SUMMARY The occurrence of major cardiovascular complications during exercise training of cardiac patients in 30 cardiac rehabilitation programs in North America was determined by questionnaire. These programs conducted medically supervised cardiac exercise classes in 103 locations and reported information on 13,570 participants who accumulated a total of 1,629,634 patient hours of supervised exercise. Cardiovascular complications were reported as nonfatal or fatal and included cardiac arrest, myocardial infarction and other. A total of 50 cardiac arrests were observed during exercise, 42 of which were successfully resuscitated while eight were fatal. Seven myocardial infarctions were reported; five were nonfatal and two were fatal. Four other fatalities were reported due to acute cardiopulmonary disorders. The average complication rate for all programs was one nonfatal and one fatal event every 34,673 and 116,402 patient hours of participation, respectively. Complication rates are lower in programs which continuously monitor the electrocardiogram during exercise and are lower when only the experience since 1970 is evaluated. These data support the recommendation that medically prescribed and supervised exercise can be performed reasonably safely by medically selected cardiac patients.

AS PART OF A PROGRAM of comprehensive cardiac rehabilitation, coronary artery disease patients frequently are recommended a program of increased physical activity. The primary reasons given for encouraging cardiac patients to exercise include enhancement of cardiovascular function, improvement of psychological status and a reduction in the recurrence of clinical manifestations including cardiac arrest, myocardial infarction and sudden death. Exercise recommendations are made even though the specific benefits derived from an increase in physical activity by cardiac patients have not been established definitively nor has the relative safety of such participation been defined adequately. Data from various studies have consistently demonstrated an improved physical working capacity as the result of exercise training by selected cardiac patients due to changes in skeletal muscle and peripheral circulation with little apparent change in intrinsic myocardial performance. Generally these changes in work capacity are reflected in a slower heart rate at any submaximal workload and the ability to perform a higher workload before the onset of myocardial ischemia. Whether or not exercise training improves myocardial oxygen delivery still is an open question, but available results suggest that enhanced coronary blood

Cardiovascular Complications during Exercise Training of Cardiac Patients

WILLIAM L. HASKELL, PH.D.

34. Spach MS, Barr RC, Lanning CF, Tucek P: Origin of body surface QRS and T wave potentials from epicardial potential distribution in the intact chimpanzee. Circulation 55: 268, 1977

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flow is not a frequently derived benefit of exercise training by cardiac patients. Both objective and subjective evaluations strongly support the contention that the psychological status of most sedentary cardiac patients is improved by participation in an appropriate program of physical activity.

No study of adequate design, size and duration has been completed to determine if a systematic increase in physical activity reduces morbidity or mortality, but preliminary data from several sources suggest such a benefit might exist. Two collaborative trials designed to answer this very important question are now underway in North America

A question that should be asked regarding all medical regimens, including alterations in habits such as exercise, pertains to the safety of the new behavior in relation to the potential benefits to be derived from the recommended change. That exercise, by increasing myocardial work, can precipitate a discrepancy between myocardial oxygen supply and demand which in turn can trigger cardiac arrest or myocardial infarction in coronary artery disease patients is generally accepted. In prescribing exercise for cardiac patients, the safety of a particular approach appears closely related to successfully identifying and excluding patients with significant myocardial ischemia, ventricular dysfunction or electrical instability at rest or during mild exercise and prescribing for acceptable patients an activity regimen which maintains them well within their exercise tolerance. However, even with such precautions, due to the vagaries of the atherosclerotic process or if a sufficiently large number of patients are engaged in exercise for extended periods of time, major cardiovascular complications occurring during exercise should be expected. Several reports indicate that serious complications, especially cardiac arrest, can be a reasonably frequent occurrence during medically supervised exercise programs for cardiac patients while other investigators have reported no such complications. In an attempt to obtain some indication of the frequency of major cardiovascular complications, particularly cardiac arrest and myocardial infarction, associated with individually prescribed and medically supervised physical activity by coronary artery disease patients, a retrospective survey of selected cardiac exercise programs in the United States and Canada was performed.

Methods

Beginning in 1974, a brief questionnaire was mailed to directors of exercise programs that met predetermined criteria regarding their design and method of operation. To be included in the survey, each exercise program had to meet the following minimal criteria: (1) the exercise program be designed and operated specifically for cardiac patients; (2) a medical examination be required on entry and at least annually thereafter; (3) all exercise sessions be medically supervised with the capability to provide cardiopulmonary resuscitation including emergency medications and electrical defibrillation; and (4) the program have been in operation for at least one year. Potential programs to be included in the survey were identified by review of the Cardiac Exercise Program Directory and the Rehabilitation Unit Directory published by the American Heart Association, other current medical publications describing cardiac exercise programs, and from a personal knowledge of existing programs. No program was excluded from the survey if it met the criteria stated above.

The questionnaire was designed to elicit information regarding the starting date of the program, number of cardiac patients that had participated since the inception of the program; the number and type of nonfatal or fatal cardiovascular complications occurring while patients were involved in an exercise session or anytime proximal to the exercise session which might be interpreted as resulting from their participation; criteria for patient entry (i.e., patient medical status, weeks postinfarction, etc.); number of exercise sessions per week; characteristics of the exercise training program and the type and extent of medical supervision provided during the exercise training sessions. In some cases ongoing records had been maintained on patient participation while for other programs participation information was reconstructed or estimated from other records or memory. Many program directors also provided comprehensive written descriptions of their programs, record forms and detailed accounts of the circumstances surrounding any major cardiovascular complications experienced by patients during exercise sessions. If questionnaires were not returned in a reasonable time interval after mailing, a second questionnaire was sent, which was then followed by a telephone call or personal contact in order to obtain information from all programs surveyed.

Results

Between June 1974 and December 1976, thirty programs were identified as meeting eligibility criteria for inclusion in the survey. Questionnaires were sent to the directors of these programs and results were obtained from each one of the 30 programs for a 100% response rate. Data from a majority of these programs still operational in January 1977 were updated by repeat questionnaires so that the results of the survey include recent experience as well as experience obtained as early as 1960–65 for several programs.

Program Characteristics

The 30 programs participating in the survey represented 103 exercise class locations distributed throughout major population centers in North America. Twenty-four of the programs with a total of 95 classes were located in the United States while six programs with eight classes were located in Canada. These 103 cardiac exercise classes were conducted in several different types of exercise facilities; 21 were located in YMCAs or YMHA's, 45 in hospitals, 11 in universities and 26 in independent facilities such as medical clinics or office buildings. Fourteen of the 30 programs (44%) began before 1970 with 11 of these 14 still in operation in January 1977, while only one of the 16 initiated since 1970 was no longer operating.

The minimum time following myocardial infarction or cardiac surgery before a patient was allowed into an exercise program ranged from two to twelve weeks with a median of eight weeks and a mean of nine weeks. The number of exercise sessions recommended per week ranged from one to five with a mean and median of three sessions per week. The most prevalent forms of exercise were walking, jogging, run-
ning, and calisthenics with approximately one-half (17 of 30) of the programs including some type of active games.

To be included in the survey, all programs had to provide on-site medical supervision of each exercise session. This supervision was provided primarily by physicians but an increasing number of the newer programs reported utilizing cardiovascular (CCU) trained nurses for this purpose. Medical supervision in 28 of the programs included checking with patients who had medically related questions at the beginning of or during an exercise session; examining or recording the ECG or blood pressure of patients whose disease status possibly had changed since their most recent training session; providing instruction related to medications, diet, activity or other medically related topics and the providing of medical care in the case of an emergency. In the two other programs, which between them conducted 70 exercise classes in the United States, additional medical supervision was provided by continuous ECG monitoring by specially trained cardiovascular nurses during each exercise session. In these two programs, subjects exercised on stationary bicycles, motor driven treadmills or rowing machines while their electrocardiograms were monitored using telemetry or hardware recording equipment including oscilloscopes and strip chart recorders.

Number of Participants

The total number of cardiac patients participating in each of the 30 programs surveyed and their hours of exercise class participation are provided in table 1. During the period surveyed, 13,570 patients were reported enrolled in the programs and contributed to a total of 1,629,634 patient hours of exercise participation. Based on the exercise program descriptions, it is estimated that each time a patient participated in an exercise session he was at the exercise facility approximately one hour. Thus, if a patient participated in a program three times per week for 30 weeks he contributed 90 patient hours to the total, or if a class of 30 patients met three times per week that would be 90 patient hours of participation. If such participation occurred for all 52 weeks of the year this would yield 90 × 52 or 4,680 participant hours for an exercise class of 30 patients (100% attendance) or slightly fewer than for the smallest program surveyed (5,069 hours). The average number of exercise sessions participated in by each patient was 111 or equivalent to 37 weeks of participation three times per week.

Major Cardiovascular Complications

During the 1,629,634 hours of participation, a total of 61 major cardiovascular complications were reported. These complications were recorded as cardiac arrest, myocardial infarction or other and as fatal or nonfatal. The distribution of the 60 events among these categories is provided in table 2. Fourteen events were fatal while 47 nonfatal cardiac arrests or myocardial infarctions were reported. Of the 50 cardiac arrests, 42 or 84% were successfully resuscitated and eight (16%) were fatal, while five (7%) of the seven patients with documented myocardial infarction recovered. Four other fatal complications included two attributed to pulmonary embolism and one each as a result of pulmonary edema and cardiogenic shock. These four deaths occurred following exercise sessions during which symptoms developed and the patient was hospitalized.

An attempt was made to determine the frequency of nonfatal complications other than cardiac arrest or myocardial infarction, but because of the extremely variable recordkeeping and reporting rate by the different programs, these data were not included in the data analyses. It is very likely that the true frequency of nonfatal complications other than cardiac arrest or myocardial infarction was generally under-reported since one can be reasonably sure that various complications occurred and did not receive medical attention while others received medical attention but were not recorded. The reported nonfatal cardiovascular related complications other than cardiac arrest or myocardial infarction that may have resulted in medical attention included atrial tachycardia, atrial fibrillation, coronary insufficiency, hypoglycemia, and syncope.

Complication Rate

By dividing the patient hours of participation by the number of complications, a complication rate expressed as the number of patient hours per event for each category was obtained. The mean complication rates for the 30 programs surveyed for nonfatal cardiac arrest and myocardial infarction, and fatal cardiac arrest, myocardial infarction and other causes are provided in table 2. Cardiac arrest was by far the most frequent complication with a rate of one event per 32,593 patient hours (nonfatal plus fatal) while myocardial infarction on the average was reported only once every 232,809 patient hours. The overall rate for all complications recorded (fatal and nonfatal) was one event every 26,715 patient hours. The fatal complication rate was one mortality every 116,402 patient hours of participation.

The two programs that included continuous electrocardiographic monitoring of all patients during exercise training sessions (programs #29 and #30 in table 1) reported a total of three nonfatal cardiac arrests during a total of 352,200 patient hours of experience for a complication rate of one event per 117,333 participant hours. This experience was accumulated from a total of 3,940 patients participating at 70 exercise class locations in the United States between 1970 and 1976. The experience for the 28 programs that did not conduct continuous ECG monitoring during exercise training was one major complication (fatal or nonfatal) every 22,028 patient hours. The differences in these two rates is significant at $P < 0.01$.

Discussion

The results of this survey demonstrate that the rate of cardiac arrest and myocardial infarction occurring during medically supervised exercise training of cardiac patients varies substantially among programs in North America. In the 16 programs with more than 25,000 patient hours of participation, the nonfatal cardiac arrest and myocardial infarction rate ranged from a low of none for 52,200 participant hours to a high of 19 in 150,580 participant hours (one nonfatal event every 7,925 patient hours of participation) while the fatal event rate in these same programs ranged from none in 300,000 patient hours to five in 120,000 patient hours. This latter program with the highest mortality rate was one of the first in operation, beginning in 1960, was experimental in design and preceded much of the currently available cardiopulmonary resuscitation knowledge and technology. Of the more contemporary programs (still in
COMPLICATIONS DURING EXERCISE TRAINING/Haskell

Table 1. Number of Patients, Patient Hours of Participation and Number of Major Cardiovascular Complications in 30 Cardiac Exercise Programs

<table>
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<tr>
<th>Program no.</th>
<th>Year*</th>
<th>No. of patients†</th>
<th>Patient hours of participation</th>
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<th>MI§</th>
<th>Fatal CA</th>
<th>MI</th>
<th>Other</th>
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<td>1,629,654</td>
<td>42</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>61</td>
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Range: 35-3,200
Mean: 452
Median: 265

*Year program started.
†Number of patients enrolled since beginning of each program.
§CA = cardiac arrest.
¶MI = myocardial infarction.

operation after 1970) the highest mortality rate is four fatal events in 210,000 patient hours of participation (one event per 52,500 patient hours).

Based on information collected during this survey, the differences in complication rates reported by contemporary programs cannot be explained readily by how soon patients enter a program after hospitalization for myocardial infarction or for surgery; by the type of exercise performed (walking, jogging, games or calisthenics); or by the type of facility in which the program is operated (i.e., YMCA vs hospital). Some of the differences in event rates may be due to differences in the characteristics of the warming-up or tapering-off periods at the beginning and end of the class, respectively, since these are the times when the greatest number of complications appear to develop, especially cardiac arrest. Of the 61 complications reported in table 2, at least 44 occurred either during the warm-up phase or during the cool-down or tapering-off period at the end of the exercise session. It is not possible to determine from the data collected during this survey if complication rate is related to the intensity of exercise performed during the session.

The one program characteristic which appears to influence the cardiovascular complication rate, especially the fatal complication rate, is the use of continuous electrocardiographic (ECG) monitoring during the exercise training session. Even though both the nonfatal and fatal complication rates are significantly lower in the two ECG monitored programs as compared to the rates for 28 programs not using continuous monitoring, some of this difference might be due to other program characteristics. For example, the patient to medical supervisor ratio ranges from one-to-one to four-to-one in the continually monitored programs while in the group supervised programs it typically ranges from ten-to-one up to thirty-five-to-one. Just this closer medical supervision, without continuous ECG monitoring, might result in greater patient safety by iden-

Table 2. Rate of Major Cardiovascular Complications during Exercise Training of Cardiac*

<table>
<thead>
<tr>
<th>Non-fatal</th>
<th>Fatal</th>
<th>Total</th>
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<td>Cardiac arrest</td>
<td>38,801</td>
<td>203,704</td>
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<tr>
<td>Myocardial infarction</td>
<td>325,927</td>
<td>814,816</td>
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<tr>
<td>Other</td>
<td>407,408</td>
<td>407,408</td>
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<tr>
<td>Total</td>
<td>34,673</td>
<td>116,402</td>
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*No. of patient hours of participation per event—average for all 30 programs surveyed with total of 1,629,654 patient hours of participation.
†Number of events for each classification.
tifying changes in patient symptoms prior to the occurrence of a major cardiovascular complication thus preventing the complication from developing. Also, closer supervision might help prevent patients from exercising above their prescribed intensity and eliciting myocardial ischemia or electrical instability.

In an attempt to determine if cardiac patients are at higher risk of dying while exercising under medical supervision than when not exercising, annualized mortality rates were calculated. Three programs included in the survey were no longer in operation in 1974. Two were early programs starting before 1965 and the other was one of the first to include patients as early as four weeks after MI. These three programs had seven (50%) of the 14 deaths reported here while they contributed less than 10% of the patient hours of participation. Thus, current programs have a much lower mortality experience than that reported for all programs. For example, an annualized mortality rate during exercise of 7.5% is obtained for all programs based on one death per 116,402 patient hours of participation versus a mortality rate of 4.1% for current programs only, based on one death per 212,182 patient hours of participation. Currently the risk of death for cardiac patients while exercising in medically supervised exercise programs is not in excess of that reported for post myocardial infarction patients during the first several years following hospitalization. 

References

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W L Haskell

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