TABLE IV Prognostic Variables for New Atherothrombotic Brain Infarction in Older Women and Their Regression Coefficients in the Multivariate Cox Regression Model

Variable	Regression Coefficient	Standard Error	p Value	Relative Risk	95% Confidence Limits
Age	0.008	0.008	0.290	1.008	(0.993, 1.024)
Prior ABI	1.062	0.131	0.0001	2.893	(2.237, 3.742)
Cigarette smoking	0.635	0.175	0.0003	1.886	(1.337, 2.661)
Hypertension	0.887	0.142	0.0001	2.427	(1.836, 3.208)
Diabetes mellitus	0.424	0.139	0.0022	1.529	(1.165, 2.006)
Obesity	0.237	0.187	0.205	1.267	(0.878, 1.829)
Total cholesterol	0.005	0.002	0.0003	1.005	(1.002, 1.008)
HDL cholesterol	−0.013	0.006	0.037	0.987	(0.975, 0.999)
Triglycerides	0.0005	0.001	0.635	1.000	(0.998, 1.003)

Abbreviations as in Table I.

lesterol and new ABI in older men ($p = 0.059$; relative risk 0.983). There was a significant association between serum total cholesterol and new ABI and a significant inverse association between serum HDL cholesterol and new ABI in older women. There was no association between serum triglycerides and new ABI in older women.

Serum total cholesterol and serum HDL cholesterol (inverse association) were found by multivariate analysis to be independent risk factors for the development of new coronary events in our older men and women.[13] Therefore, we would consider treating abnormal serum lipids in older men and women to reduce new coronary events.

The relation between obesity and new ABI is also unclear. The Framingham Study found that relative weight was not a risk factor for new ABI in older men but was a weak risk factor for new ABI in older women.[1] Barrett-Connor and Khaw[6] found no association between body mass index and new ABI in older men or women. The present study showed that obesity was not a risk factor for new ABI in older men. Obesity was a risk factor for new ABI in older women by univariate analysis but not by multivariate analysis. However, because obesity is associated with other risk factors for ABI and new coronary events, we would try to lower weight in obese older men and women.

1. Wolf PA. Cerebrovascular disease in the elderly. In: Tresch DD, Aronow WS, eds. Cardiovascular Disease in the Elderly Patient. New York City: Marcel Dekker, Inc, 1994:125–147.
2. Aronow WS, Ahn C, Schoenfeld M, Gutstein H. Extracranial carotid arterial disease: a prognostic factor for atherothrombotic brain infarction and cerebral transient ischemic attack. *N Y State J Med* 1992;92:424–425.
3. Garland C, Barrett-Connor E, Suarez L, Criqui MH. Isolated systolic hypertension and mortality after age 60 years: a prospective population-based study. *Am J Epidemiol* 1983;118:365–376.
4. Aronow WS, Gutstein H, Lee NH, Edwards M. Three-year follow-up of risk factors correlated with new atherothrombotic brain infarction in 708 elderly patients. *Angiology* 1988;39:563–566.
5. SHEP Cooperative Research Group. Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension: final results of the Systolic Hypertension in the Elderly Program (SHEP). *JAMA* 1991;265:3255–3264.
6. Barrett-Connor E, Khaw K-T. Diabetes mellitus: an independent risk factor for stroke. *Am J Epidemiol* 1988;128:116–123.
7. Khaw K-T, Barrett-Connor E, Suarez L, Criqui MH. Predictors of stroke-associated mortality in the elderly. *Stroke* 1984;15:244–248.
8. Aronow WS, Ahn C. Correlation of serum lipids with the presence or absence of atherothrombotic brain infarction and peripheral arterial disease in 1,834 men and women aged ≥62 years. *Am J Cardiol* 1994;73:995–997.
9. Bihari-Varga M, Szekely J, Gruber E. Plasma high density lipoproteins in coronary, cerebral and peripheral vascular disease. *Atherosclerosis* 1981; 40:337–345.
10. 1988 Joint National Committee. The 1988 report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. *Arch Intern Med* 1988;148:1023–1038.
11. National Diabetes Data Group. Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. *Diabetes* 1979;28: 1039–1057.
12. Master AM, Lasser RP, Beckman G. Tables of average weight and height of Americans aged 65 to 94 years: relationship of weight and height to survival. *JAMA* 1960;172:658–662.
13. Aronow WS, Ahn C. Risk factors for new coronary events in a large cohort of very elderly patients with and without coronary artery disease. *Am J Cardiol* 1996;77:864–866.

Safety of Medically Supervised Exercise in a Cardiac Rehabilitation Center

Piyanuj Vongvanich, MD, Maura J. Paul-Labrador, MPH, and C. Noel Bairey Merz, MD

Two previous survey studies published in 1978[1] and 1986[2] documented relatively low rates of cardiac arrest and myocardial infarction during medically supervised cardiac rehabilitation exercise. These studies used pooled data from multiple centers based on questionnaire reporting of patient exercise hours and complications, a method that could pos-

From the Division of Cardiology, Department of Medicine, Cedars Sinai Research Institute, Cedars-Sinai Medical Center, and Department of Medicine, University of California at Los Angeles, School of Medicine, Los Angeles, California.

This work was supported in part by a grant from the Division of Cardiology, Department of Medicine, Cedars-Sinai Medical Center.

Dr. Merz's address is: Preventive and Rehabilitative Cardiac Center, Cedars-Sinai Medical Center, 444 S. San Vicente Boulevard, Suite 901, Los Angeles, California 90048.

Manuscript received November 7, 1995; revised manuscript received and accepted January 12, 1996.

0002-9149/96/$15.00
PII S0002-9149(96)00215-9

sibly lead to erroneous complication rates. Moreover, the current relevance of these studies performed 17 and 9 years ago, respectively, to today's cardiac patients is unknown. Whereas patients with coronary artery disease currently receive more aggressive therapies aimed at lowering their risk compared with previous decades, these patients are also increasingly elderly, with residual complex postprocedure disease, which possibly elevates their risk of a complication during exercise. We undertook a study to (1) examine the current safety of medically supervised cardiac rehabilitation exercise in a single center over a 9-year period (April 1, 1986, to March 31,1995) and (2) retrospectively assess current risk stratification criteria for identifying patients at risk for major complications during exercise.

• • •

The Cedars-Sinai Medical Center Preventive and Rehabilitative Cardiac Center is a large cardiac rehabilitation program located in a free-standing office building on the medical center campus several blocks from the hospital. Between April 1, 1986, and March 31, 1992, the medically supervised exercise programs included phase 2 and 3 outpatient cardiac rehabilitation. The programs were expanded to include phase 4 in April 1992 and phase 5 in October 1993.

Patients are referred to the cardiac rehabilitation program by their attending physician typically 2 to 6 weeks after discharge from the hospital for myocardial infarction (MI), new-onset angina, cardiac surgery, or coronary angioplasty. Entry stress tests are not required, but patients must be ambulatory and cognitively intact. The phase 2 cardiac rehabilitation program consists of 60-minute aerobic exercise sessions performed 3 times per week for 12 weeks and includes continuous telemetry monitoring and blood pressure measurement. Phases 3 through 5 have the same exercise format but with intermittent electrocardiographic telemetry and blood pressure monitoring (once a month and once a week, respectively, for phase 3; once every 3 months and monthly, respectively, for phase 4; and no monitoring for phase 5). Patients are encouraged to enter the phase 3 program after phase 2 and may graduate to phases 4 and 5 after 3 to 6 months of phase 3, in the absence of severe left ventricular dysfunction, severe ischemia, life-threatening arrhythmia, or severe high blood pressure. Compliance with the 3 times weekly exercise sessions in all programs ranges from 63% to 77%.

In each program prescription heart rate and metabolic energy equivalent (MET) ranges are set at 50% to 75% of the maximum achieved during exercise stress testing using Karvonen's heart rate reserve method and/or below heart rate when ischemia was indicated by stress testing. For phase 2 participants who have not yet undergone stress testing, the exercise prescription is a range 20 to 30 beats/min above resting heart rate. In phases 3 through 5, exercise stress tests are required annually and a new exercise prescription calculated.

Supervisory gym staff included registered nurses (58%), exercise physiologists (34%), and an exercise technician (8%) trained in current basic and advanced cardiac life support. Crash carts with defibrillator, oxygen, and suction are available in the gyms. Emergency response in-service training for staff is performed quarterly. Supervisory staff-to-patient ratios are approximately 1:4 in phase 2 and approximately 1:20 in phases 3 through 5. Supervising physicians are available within the immediate medical center area for emergency response and consultation but are not required to be present in the gyms.

Patient attendance in the programs and major medical complication records were available for review from April 1, 1986, through March 31, 1995. Retrospective risk stratification was performed with the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) criteria.[3]

During a 9-year period between April 1, 1986, and March 31, 1995, 268,503 overall patient exercise hours (81,497 phase 2, 187,006 phases 3 through 5 combined) were recorded for 4,752 patients. Average age was 64 ± 10 and 69 ± 11 years for phase 2 and phase 3 through 5 patients, respectively. Men made up 73% of the population. Overall, 23% were post-MI, 52% were post–coronary bypass surgery, 19% were post–coronary angioplasty, and 6% were referred after new-onset angina or other diagnosis.

Overall, 4 major cardiovascular complications (3 arrests and 1 nonfatal MI) occurred. There were no fatalities. Three of the 4 complications occurred in phase 3 (total duration in the cardiac rehabilitation program ranging from 6 to 18 months), with the exception of the 1 non-fatal MI, which occurred during phase 2 (3 weeks after enrollment). All 3 patients who had cardiac arrests were successfully resuscitated without complication by supervisory gym staff before or coincident with the arrival of physician support. The nonfatal reinfarction was detected upon entry into the gym before beginning exercise because of a complaint of chest pain since the preceding night. The patient was hospitalized without complication. Overall rates of major cardiovascular complications per patient exercise hours were 1/87,497 for phase 2, 1/62,335 for phases 3 through 5, and 1/67,126 for all phases combined.

Using the AACVPR criteria for assignment of risk during exercise,[3] 1 patient with cardiac arrest was classified as high risk because of a low left ventricular ejection fraction (<30%) and complicated hospital course; and the other 2 patients with cardiac arrest were classified as intermediate risk according to stress perfusion imaging studies demonstrating reversible defects; the MI patient was classified as low risk due to normal left ventricular ejection fraction and uncomplicated hospital course.

• • •

These results demonstrate a low frequency of major cardiovascular complications in a single center cardiac rehabilitation exercise program over a 9-year period ending in 1995. Four major complications (3 cardiac arrests and 1 nonfatal MI) resulted in a fre-

TABLE I Summary of Supervised Exercise Complication Rates

Study/Year	Patient Exercise Hours	Cardiac Arrest	Myocardial Infarction	Fatal Events	Serious Complications
Mead[4] 1968–1975	90,000	1/6,000 Fatal 0%		0/90,000	1/6,000
Fletcher[5] 1970s	75,000	1/15,000 Fatal 0%		0/75,000	1/15,000
Haskell[1] 1960–1977	1,629,634	1/32,593 Fatal 16%	1/232,805 Fatal 29%	1/116,402	1/26,715
Hossack[6] 1968–1981	374,616	1/14,985 Fatal 0%		0/374,616	1/14,985
Hossack[6] 1979–1981	131,579	1/26,316		0/131,579	1/26,316
Leach[7] 1971–1981	36,346	1/12,115 Fatal 0%		0/36,346	1/12,115
Shephard[8] 1970–1983		1/13,583			1/13,583
Fagan[9] 1979–1983	62,733	1/20,911 Fatal 33%		1/62,733	1/20,911
Van Camp[2] 1980–1984	2,351,916	1/111,996 Fatal 14%	1/293,990	1/783,972	1/81,101
Digenio[10] 1982–1988	480,000	1/120,000 Fatal 75%		1/160,000	1/120,000
CSMC data 1986–1995	268,503	1/89,501 Fatal 0%	1/268,503 Fatal 0%	0/268,503	1/67,126

quency of 1 major complication per 67,126 patient exercise hours, a figure that is lower than the rate of 1/26,715 reported by Haskell[1] in 1978 and slightly higher than the rate of 1/81,101 reported by Van Camp and Peterson[2] in 1986. Notably, all 3 patients with cardiac arrest were successfully resuscitated, resulting in a 0% mortality rate, which is superior to both these prior publications.[1,2]

A comparative summary of the reports regarding the incidence of serious complications in supervised cardiac rehabilitation exercise programs is shown in Table I.[1,2,4–10] Data acquired since the mid-1980s (references 2 and 10 and current Cedars-Sinai Medical Center study data) demonstrate fairly consistently low cardiac arrest rates, ranging from 1/89,501 patient exercise hours to 1/120,000, although the incidence of successful resuscitation varies, possibly in relation to varying emergency response protocols. Notably, the 0% mortality rate in the current study was accomplished with an emergency response protocol that uses intensive gym staff training and physician support rather than direct gym supervision by a physician. Alternatively, it is possible that we have not yet accumulated enough patient exercise hours for this relatively rare fatal complication to occur.

Previous work has documented the safety of supervised aerobic exercise in a cardiac rehabilitation model with an initial 12 weeks of electrocardiographic monitoring.[1,2, 4–7, 9,10] Nevertheless, position statements from the American College of Physicians,[11] the American College of Cardiology,[12] the American Heart Association,[13] and the AACVPR[3] have recommended risk stratification guidelines to reduce the number of patients monitored with electrocardiographic telemetry for economic reasons. The impact of these recommendations on program safety are untested and unknown. Importantly, none of our arrests occurred in phase 2, in which patients are continuously monitored and more intensely supervised.

Medically supervised exercise continues to have a low major cardiovascular complication rate. Direct gym supervision by a physician does not appear necessary for safety. The currently proposed cardiac rehabilitation risk stratification criteria do not appear to identify patients at risk for these major complications. The safety of exercise programs with less supervision and electrocardiographic telemetry monitoring is unknown.

1. Haskell WL. Cardiovascular complications during exercise training of cardiac patients. *Circulation* 1978;57:920–924.
2. Van Camp SP, Peterson RA. Cardiovascular complication of outpatient cardiac rehabilitation programs. *JAMA* 1986;256:1160–1163.
3. American Association of Cardiovascular and Pulmonary Rehabilitation. Guidelines for Cardiac Rehabilitation Programs, ed 2. Champaign, Ill: Human Kinetics,1995,19–22.
4. Mead WF, Pyfer HR, Trombold JC, Frederick RC. Successful resuscitation of two near simultaneous cases of cardiac arrest with a review of fifteen cases occurring during supervised exercise. *Circulation*1976;53:187–189.
5. Fletcher GF, Cantwell JD. Ventricular fibrillation in medically supervised cardiac exercise programs: clinical, angiographic, and surgical correlation. *JAMA* 1977;238:2627–2629.
6. Hossack KF, Hartwig R. Cardiac arrest associated with supervised cardiac rehabilitation. *J Cardiopulmonary Rehabil* 1982;2:402–408.
7. Leach CN, Sands MJ, Lachman AS, Skinner W. Cardiac arrest during exercise training after myocardial infarction. *Conn Med* 1982:46:239–243.
8. Shephard RJ, Kavanagh T, Tuck J, Kennedy J. Marathon jogging in post-myocardial infarction patients. *J Cardiopulmonary Rehabil* 1983;3:321–329.
9. Fagan ET, Wayne VS, McConachy DL. Serious ventricular arrhythmias in a cardiac rehabilitation programme. *Med J Aust* 1984;September 29:421–424.
10. Digenio AG, Sim JGM, Dowdeswell RJ, Morris R. Exercise-related cardiac arrest in cardiac rehabilitation: the Johannesburg experience. *S Afr Med J* 1991;79:188–191.
11. American College of Physicians. Cardiac rehabilitation services. *Ann Intern Med* 1988;109:671–673.
12. American College of Cardiology. Cardiovascular rehabilitation. *J Am Coll Cardiol* 1986;7:451–453.
13. Exercise standards: a statement for healthcare professionals from the American Heart Association. *Circulation* 1995;91:580–615.