Cardiopulmonary Rehabilitation, Exercise Training, and Preventive Cardiology: An Overview of a Decade of Research at the Ochsner Heart and Vascular Institute

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A decade of research from the Ochsner Heart and Vascular Institute's cardiopulmonary rehabilitation and exercise training programs demonstrates the benefits of this therapy on coronary risk factors, exercise capacity, cardiopulmonary parameters, behavioral characteristics, and quality of life in various subgroups of patients, including the elderly, women, obese patients, and groups with dyslipidemia and psychological distress, as well as in patients with congestive heart failure or severe lung disease. Substantial data from our program support the idea that cardiopulmonary rehabilitation and exercise training programs are underemphasized and underutilized for the secondary prevention of coronary artery disease.

During the past 2 decades, significant declines in cardiovascular and, particularly, coronary mortality trends have been noted (1-3). Although various pharmacologic and aggressive interventional strategies are often credited for these major advances, lifestyle modifications account for a substantial percentage of the reduction in coronary artery disease (CAD) risk. Cardiac rehabilitation is one of various lifestyle modifying modalities which involve a multidisciplinary program of exercise and education designed to promote the development and maintenance of a desirable level of physical, social, and psychological function at the onset of an acute cardiovascular illness. The specific goals of cardiac rehabilitation and exercise training programs include risk stratification, improving emotional well-being, decreasing symptoms, improving functional capacity, and decreasing morbidity and mortality (1-6).

Table 1 lists the phases of cardiac rehabilitation. Substantial evidence has demonstrated the benefits of phase II cardiopulmonary rehabilitation and exercise training programs in patients after major CAD events (Table 2). Significant improvements in exercise capacity and in risk factor reduction (such as increasing levels of high-density lipoprotein cholesterol [HDL-C], and reducing triglycerides, low-density lipoprotein cholesterol [LDL-C], and obesity indices) have been associated with psychosocial benefits, reduced subsequent hospitalization costs, and reduced major CAD morbidity and mortality (1-6). However, despite this evidence, substantial data indicate that cardiopulmonary rehabilitation programs are underutilized nationally (less than 10% of eligible patients attend these programs, and only 25% of eligible Ochsner patients attend), due to multiple reasons, including lack of

Table 1. Phases of Cardiac Rehabilitation

Phase	Type of Program	Duration
I	Inpatient	Days
II	Outpatient, immediately after hospitalization	2-12 weeks
III	Late Recovery Period	Minimum of 6 months beyond phase II
IV	Maintenance	Indefinite

Table 2. Benefits of Phase II Cardiopulmonary Rehabilitation and Exercise Training Programs

1. Improved Exercise Capacity and Peak VO_2
2. Improved Work Efficiency
3. Improved Lipids
   a. Increased HDL Cholesterol
   b. Reduced Triglycerides
   c. Possibly Reduced LDL Cholesterol
4. Improved Obesity Indices
5. Improved Behavioral Characteristics (especially Depression and Hostility)
6. Improved Quality of Life
7. Decreased Hospitalization Costs
8. Reduced Major Cardiac Morbidity and Mortality

VO_2 = oxygen consumption
HDL = high density lipoprotein
LDL = low density lipoprotein

physician referrals (which is not a problem at our institution, with >95% referral), inadequate "strength" of the referral (or lack of physician encouragement), as well as geographic and financial barriers and lack of patient interest.

During the past decade, we have followed a large number of patients in our phase II cardiac rehabilitation and exercise training programs at the Ochsner Heart and Vascular Institute. We assessed exercise capacity and cardiopulmonary parameters, plasma lipids, obesity indices, various behavioral characteristics (including scores for depression, hostility, anxiety, and somatization) using the Kellner Symptom Questionnaire, and quality of life (QoL) using the Medical Outcomes Study (MOS) short form survey (SF-36), to evaluate the benefits in several subgroups of patients listed in Table 3. We have also demonstrated benefits in work-site primary prevention settings.

Elderly

We recently compared benefits of cardiac rehabilitation and exercise training programs in 199 elderly CAD patients and 259 younger patients (7). At baseline, as previously demonstrated in a similar cohort of patients (8,9), elderly patients had nearly 30% lower exercise capacity, and had lower triglycerides, body mass indices (BMI), hostility scores, and overall function scores, as well as higher percent body fat and higher levels of HDL-C than did the younger patients. The two groups were statistically similar regarding all other major baseline factors. Following formal cardiac rehabilitation and exercise training programs, this large elderly cohort demonstrated modest, but statistically significant, improvements in total cholesterol and LDL-C (-2% and -3%, respectively), HDL-C (+3%), and LDL/HDL ratio (-5%). The elderly, however, showed dramatic improvements in estimated exercise capacity (+43%) and modest improvements in obesity indices. Almost all behavioral components and QoL improved significantly in the elderly patients after cardiac rehabilitation. Improvements in most of the parameters were statistically similar in older and younger patients; however, the elderly had statistically greater improvements in both estimated exercise capacity (+43% versus +32%; $p<0.01$) and in mental health scores (+5% versus +2%; $p=0.05$) than did younger patients.

In our study of a small cohort of very elderly patients over the age of 75 (n=74), CAD risk factors, behavioral characteristics, and QoL components

Table 3. Subgroups Proven to Benefit from Cardiopulmonary Programs at Ochsner Heart and Vascular Institute.

1. Elderly
2. Women
3. Obese
4. Patients with High or Low Exercise Capacity
5. Diabetic Patients
6. Patients with Psychological Distress
a. Depression
b. Hostility
7. Patients with Dyslipidemia
a. Low HDL Cholesterol
b. "Isolated" Low HDL Cholesterol
c. Hypertriglyceridemia
8. Patients with Other Coronary Risk Factors
a. High Homocysteine
b. High Blood Viscosity
9. Congestive Heart Failure
10. Chronic Obstructive Lung Disease

(HDL = high density lipoprotein)

improved significantly (10). Compared with patients younger than 60, the very elderly had greater relative improvements in exercise capacity, overall QoL, well-being, and hostility scores, and had similar improvements in all other parameters. These studies further support the fact that the elderly, including groups of patients well over the age of 75, should not only be referred to, but should be vigorously encouraged to attend formal cardiac rehabilitation and exercise training programs following major CAD events. Since the very elderly had greater than 40% lower exercise capacity at baseline compared with younger patients, the improvements may be even more "clinically significant" in the older compared with younger patients, who had fairly good baseline exercise capacity.

We recently reported that elderly patients also had small, but statistically significant, improvements in cardiopulmonary parameters, including peak oxygen consumption (VO_2) (+ 13%; $p<0.0001$) and anaerobic threshold (AT) (+11%; $p=0.03$) (11). Although the younger patients had greater improvements in cardiopulmonary parameters than did elderly patients, the elderly had significantly greater improvements in function scores (+27% versus +20%; $p=0.02$) and total QoL scores (+20% versus =14%; $p=0.03$), showing the disparate effects of cardiac rehabilitation programs on improvements in exercise capacity and QoL in young and elderly patients with CAD. As we had previously demonstrated in a cohort of 50 CAD patients (12), we found that estimating exercise capacity using standard published formulas greatly overestimates the exercise capacity previously determined by cardiopulmonary stress testing. This overestimation is more marked in the younger compared with the elderly patients, and in both groups the overestimation is even more notable after the exercise training program (11). These data support the benefits of precisely measuring functional capacity by cardiopulmonary stress testing.

Women

On average, women develop CAD 10 years later than men, yet this disease remains the leading cause of morbidity and mortality in women, and there is substantial evidence that women with CAD, particularly older women, often are not referred to cardiac rehabilitation and exercise training programs and are not vigorously encouraged to attend these programs (1,2,13-15). However, we have recently found quite significant improvements in CAD risk factors, exercise capacity, behavioral characteristics, and QoL parameters after cardiac rehabilitation and exercise training in women (3,4,16). Even more recently, we demonstrated the effects of cardiac rehabilitation and exercise training in a cohort of 83 women and 375 men (17). At baseline, women with CAD had lower exercise capacity, lower LDL/HDL ratios, and lower scores for energy, function, and total QoL. The women, however, had higher levels of total cholesterol, LDL-C, percent body fat, and HDL-C than their male counterparts. After cardiac rehabilitation and exercise training, women improved their exercise capacities and lipid levels, as well as anxiety and somatization scores. However, improvements in depression and hostility scores did not reach statistical significance in women. Male patients with CAD appeared to have two times greater improvements in both depression and somatization scores than did women, although these relative differences were not quite statistically significant. With the exception of mental health scores, all QoL parameters improved significantly in women after cardiac rehabilitation and exercise training programs, including total QoL scores. We concluded that women also have significant benefits from cardiac rehabilitation and exercise training programs and should therefore be routinely referred to these programs after major CAD events and vigorously encouraged to pursue them. Since women had significantly lower exercise capacities, as well as scores for energy, function, and total QoL at baseline, the relative clinical benefit may be even greater for them.

Elderly women are probably the largest growing segment in society and in cardiovascular practices, and members of this group are the least likely to be referred to, and to attend, cardiac rehabilitation programs. We recently analyzed results of cardiac rehabilitation in 70 elderly women (mean age >71) and compared the effects of this therapy with that of 574 other patients (91% men, mean age approximately 60) (18). At baseline, elderly women had 26% lower exercise capacity and 7% higher body mass index (BMI), higher percentage of body fat (+29%), and higher levels of total cholesterol, LDL-C, and HDL-C than did the other patients. Both groups were statistically similar regarding other parameters studied. Following the cardiac rehabilitation and exercise training program, elderly women had significant (30%) improvements in exercise capacity, obesity indices (BMI -2% and percent body fat -10%), and in LDL/HDL ratio (-12%), and borderline improvements in triglycerides (-13%; $p=0.08$). For most parameters, improvements after cardiac rehabilitation were statistically similar in elderly women and other patients. However, elderly women had significantly greater improvements in obesity indices, including BMI (-2% versus 0%; $p<0.03$), and percent body fat (-10% versus -5%; $p<0.01$), compared with the other patients. These improvements were particularly noteworthy since obesity seems to be a stronger CAD risk factor in women than in men. Elderly women also had significant improvements in anxiety, somatization, and total QoL and six other QoL components studied, as well as borderline improvements in depression scores (-31%, $p=0.07$) following cardiac rehabilitation.

Obesity

In addition to the adverse effects of obesity on other CAD risk factors, including unfavorable plasma lipid levels (particularly elevated triglyceride levels and low levels of HDL-C), insulin resistance, promoting a sedentary lifestyle, elevated arterial blood pressure, and the development of left ventricular hypertrophy (LVH), numerous studies indicate that obesity is an independent risk factor for CAD events (19-26). We assessed the benefits of cardiac rehabilitation and exercise training programs in 116 obese coronary patients (defined as BMI $\geq$ 27.3 kg/m^2 in women and $\geq$ 27.8 kg/m^2 in men) (26). Unfortunately, the prevalence of obesity changed only minimally after cardiac rehabilitation programs (37% to 33%), and the prevalence of severe obesity (defined as BMI $\geq$ 35 kg/m^2) also improved only slightly (3.5% to 2.5%). However, the obese patients did show significant improvements in lipid values, including significant reductions in total cholesterol levels (-2%), LDL-C (-4%), triglycerides (-6%), and LDL/HDL ratios (-10%), and increases in HDL-C (+6%). The obese patients had improvements in BMI (-3%; $p<0.0001$), percent body fat (-5%; $p<0.0001$), and estimated exercise capacity (+24%; $p<0.001$). However, when the relative benefits of the cardiac rehabilitation and exercise training programs were compared, the obese had significantly less improvements in estimated exercise capacity than did non-obese coronary patients (+24% vs +36%; $p<0.01$). In a more recent study (27), 235 obese patients also had significant improvements in behavioral characteristics and QoL parameters following cardiac rehabilitation. In obese patients with at least 5% weight reduction, improvements in exercise capacity (+34% versus +26%; $p<0.001$), total cholesterol (-7% versus -2%; $p=0.03$), HDL-C (+11% versus + 2%; $p<0.001$), LDL-C (-7% versus -4%; $p=0.02$), and LDL/HDL (-16% versus -7%; $p<0.0001$) were significantly greater than in obese patients who did not lose weight (27). Therefore, we feel that greater emphasis on successful weight reduction programs could further enhance CAD risk factor reduction in the nearly 40% of CAD patients who meet the criteria for obesity. In a small study of obese hypertensive patients with LVH, high doses of a drug used for depression, sertraline, which is a serotonin uptake inhibitor, significantly lowered body weight and produced modest, but significant, improvements in blood pressure and LVH (28).

Very recently, we analyzed cardiopulmonary parameters in 99 obese patients and 76 lean patients before and after cardiac rehabilitation (29). At baseline, obese patients had significantly lower peak VO_2 and AT compared with lean patients, whereas both groups were statistically similar regarding peak VO_2 corrected for lean body mass (LBM) and work efficiency (Δ Watts/Δ VO_2), which is a marker of peripheral work mechanics. Whereas both obese and lean patients had significant improvements in all cardiopulmonary parameters after cardiac rehabilitation, peak VO_2 and AT adequately described exercise capacity in the lean patients, but exercise capacity was best described by peak VO_2 corrected for LBM (+11%; $p<0.001$) and work efficiency (+35%; $p<0.0001$) in obese patients (29,30).

Patients with High Baseline Exercise Capacity

Some experts have suggested that patients with very good baseline exercise capacity may not obtain significant benefits from cardiac rehabilitation programs and could enroll in less intensive and, therefore, less expensive programs. We reviewed and compared the benefits of cardiac rehabilitation and exercise training programs in 163 patients with a high baseline exercise capacity ($\geq$ 6 estimated metabolic equivalents [METs]; mean 8.8 METs) with 125 patients having a low baseline exercise capacity (<6 estimated METs; mean 4.5 METs) (31).

Those with a high baseline exercise capacity revealed significant improvements in total cholesterol (-2%), LDL-C (-4%), triglycerides (-10%), LDL/HDL ratio (-10%), HDL-C (+7%), and estimated exercise capacity (+22%; $p<0.0001$). Although patients with lower baseline exercise capacity had greater relative improvements in estimated exercise capacity after the exercise training programs (+48% versus +22%; $p<0.0001$), the group with high baseline exercise capacity, for reasons that have not been totally explained, had significantly greater reductions in both LDL-C (-4% versus 0%; $p<0.05$) and LDL/HDL ratio (-10% versus -4%; $p<0.01$). Improvements in all other parameters were statistically similar in the two groups. Therefore, we believe that these data support the potential benefits of cardiac rehabilitation programs, even in patients with relatively preserved baseline exercise capacity.

Diabetic Patients

In a study of 291 patients with CAD (70 diabetics, or 24% of the cohort) before and after cardiac rehabilitation (32), diabetic patients were more likely to be female ($p=0.08$), hypertensive ($p=0.05$), and obese ($p=0.08$). Additionally, diabetics had lower exercise capacity (-19%; $p<0.01$), HDL-C (-10%; $p<0.01$) and LDL-C (-10%; $p=0.02$) and had higher triglycerides (+26%; $p=0.04$) than did those not suffering from diabetes. Diabetic patients also had a higher prevalence of depression (26% versus 14%; $p<0.03$) and had more somatization ($p=0.05$) and significantly lower scores for QoL (-7%; $p<0.01$). Following cardiac rehabilitation and exercise training programs, diabetic patients had marked improvements in exercise capacity, obesity indices, lipids, behavioral characteristics, and QoL. Moreover, after cardiac rehabilitation, the incidence of depression was reduced in diabetic patients by 67% ($p=0.01$) and ultimately equaled the 9% prevalence for the non-diabetic group. These diabetic patients also had marked benefits in scores for anxiety, somatization, and total QoL and its components.

Patients with Psychological Distress

Baseline psychological factors help predict improvements in exercise capacity following cardiac rehabilitation and exercise training programs (33-37). However, the medical and cardiovascular communities have greatly underemphasized the importance of psychological distress in patients with CAD, and substantial data indicate that psychological distress is a risk factor for CAD and adversely affects recovery following CAD events (36,37). In cohorts with CAD, as well as in elderly CAD patients, the prevalence of depression approached 20% and the prevalence of depression in women with CAD was 23% (38-40). Depressed patients will generally have lower exercise capacity and have more adverse baseline CAD risk profiles and lower QoL scores compared with patients without depression. Following cardiac rehabilitation programs, the prevalence of depression was reduced by more than 50%, and the rest of the cardiovascular profile improved markedly in depressed patients. High levels of hostility, or unexpressed anger, were present in nearly 15% of patients with CAD, who also had more abnormal baseline CAD risk profiles and more adverse behavioral characteristics and lower QoL than patients without high hostility scores (41). Likewise, the prevalence of high hostility following cardiac rehabilitation was reduced 40%, and marked improvements were noted in the other CAD risk factors, behavioral characteristics, and QoL. These data indicate that patients with depression and high hostility have marked benefits following cardiac rehabilitation and exercise training programs. In addition, we believe that greater attention in general should be directed at behavioral characteristics and psychological distress, particularly depression and hostility, to enhance both the primary and secondary prevention of CAD.

Patients with Dyslipidemia

Considerable evidence during the past 2 decades has indicated the importance of lipids, including LDL-C, HDL-C, and triglycerides, in contributing to atherosclerosis and, particularly, CAD (42-45). Several years ago, the National Cholesterol Education Program (NCEP) made firm recommendations regarding lipid assessment and treatment, which were mostly aimed at LDL-C levels (46). However, in our review of 238 patients with CAD, nearly half had ideal levels of total cholesterol and LDL-C (46), fewer than 25% had a high-risk LDL-C, originally defined as LDL-C ≥ 160 mg/dl. Nearly 50% of our patients, however, had high-risk HDL-C values of < 35 mg/dl, and 25% of our CAD patients had extremely low HDL-C (<30 mg/dl) (46,47). Although, as mentioned above, elderly patients had higher HDL-C levels than did younger patients, low HDL-C levels were considerably more prevalent than high-risk LDL-C levels both before and after a cardiac rehabilitation and exercise training program, even in the elderly patients (48). Therefore, we concluded several years ago that the NCEP should reassess the pivotal role of HDL-C in its assessment and treatment guidelines, particularly in patients with established CAD, since emphasis on both LDL-C and HDL-C is needed for optimal CAD prevention.

Substantial evidence in the literature suggests that patients with "isolated" low levels of HDL-C are extremely resistant to both pharmacologic and non-pharmacologic treatments (49). This is of critical importance, since approximately 25% of our patients with CAD have "isolated" low HDL-C levels and relatively normal levels of LDL-C and triglycerides. We recently demonstrated that these patients have quite dramatic responses to vigorous non-pharmacologic therapy, including significant increases in HDL-C (+17%;

$p<0.001$) and LDL/HDL ratios (-11%; $p<0.0001$) (42). In fact, patients with "isolated" low HDL-C levels had greater improvements in both HDL-C and LDL/HDL ratios than did other coronary patients after cardiac rehabilitation and exercise training programs.

Considerable controversy remains regarding the role that triglycerides play in the atherosclerotic process (42,50). Although physicians generally believe that patients with high levels of triglycerides often respond better to vigorous non-pharmacologic therapy than patients with low baseline triglycerides, recent data strongly dispute this. In fact, in a comparison of patients with hypertriglyceridemia (≥250 mg/dl) with patients having normal triglyceride levels (<150 mg/dl), patients with low baseline triglyceride levels had statistically greater improvements in both LDL-C and LDL/HDL ratios (50). In multivariable analyses, a low baseline triglyceride value is one of the strongest independent predictors for improving both LDL-C and LDL/HDL ratio after a vigorous non-pharmacologic program. In addition, since nearly half of our coronary patients have low levels of HDL-C, we also showed that a low baseline triglyceride value was one of the strongest independent predictors for improving both LDL-C and LDL/HDL ratio in a study of nearly 250 patients with HDL-C < 35 mg/dl (51). Therefore, contrary to popular belief, patients with hypertriglyceridemia are actually more resistant to non-pharmacologic therapy, at least with regard to improving levels of LDL-C and LDL/HDL ratios; therefore, these patients are even more likely than patients with low triglyceride levels to require drug treatment aimed at reducing LDL-C values (40-51).

Our large experience in using various lipid therapies in CAD patients (52-57) included the use of sustained-release niacin preparations to treat patients with CAD and low levels of HDL-C (58-62). Using a mean dose of niacin of approximately 2.4 g/d (62), we demonstrated that in patients with very low baseline HDL-C levels (<30 mg/dl), significant improvements in total cholesterol levels (-11%; $p<0.005$), LDL-C (-20%; $p<0.01$), HDL-C (+30%; $p<0.0001$), and LDL/HDL ratio (-37%; $p<0.0001$) occurred after niacin therapy. Although patients with hypertriglyceridemia responded even better to sustained-release niacin therapy than did patients with normal triglyceride levels (including 25% reduction in triglycerides, 35% reduction in LDL-C, 41% increase in HDL-C, and 56% reduction in LDL/HDL ratio), improvements after niacin therapy were still quite significant in the total cohort of patients, as well as in those with "isolated"low levels of HDL-C (greater than 25% increase in HDL-C and greater than 25% reduction in LDL/HDL ratio).

Other CAD Risk Factors

Cardiac rehabilitation and exercise training may affect other CAD risk factors, including levels of dehydroepiandrosterone sulfate (DHEA-S), homocysteine, parameters of blood viscosity and rheology, as well as therapy with omega-3 fatty acids (fish oils). Some studies have suggested that high levels of DHEA-S are associated with reduced atherosclerosis and CAD. Unfortunately, levels of DHEA-S did not increase after our cardiac rehabilitation and exercise training programs (63). Substantial data also indicate that high levels of homocysteine may damage endothelium and enhance coagulation, and high levels have been associated with increased CAD, peripheral vascular disease, and cerebral vascular disease events (64, 65). Although we recently demonstrated only small and non-statistically significant reductions in homocysteine levels following exercise training in a cohort of 76 CAD patients, a subgroup of 11 patients with elevated levels of homocysteine (>15 mmol/L) had significant (-12 %; $p<0.02$) reductions in levels in homocysteine after an exercise training program (64). Several studies have indicated that elevated blood viscosity is associated with increases in cardiovascular disease events (66). Recently, we noted that CAD patients had considerably higher levels of blood and plasma viscosity and decreased plasma conductance compared with control patients; these abnormalities markedly normalized after a 12-week program of cardiac rehabilitation and exercise training (66). Considerable evidence also points to the benefits of using fish oils in the prevention and treatment of various cardiovascular disorders (53,67,68). This therapy resulted in reductions of approximately 25% in mean arterial blood pressure and systemic vascular resistance, modest reductions in LVH, and modest improvements in left ventricular diastolic filling in cardiac transplant patients with cyclosporine-induced hypertension (69,70). Fish oil therapy also resulted in greater than 50% reductions in the levels of tumor necrosis factor and greater than 70% reductions in interleukin-1 levels, which were associated with significant improvements in percent body fat in patients with end-stage CHF and cardiac cachexia (71-74).

Congestive Heart Failure (CHF)

We have evaluated exercise training in patients with CHF, as well as the value of cardiopulmonary stress testing to assess prognosis and need for transplantation (75-77). Although 15 - 20 years ago CHF was considered a contraindication to cardiac rehabilitation and exercise training, the safety and efficacy of the therapy was previously noted in a small study of 20 patients post myocardial infarction (MI) with a mean ejection fraction of only 20% (78). In a small study of cardiac rehabilitation and exercise training in 20 patients with severe CHF, there were very minimal improvements in peak VO_2, but marked improvements in work efficiency (+34%; $p=0.03$) following exercise training, which correlated with very significant improvements (+13%; p=0.02) in parameters of QoL (79). In another small study of 15 patients with severe CHF, a 12-week exercise training program was associated with marked improvements in Q-Tc and other indices of ventricular repolarization dispersion, which may decrease the risk of malignant ventricular dysrhythmias and sudden death (80). Along with our colleagues in cardiac transplantation, we are beginning to evaluate the benefits of cardiac rehabilitation in a prospective, randomized study on the effect of this therapy on major CHF morbidity and mortality.

Chronic Obstructive Lung Disease (COLD)

Although cardiopulmonary rehabilitation programs in patients with COLD resulted in only minimal improvements in peak VO_2 in patients with severe lung disease, major morbidity and subsequent medical costs were reduced by this therapy (81). Compared with CAD patients (81), those with COLD (n=25) had minimal improvements in peak VO_2 (+5%; $p<0.001$) but much more marked improvements in work efficiency (+36%; $p<0.001$). Like in patients with CHF, improvements in work efficiency correlated strongly with QoL improvements in patients with COLD.

Primary Prevention Work-site Programs

In a multidisciplinary program aimed at primary work-site interventions in individuals at high risk of medical utilization (82,83), depression, anxiety, and somatization, scores were reduced more than 30% and hostility scores 47%, along with significant improvements in other cardiovascular risk factors and high-risk characteristics in 164 participants, whereas we noticed no improvements in 161 "control" subjects from the same work-site who did not receive specific intervention. Most of the treatment group with high-risk clinical profiles crossed over into a low-risk profile. When followed for 1 year, the intervention group had marked reductions in outpatient, inpatient, and total medical costs, which approached nearly $1,000 per patient per year. Further studies are needed to demonstrate the clinical benefits and "cost-effectiveness" of many primary and secondary preventive strategies.

Conclusions

During the last decade, numerous studies from our program have demonstrated the marked benefits of cardiopulmonary rehabilitation and exercise training programs in preventive cardiology, including marked benefits on exercise capacity, cardiopulmonary parameters, CAD risk factors, behavioral characteristics, and QoL. Our challenge for the next decade is to increase referrals and attendance to these highly effective but underutilized services and to find ways to deliver these therapies more efficiently and cost-effectively (84,85).

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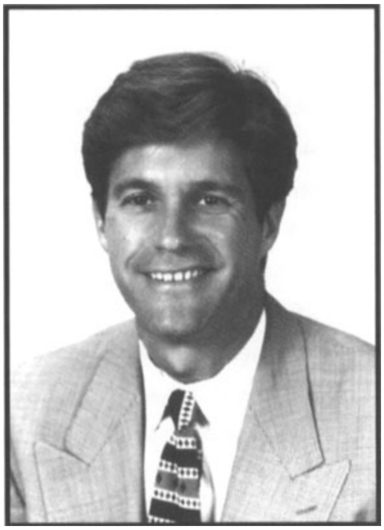

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