JACC Vol. 15, No. 5
April 1990:983–5

Editorial Comment

Predicting Outcome in Cardiac Rehabilitation*

JONATHAN MYERS, MA,
VICTOR F. FROELICHER, MD, FACC
Long Beach, California

Although there is considerable research to support the benefits of regular exercise for patients after myocardial infarction, many of us have been puzzled by the lack of objective training benefits in certain patients (1). Identification of patients who might benefit most from an exercise program or be at risk of harm has several important clinical implications, particularly in relation to disability and reimbursement. Early studies suggested that patients with poor left ventricular function were least likely to benefit from training because of their inability to increase cardiac output; however, recent research has yielded evidence to the contrary (2,3). Concerns have also been raised regarding the dangers of exercise therapy for patients with silent myocardial ischemia (4) and patients with anterior Q wave myocardial infarction (5). However, recent investigations of silent ischemia have allayed exaggerated concerns regarding risk, demonstrating better survival and milder disease in such patients compared with those with angina (6). In fact, patients with silent ischemia may benefit most from training programs, because they can exercise to higher levels than can patients with angina and perhaps can develop better collateralization (7). In addition, radionuclide data from our laboratory (8) and Duke University (3) in patients with congestive heart failure indicate that infarct expansion is an unlikely outcome of exercise training. Previous efforts to quantify training success among heterogeneous patients with coronary artery disease have been largely unsuccessful (9,10).

The current study: quantifying predictors of training success. In this issue of the Journal, van Dixhoorn et al. (11) have quantified predictors of training success with clinical, exercise and psychosocial variables. With use of multivariate techniques, training success or failure was correctly classified 81% and 85% of the time, respectively. The authors were remarkably accurate in predicting success and failure of rehabilitation, perhaps by being the first to include psychosocial data, which contributed significantly to the prediction of training failure, although not to prediction of its benefit.

However, this study appears to raise more questions than it answers: 1) Can "success" be defined on the basis of a single outcome measure? This approach seems inappropriate, because there are many goals of cardiac rehabilitation (12). 2) Because many of the benefits of an exercise program are intangible, is it valid to dichotomize success and failure? Does the absence of benefit as dictated by one measure imply failure of the program? 3) Should dropouts be considered "failures" even if they successfully return to work or activities of daily living? 4) How well are psychosocial data quantified with use of questionnaires? Difficulties in quantifying and reproducing quality of life assessment (13) make validity of the findings of van Dixhoorn et al. (11) debatable. 5) Shouldn't the 35% of patients who fall into a "no change" category be considered successes, because they are not disabled by their myocardial infarction? 6) What characterizes the patients whose condition deteriorates despite a training program? How does the natural course of disease affect attempts to predict outcome? 7) Should outcome measures be forced into dichotomous categories after only 5 weeks of rehabilitation when benefits of rehabilitation may occur later?

Previous studies. Fioretti et al. (10) addressed these issues in 141 consecutive patients who completed 3 months of training after myocardial infarction. Predischarge clinical data, left ventricular ejection fraction at rest and exercise-induced angina or ST segment depression were not predictive of exercise capacity. There was no significant correlation between the change in exercise capacity and initial exercise capacity. Diedericks et al. (14) trained 27 men 3 to 6 months after myocardial infarction. One year after infarction, 11 clinical and psychologic variables were studied by multivariate regression analysis to determine predictors of exercise performance. The two most important determinants of exercise capacity after the year were exercise capacity at 3 months after infarction and the expectation of return to work ($r = 0.76$ and 0.42, respectively). Because changes in exercise capacity over the year were not evaluated, the study of Diedericks et al. (14) does not help to determine "training" success. Like the findings of van Dixhoorn et al. (11), however, it suggests that the addition of psychosocial data may contribute to determining the variance in training success.

Sullivan et al. (3) studied 12 patients with chronic heart failure and reported no relation between changes in maximal oxygen uptake after training and baseline rest or peak

*Editorials published in *Journal of the American College of Cardiology* reflect the views of the authors and do not necessarily represent the views of JACC or the American College of Cardiology.

From the Department of Cardiology, Veterans Affairs Medical Center, Long Beach, California.

Address for reprints: Victor F. Froelicher, MD, Chief, Cardiology (111C), Veterans Affairs Medical Center, 5901 East Seventh Street, Long Beach, California 90822.

0735-1097/90/$3.50

exercise ejection fraction, stroke volume, cardiac output, systemic or leg arteriovenous oxygen difference, oxygen uptake or femoral vein oxygen saturation. Hammond et al. (9) reported that of 60 clinical, exercise and radionuclide variables tested, the best predictor of improvement in exercise performance after 1 year was low initial exercise capacity. The findings of a recent report by Ades et al. (15) contrasted with those of Hammond et al. (9), suggesting that the magnitude of the training effect was markedly reduced in patients with ischemia (angina, ST segment depression, or both, during baseline exercise testing) versus patients with no evidence of ischemia (10% versus 28% improvement in maximal oxygen uptake after training in the ischemic and nonischemic groups, respectively).

Two points from these studies are worth emphasizing. First, it appears to be difficult to predict which patients with heart failure or coronary artery disease may benefit from training. Second, those patients we intuitively think would benefit the most from rehabilitation, that is, those with the poorest initial exercise capacity, did so in the study of Hammond et al. (9), but not in the study of van Dixhoorn et al. (11). Although maximal work capacity as a percent of that predicted for age was nearly a significant predictor of success in the latter group ($p = 0.06$), the absolute value of the initial exercise capacity was not a determinant of training success. Thus, rehabilitation programs that commonly select only the healthiest postmyocardial infarction patients for entry into training may exclude those who might benefit the most (i.e., those with the poorest initial exercise capacity).

The concept that enrollment in cardiac rehabilitation programs could be accomplished with use of clinical or psychosocial factors to predict outcome is provocative. Cardiac rehabilitation is commonly defined as the process by which a patient with cardiovascular disease is restored to optimal physical, medical, physiologic, social, emotional, vocational and economic status (12). Therefore, for each candidate an estimate must be made of the physical demands of his or her expected occupational and recreational activities after recovery. Whether a given patient is capable of meeting the physical demands should be determined on the basis of the results of an exercise test. Because cardiac rehabilitation can be expensive and involves a certain risk, the idea that effort, money and risk could be saved when a low likelihood of benefit is predicted on the basis of initial data is intriguing. However, exercise criteria alone are not sufficient to assess the effectiveness of rehabilitation. A lack of physical benefit should not imply an absence of vocational, social or psychologic benefit. If the likelihood of physical training benefit could be accurately predicted as being low in a given patient, one option would be to focus rehabilitation on psychosocial issues, such as return to work, and educational issues, such as risk factor reduction. Although van Dixhoorn et al. (11) provide some baseline data, more studies are clearly needed to determine whether certain factors accurately indicate predisposition to success or failure of exercise training.

Physiologic benefits that accompany exercise training after myocardial infarction are now well accepted. As insurance reimbursement for cardiac rehabilitation in the United States becomes of greater concern, factors that determine success or failure of exercise programs should be investigated in future trials. van Dixhoorn et al. (11) suggested that psychosocial variables may add to the prediction of success or failure of training after myocardial infarction. Because, with some notable exceptions (16–18), previous studies describing improved psychosocial status before and after cardiac rehabilitation have generally not been randomized or controlled, such studies are needed to confirm the current observations.

Current status of cardiac rehabilitation. Rehabilitation of the patient with heart disease has changed greatly over the last 30 years. In 1956 it was recommended that after myocardial infarction "patients should be confined to bed at once and remain there three to six weeks, or longer . . ." (19). Approximately 10 years later, the first English language reports (20–22) of the effects of training for patients with heart disease were published. The 1980s brought an abundance of studies on the effects of rehabilitation programs that use more sophisticated techniques to document training benefits (3,5,8). Whether these benefits can be attributed to central cardiac changes or solely to peripheral adaptations remains unclear, as does the effect of rehabilitation on mortality. Difficulties in study design (lack of randomization, lack of control groups and inadequate study group size) have precluded definitive conclusions concerning mortality. Although the National Exercise and Heart Disease Project reported a 37% decrease in mortality among patients randomized to an exercise program, this decrease was not statistically different from that in the control group. This issue was reviewed with use of meta analytic techniques three times in the 1980s. May et al. (23) reviewed various interventions after myocardial infarction and by combining studies reported a significant 19% decrease in cardiovascular mortality associated with an exercise program. These data suggested that exercise training was equally as beneficial as beta-adrenergic blockade and more effective than anticoagulation and platelet-active drugs. Later, Oldridge et al. (24) and O'Connor et al. (25) combined the randomized exercise trials of the 1970s and 1980s (including >2,000 patients) to evaluate the efficacy of secondary prevention after myocardial infarction. Significantly lower pooled odds ratios of 0.75 (95% confidence interval 0.62 to 0.93) and 0.78 (95% confidence interval 0.63 to 0.96) were reported for cardiovascular mortality in the exercise groups for the studies of Oldridge et al. (24) and O'Connor et al. (25), respectively.

The United States Department of Health and Human Services, whose reports determine health care coverage under Medicare, released a report on cardiac rehabilitation in 1987 (26). This report concluded that cardiac rehabilitation is safe and efficacious in improving the cardiovascular and psychosocial status of patients with heart disease. Despite this favorable report, an inconsistent approach to reimbursement continues to hinder many patients from participation in cardiac rehabilitation. Because of variable or minimal insurance coverage for cardiac rehabilitation programs, many patients are unable to obtain this treatment. As more patients benefit from new therapeutic modalities, there are more survivors needing rehabilitative services. The study of van Dixhoorn et al. (11) provides a provocative basis for further studies to determine which patients can benefit most or are at risk of harm from exercise training programs.

References

1. Gamble P, Froelicher VF. Can an exercise program worsen heart disease? Physician/Sportsmed 1982;10:69-77.
2. Conn EH, Williams RS, Wallace AG. Exercise responses before and after physical conditioning in patients with severely depressed left ventricular function. Am J Cardiol 1982;49:296-300.
3. Sullivan MJ, Higginbotham MB, Cobb FR. Exercise training in patients with severe left ventricular dysfunction: hemodynamic and metabolic effects. Circulation 1988;78:506-15.
4. Ellestad MH. Is exercise harmful in ischemic heart disease? Am J Noninvasive Cardiol 1987;1:15-7.
5. Jugdutt BI, Michorowski BL, Kappagoda CT. Exercise training after anterior Q wave myocardial infarction: importance of regional left ventricular function and topography. J Am Coll Cardiol 1988;12:362-72.
6. Mark DB, Hlatky MA, Califf RM, et al. Painless exercise ST deviation on the treadmill: long-term prognosis. J Am Coll Cardiol 1989;14:885-92.
7. Schuler G, Shlierf G, Wirth A, et al. Low fat diet and regular, supervised physical exercise in patients with symptomatic coronary artery disease: reduction of stress-induced myocardial ischemia. Circulation 1988;77:172-81.
8. Froelicher VF, Jensen D, Genter F, et al. A randomized trial of exercise training in patients with coronary heart disease. JAMA 1984;252:1291-7.
9. Hammond HK, Kelly TL, Froelicher VF, Pewen W. Use of clinical data in predicting improvement in exercise capacity after cardiac rehabilitation. J Am Coll Cardiol 1985;6:19-26.
10. Fioretti P, Simoons ML, Zwiers G, et al. Value of predischarge data for the prediction of exercise capacity after cardiac rehabilitation in patients with recent myocardial infarction. Eur Heart J 1987;8:330-8.
11. van Dixhoorn J, Duivenvoorden HJ, Pool J. Success and failure of exercise training after myocardial infarction: is the outcome predictable? J Am Coll Cardiol 1990;15:974-82.
12. Parmley WW. President's page: position report on cardiac rehabilitation. J Am Coll Cardiol 1986;7:451-3.
13. Ott CR, Sivarajan ES, Newton KM, et al. A controlled randomized study of early cardiac rehabilitation: the Sickness Impact Profile as an assessment tool. Heart Lung 1982;12:162-74.
14. Diedericks JPM, van der Sluijs H, Weeda HWH, Schobre MG. Predictors of physical activity one year after myocardial infarction. Scand J Rehabil Med 1983;15:103-7.
15. Ades PA, Grunvald MH, Weiss RM, Hanson JS. Usefulness of myocardial ischemia as predictor of training effect in cardiac rehabilitation after acute myocardial infarction or coronary artery bypass grafting. Am J Cardiol 1989;63:1032-6.
16. Erdman RAM, Duivenvoorden HJ, Verhage F, Kazemier M, Hugenholtz PG. Predictability of beneficial effects in cardiac rehabilitation: a randomized clinical trial of psychosocial variables. J Cardiopulmonary Rehabil 1986;6:206-13.
17. Perk J. Cardiac rehabilitation: medical and socioeconomic results of a comprehensive program. Doctoral Dissertation, Linkoping University, Oskarsham, Sweden, 1989.
18. Dennis C, Houston-Miller N, Schwartz RG, et al. Early return to work after uncomplicated myocardial infarction: results of a randomized trial. JAMA 1988;260:214-20.
19. Wood P. Diseases of the Heart and Circulation. 2nd ed. London: Eyre & Spottiswoode, 1956.
20. Hellerstein H, Burlando A, Hirsch EZ, et al. Active physical reconditioning of coronary patients. Circulation 1965;32:110-1.
21. Naughton J, Shanbour K, Armstrong R, et al. Cardiovascular responses to exercise following myocardial infarction. Arch Intern Med 1966;117:541-5.
22. Rechnitzer PA. The effects of a graduated exercise program on patients with previous myocardial infarction. Can Med Assoc J 1965;92:858-60.
23. May GS, Eberlein KA, Friberg CD. Secondary prevention after myocardial infarction: A review of long-term trials. Prog Cardiovasc Dis 1984;24:331-51.
24. Oldridge NB, Guyatt GH, Fischer ME, Rimm AA. Cardiac rehabilitation after myocardial infarction. Combined experience of randomized clinical trials. JAMA 1988;260:945-50.
25. O'Connor GT, Buring JE, Yusuf S, et al. An overview of randomized trials of rehabilitation with exercise after myocardial infarction. Circulation 1989;80:234-44.
26. U.S. Department of Health and Human Services. Health Technology Assessment Reports: Cardiac Rehabilitation Services, 1987, no. 6.