supervised endurance training is an important component of a multifactorial rehabilitation programme. Endurance training in patients with and without previous infarction leads to both improved exercise capacity and to several factors associated with prognosis<sup>[69,70]</sup>. These are improved peripheral adaptation, improved angina or dyspnoea threshold, and lower heart rate–blood pressure product at comparable workloads. Lower catecholamine levels during daily work leads to a higher fibrillation threshold and a lower risk for sudden cardiac death<sup>[71–73]</sup>. Other improvements are an increase in protective HDL-cholesterol and a decrease in LDL-cholesterol and triglycerides. The carbohydrate metabolism is improved, fibrinolytic activity is increased and whole blood viscosity is reduced. The anorectic effect of physical activity, in combination with increased caloric expenditure, help to reduce overweight. In addition regular physical activity has an antidepressive effect<sup>[69,74–77]</sup>.

Endurance exercise, using more than 2000 Kcal per week, may lead to angiographic regression of coronary disease. However, overzealous activity should be avoided<sup>[78]</sup>. There are some potential dangers in physical exercise: increased catecholamine levels during exercise may favour ischaemia in the border zone of myocardial infarction. The risk of severe arrhythmias or sudden death is increased severalfold during exercise, particularly in patients with severe left ventricular dysfunction or marked ECG abnormalities<sup>[79]</sup>. Exercise training of moderate intensity in combination with a multifactorial rehabilitation programme will lead to improved exercise performance and a reduction of cardiovascular events<sup>[70,80–83]</sup>.

In patients with compensated heart failure, with severely impaired left ventricular function, exercise training has a beneficial effect on functional capacity, resulting in delayed onset of anaerobic metabolism<sup>[84]</sup>. Endothelial function may improve in patients with chronic heart failure<sup>[85]</sup> and oxidative enzyme activity in the working skeletal muscle is enhanced<sup>[86]</sup>. Cardiac output and left ventricular ejection fraction remain unchanged<sup>[85,87–90]</sup>.

In a retrospective analysis there was a suggestion that prognosis is improved by a 4-week exercise programme in patients with a low ejection fraction<sup>[91]</sup>. The

potentially protective effects of physical activity are associated with a favourable modulation of the autonomic nervous systems<sup>[92]</sup>. However, improved exercise performance is only maintained as long as training is kept up. The functional improvement of a short-term training programme is lost after a period of inactivity of 3 weeks<sup>[93]</sup>.

### Survival

The main purpose of exercise training is to improve exercise performance and quality of life. However, the improvement of multiple factors associated with a favourable prognosis suggests that a decrease in mortality is a possibility.

Single studies were not of adequate size to allow evaluation of the effect of exercise training on survival, but two meta-analyses of randomized studies suggest that participation in a rehabilitation programme, with emphasis on exercise training, may reduce mortality by approximately 25% at 3-year follow-up compared to control patients<sup>[94,95]</sup>. However, this cannot be solely attributed to exercise training because in several studies exercise was only one component of a multifactorial rehabilitation programme. The beneficial mortality outcome was greater in the 15 trials that used multifactorial cardiac rehabilitation (odds ratio 0.74) compared with the seven trials that used exercise training as the sole intervention (odds ratio 0.85)<sup>[94]</sup>.

### Stress-modification and relaxation

There is increasing data linking acute emotional stress to myocardial infarction and sudden death<sup>[96–98]</sup>. The individual stress-associated mechanisms leading to an increased risk for coronary disease are not entirely clear, but the autonomic nervous system probably plays a major role: heart rate, blood pressure, arrhythmias, clotting factors, platelet aggregation, cholesterol levels, coronary tone and catecholamine levels are modulated by stress via the autonomic nervous system<sup>[99]</sup>. Comprehensive rehabilitation programmes include psychosocial sessions, teaching of relaxation techniques and psychosocial counselling for the individual patient and his/her spouse or partner. Quality of life and depression can be improved by these interventions even in patients suffering minor distress<sup>[100–102]</sup>. In addition to improvements in well being, anxiety, depression and performance of daily activities, biological risk factors such as heart rate, blood pressure, cholesterol levels and possibly platelet activation are affected<sup>[103,104]</sup>; in a meta-analysis of randomized studies, psychosocial interventions could be shown to influence favourably mortality and reinfarction rate for 2 years when added to a cardiac rehabilitation programme<sup>[105]</sup>. Despite the apparent overall benefit from psychosocial interventions there is at present no clear explanation about how they work.

Emotional support, establishment of hope and a sense of control of the disease probably contribute to the improved outcome<sup>[106,107]</sup>. Recognition and treatment of clinical depression appear particularly important because of their impact on prognosis<sup>[108–110]</sup>.

## Vocational rehabilitation

The impact of cardiac rehabilitation on vocational rehabilitation is difficult to evaluate and is highly variable from country to country. In Germany, cardiac rehabilitation is mandatory after myocardial infarction for all employed persons and paid for by retirement funds. Therefore, control groups for comparison are difficult to establish. Aside from functional factors, the social system with the expected social benefits after early retirement play an important role. A comparative study in Sweden saw a significant advantage in return to work rate for patients participating in a rehabilitation programme<sup>[111]</sup>. A population-based, longitudinal study identified participation in a rehabilitation programme as an independent factor favouring return to work<sup>[112]</sup>.

As better functional exercise capacity is not only related to prognosis but also to the return to work rate<sup>[113–115]</sup>, it remains unclear whether the improved return to work rate after cardiac rehabilitation is the result of improved well-being and physical conditioning or the result of specific vocational counselling.

## Costs

There are few studies available on the cost-effectiveness of cardiac rehabilitation. Two randomized<sup>[116,117]</sup> and two non-randomized<sup>[118,119]</sup> controlled trials suggest that the use of resources for cardiac rehabilitation per quality adjusted life year is as cost-effective as other forms of accepted treatment. The cost savings by reduced rehospitalization and a higher return to work rate may even outweigh the initial costs of rehabilitation and lead to net savings.

## Summary and conclusion

Cardiac rehabilitation as a multifactorial intervention has been shown to improve functional capacity, emotional well-being, return to work rate and longevity. Cardiac rehabilitation is cost effective, and in many aspects represents causal therapy. The meta-analyses do not include studies where pharmacological lipid lowering was used. The use of generally accepted and recommended medical treatment strategies in the EuroAspire study has been below the expected rate<sup>[56,57]</sup>. Therefore, cardiac rehabilitation programmes should educate the patient and emphasize the need to apply the appropriate medical regimen in addition to the non-pharmacological treatment modalities of cardiac rehabilitation to achieve

maximal benefit. Cardiac rehabilitation has an important role in assuring the application of the available knowledge, to avoid cardiac complications and progression of disease, and improve cardiorespiratory fitness and survival. Cardiac rehabilitation should therefore be an integral part of cardiological management after a cardiac event.

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