

CLINICAL AVIATION MEDICINE:

A Physical-Conditioning Program for Cardiac Patients—A Progress Report

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I. Introduction.

The high incidence of coronary atherosclerosis among middle-aged men has prompted many investigations of the possible etiologies, pathogenesies, and therapies of this malady. One of the least-explored factors that might have a relationship to the development of this disease process has been physical activity. Morris^{1,2} indicated that life-long physical activity might protect men from clinically manifest coronary artery disease. These findings, coupled with the clinical experience that many patients recover from myocardial infarction and return to their jobs, have led investigators such as Hellerstein³⁻⁵ to advocate that cardiac patients should participate in physical-conditioning programs. Although it is his impression that the patients benefit emotionally and physiologically during participation in these programs, there is still very little data available that document the clinical course of these patients. It is the purpose of this report to review the growth of a physical-conditioning program for cardiac patients and to present a progress report of the clinical course to the patients during its first 2 years.

II. Methods and Materials.

Twenty men who have recovered from well-documented episodes of myocardial infarction comprise this study. All subjects were referred by their physicians to the study.

A pertinent history, physical examination, and standard electrocardiogram were done on each patient prior to entering the program. In addition, each man performed an exercise test that, was designed to induce an energy demand no greater than seven times that of the resting metabolic state.⁶ The patient began walking on a treadmill at a speed of 2.0 mph on a level grade. The speed was held constant while the slope of the treadmill bed was elevated 3.5% every 3 minutes. Each energy requirement ap-

proximated an additional increment of the resting metabolic state; i.e., 2, 3, 4 times, etc., the work of rest. Blood pressure and pulse rate were monitored by the auscultatory method while a single-lead oblique electrocardiogram⁷ was recorded during the last half of each minute. Respiratory gas exchange was determined every 3 minutes. The test was terminated either after the 18th minute on a 17.5% grade, or earlier, if the patient developed severe dyspnea, angina pectoris, or intermittent claudication.

The first five subjects were seen in the laboratory daily for 1 month, during which they walked on the treadmill for 30- to 45-second periods alternating with 30 seconds of rest. The speed and grade were varied each day. Blood pressure and pulse rate were monitored so that the energy demands were within each patient's physical working capacity.

The physical-conditioning program was conducted in a gymnasium. Each patient was encouraged to attend three times a week. The exercises were conducted in the late morning for 1 hour. An attendance record was kept. The activities were varied slightly from day to day and included calisthenics, competitive games such as volley ball, and intermittent jogging. Each patient began very slowly and was encouraged to increase his energy output gradually during each session.

The purposes of the study were explained to each patient following his initial evaluation. He was taught how to recognize an acute cardiac emergency, to administer mouth-to-mouth resuscitation, and to apply closed-chest cardiac massage. He was familiarized with the principles of operation of an external defibrillator and pacemaker. He was instructed to notify the attending physician immediately if he noticed any unusual symptoms before, during, or after the activity. The program was presented as a long-

range one with no time limit placed on participation.

The remainder of each patient's therapeutic regimen was left intact, and he was encouraged to continue consulting his personal physician just as he had before entering the program. A periodic progress report was sent to the referring physician.

The work-capacity test was repeated after 3 months of physical conditioning and at 6-month intervals thereafter.

III. Case Reports.

Case 1. R. C. was a 54-year-old, obese air traffic controller with a 1-year history of hypertension and an elevated serum cholesterol. He initiated physical conditioning 6 weeks before suffering an inferoseptal and lateral myocardial infarction. His hospital course was uneventful, and 2 months later he entered the conditioning program. His initial progress was the subject of an earlier report.⁸ During his 2 years of participation, he had two vacations that lasted 3 weeks each and was hospitalized once for 7 days. The latter was occasioned by a syncopal episode that occurred following exercise. The physician learned from the patient, upon regaining consciousness, that he had ingested three nitroglycerin tablets for "chest tightness" during a 30- to 45-minute period prior to exercising. A combination of vasodilator drugs and exercise probably precipitated this syncope. The electrocardiographic findings were unchanged following this episode and three SGOT determinations were within normal limits. He had no other rehospitalizations or cardiovascular complications.

Case 2. T. B. was a 48-year-old intermittent laborer when he had an inferoseptal myocardial infarction. He was referred to the program 3 months later after an uneventful postinfarct course. His initial evaluation revealed a blood pressure of 100/70 mm Hg and a pulse rate of 72 per minute. He was a thin, wiry man with arcus senilis who appeared much older than his stated age. He had an atrial gallop. He participated in the program for 4 months before moving to a new location. On two occasions he complained of transient episodes of lightheadedness, following which his blood pressure was within normal limits and not additional electrocardiographic abnormalities were detected. After leaving the program, he stopped training and he

did not return to work. Some weeks later he died suddenly while sitting in a chair. Post mortem examination was not performed. Death was attributed to an acute myocardial infarction.

Case 3. D.C., a 43-year-old electric-company executive volunteered for the program 4 years after suffering an anteroseptal and antero-lateral myocardial infarction. His blood pressure was 150/90 mm Hg and pulse rate 80 per minute upon entering the study. He had electrocardiographic evidence of an old anteroseptal and anterolateral myocardial infarction with peri-infarction block. He participated irregularly and without complications for 6 months before discontinuing the program because of job pressures. His clinical course has remained uncomplicated.

Case 4. L. P. was a 45-year-old flight-line mechanic when he had posterior myocardial infarction. His clinical course was complicated by severe left-sided chest pain and the development of the "Shoulder-Hand Syndrome." These events precipitated an early retirement from civil-service employment. When evaluated 7 months after suffering the myocardial infarction, he was totally invalided despite the fact that his cardiovascular status was satisfactory. His blood pressure was 130/90 mm Hg and pulse rate 100 per minute. He appeared tense and depressed. There was exquisite tenderness over the entire left chest anteriorly. His left shoulder was frozen, and there was edema with cyanosis of the left hand. He developed moderately severe dyspnea after a few minutes of walking on a level grade. Daily physical therapy was instituted for the shoulder, and the patient entered the conditioning program. Six months later, he had recovered complete function of the left upper extremity and had regained much of his physical working capacity. He left the program after he returned to a new job. His course was complicated by two short-term rehospitalizations for treatment of acute peptic esophagitis.

Case 5. W. G. was a 41-year-old pilot when he suffered an inferoseptal myocardial infarction. He entered the program 3 months later, at which time his blood pressure was 130/80 mm Hg and pulse rate 72 per minute. He has participated in the program 16 months without any known cardiovascular complications or rehospitalizations.

Case 6. A. B., a civil-service attorney, had an inferoseptal infarction at the age of 48 years.

His postinfarct course was uncomplicated and he entered the program 4 months later, at which time his blood pressure was 110/75 mm Hg and pulse rate 64 per minute. He has participated for 15 months, during which time he has been hospitalized twice, once for acute renal colic and the second time for the removal of a benign breast mass. His cardiovascular status was stable.

Case 7. C. D., 43-year-old truck driver, had an inferoseptal myocardial infarction while repairing a flat tire. His course was complicated by symptoms of congestive heart failure, following which he was digitalized. He was referred to the program 3 months later. Initially his blood pressure was 140/100 mm Hg and pulse rate 76 per minute. He participated irregularly for 1 year before discontinuing the program completely. Symptomatically, he did quite well. He has not been rehospitalized, and he has returned to work as a garage mechanic.

Case 8. H. B. was a 61-year-old postal employee who had an anteroseptal and anterolateral myocardial infarction 5 years prior to initiating physical conditioning. His clinical course had been complicated by exertional dyspnea. During the first evaluation, his blood pressure was 140/90 mm Hg and pulse rate 76 per minute. He was severely dyspneic at an oxygen demand three times that of rest. Three months later he had improved and performed the entire work-capacity test satisfactorily. He discontinued the program 3 months later, however, when he became depressed over the death of a friend.

Case 9. C. Y. was a 50-year-old insurance salesman when he had a myocardial infarction. Five months later, he had second myocardial infarction with extension anterolaterally. He recovered satisfactorily, and 7 months later he was referred to the conditioning program by his physician. He has been a cautious, but regular participant without any cardiovascular complications for 15 months.

Case 10. U. R., civil-service engineer, was 63 years old when he had a posterior myocardial infarction. His therapy included 4 months of almost total bedrest, anticoagulation, and digitalization. He volunteered for the conditioning program 6 months postinfarct because he wanted to regain his flying status. The initial evaluation revealed a small, thin white man with a blood pressure of 170/70 mm Hg and a pulse rate of

64 per minute. He had evidence of left-ventricular hypertrophy. He has participated in the program regularly for 13 months even though he was retired from the civil-service job. His cardiocascular status was uncomplicated.

Case 11. R. G. was a 37-year-old civil service employee when he had an anteroseptal and anterolateral myocardial infarction. His postinfarct course was uncomplicated, and he was referred to the program 3 months later, at which time his blood pressure was 130/75 mm Hg and pulse rate 68 per minute. He conditioned regularly for 3 month periods, which were alternated with 3 months of sedentary living. This regimen was necessitated because he worked a swing-shift. His clinical course was uneventful.

Case 12. W. S., age 58 years, was referred to the program after suffering an anterolateral and a high lateral myocardial infarction 11 months earlier. He was obese and had not performed any formal exercise since adolescence. His attendance was sporadic, and he often discontinued exercise early complaining of muscular soreness. He occasionally had episodes of left-shoulder pain following pain following exercise that were not relieved by nitroglycerin and during which no electrocardiographic alterations were detected. He was chronically depressed and was treated with pharmacologic preparations for these symptoms. He committed suicide 6 months after entering the program.

Case 13. L. G., a 43-year-old oil-company executive, had been an outstanding college and professional football player who assumed a sedentary living pattern after retiring as a professional athlete. He suffered his first posterior myocardial infarction at 41 years of age. Eleven months later he suffered a posterolateral myocardial infarction. His course following both episodes was uneventful. He entered the program 5 months after suffering the second myocardial infarction, at which time his blood pressure was 165/100 mm Hg and pulse rate 72 per minute. He was an exacting, competitive, and vigorous participant. The results of his second evaluation indicated that he was improving physiologically; however, 12 months after suffering his second infarction he died suddenly during a postexercise recovery period. Post mortem examination was not performed, and his death was attributed to an acute myocardial infarction.

Case 14. G. H. was a 47-year old Army reserve employee with diabetes mellitus when he suffered an antero-septal myocardial infarction. His hospital course was uneventful. Upon entering the program 3 months later, his blood pressure was 130/85 mm Hg and pulse rate 96 per minute. He participated regularly for 7 months without complications before taking a leave of absence for the summer months.

Case 15. L. J., an aircraft inspector, had an infarction at age 39 years. He entered the program 5-1/2 months later, at which time his blood pressure was 150/100 mm Hg and pulse rate 80 per minute. He has participated regularly for 8 months without any further complications or hospitalizations.

Case 16. A. O. was 47 when he entered the program. He had episodes of myocardial infarction at 41 and 43 years of age from which he recovered uneventfully. He was a large man with blood pressure of 130/90 mm Hg and a pulse rate of 72 per minute when evaluated initially. His standard electrocardiogram revealed evidence of an old antero-septal and anterolateral myocardial infarction. He participated in the program for 3 months before discontinuing, complaining of severe aching ankles and knees. He has continued to golf and to hunt since that time.

Case 17. W. E. was a 43-year old electric company employee who volunteered for the program 4 months after suffering an anterolateral myocardial infarction. He left the program after 3 months of conditioning because he was transferred to another plant.

Case 18. P. E. was 44 years old when he entered the program. He had an antero-septal, anterolateral myocardial infarction at age 42 years. Before initiating the conditioning program, his blood pressure was 170/120 mm Hg and pulse rate 64 per minute. He had a history of frequent bouts of chest pain that were relieved by nitroglycerin. Similar episodes did not occur, however, either during the exercise test or during the regular exercise sessions. He has participated regularly for 4 months.

Case 19. H. S., a 51-year-old civil-service electrician with a 25-year history of high blood pressure, had an infarction 3 years prior to initiating physical conditioning. He participated vigorously each day for 6 months before his supervisor made him discontinue the program. The patient has had no further cardiovascular complications and has resumed his sedentary living habits.

Case 20. L. C. was a 41-year-old office worker who entered the program 13 months after suf-

TABLE 1. The patients ranged in age from 37 to 63 years with a mean age of 47.2 years. The time interval from suffering the myocardial infarction to beginning of conditioning varied from 2 to 48 months with a mean of 12.6 months. The mean duration of conditioning was 8.8 months.

Patient	Age (yr)	Weight (Kg)	Height (cm)	Interval (months) from infarct to onset of conditioning	Months in program
R. C.	54	86.3	173.5	2	24
T. B.	48	69.0	172.5	3	4
D. C.	43	83.6	182.9	44	6
L. P.	44	64.1	180.3	7	5
W. G.	41	70.0	172.0	3	16
A. B.	48	64.1	172.7	4	15
C. D.	43	81.8	170.2	4	12
H. B.	61	72.0	177.8	48	7
C. Y.	50	68.6	162.5	6	14
U. R.	63	61.7	167.6	8	13
R. G.	37	90.9	172.7	4	12
W. S.	58	86.3	172.7	11	6
L. G.	43	86.5	190.5	5	6
G. H.	47	66.8	167.6	4	7
L. J.	39	76.8	180.3	6	7
A. O.	47	100.0	187.9	35	3
W. E.	43	75.9	172.7	3	3
P. E.	44	78.2	175.3	17	4
H. S.	51	78.6	169.2	26	6
L. C.	41	65.9	177.8	13	7

fering an anteroseptal myocardial infarction. His initial blood pressure was 145/100 mm Hg and pulse rate 88 per minute. His clinical course has been uncomplicated, and he has participated regularly for 8 months.

IV. Results.

The patients ranged from 37 to 63 years of

age with a mean age of 47.2 (Table 1). Their weight varied from 61.7 to 100.0 kg with a mean myocardial infarctions; three had histories of of 75.3 kg. Two patients had suffered two angina pectoris; and three had been digitalized (Table 2). Thirteen patients were on long-term anticoagulant therapy.

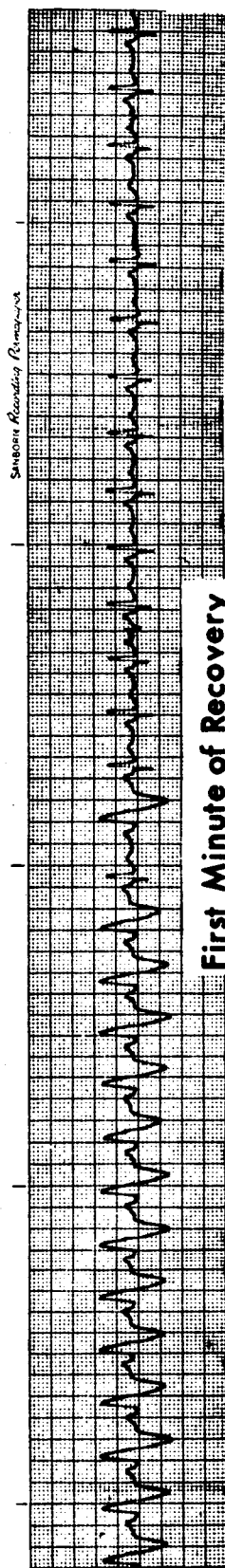
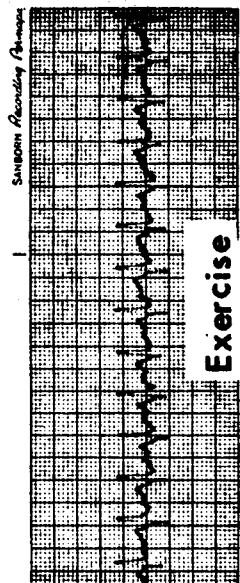
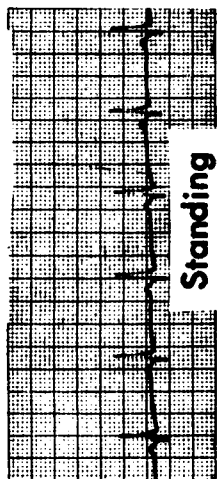
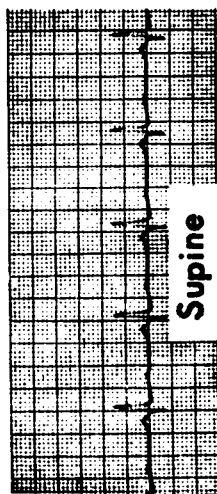
TABLE 2. Two patients had two documented episodes of myocardial infarction. Three men had histories of angina pectoris, while one patient's history was equivocal. Three were on a digitalis preparation and thirteen were anticoagulated.

Patient	No. documented infarcts	History of angina pectoris	Digitalis	Anticoagulated
R. C.	1	±	—	—
T. B.	1	—	—	+
D. C.	1	—	—	+
L. P.	1	—	—	—
W. G.	1	—	—	+
A. B.	1	—	—	+
C. D.	1	—	+	—
H. B.	1	—	—	—
C. Y.	2	—	—	+
U. R.	1	—	+	+
R. G.	1	—	—	—
W. S.	1	+	—	+
L. G.	2	—	—	+
G. H.	1	—	—	—
L. J.	1	—	—	+
A. O.	1	—	—	+
W. E.	1	—	—	+
P. E.	1	+	+	—
H. S.	1	+	—	+
L. C.	1	—	—	+

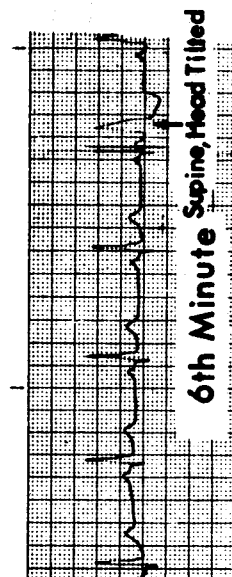
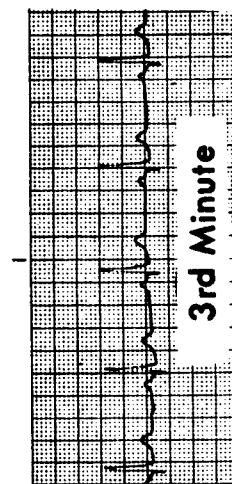
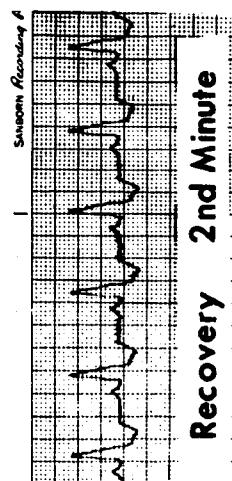
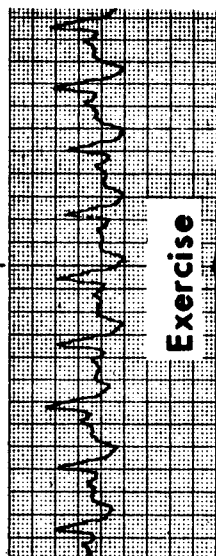
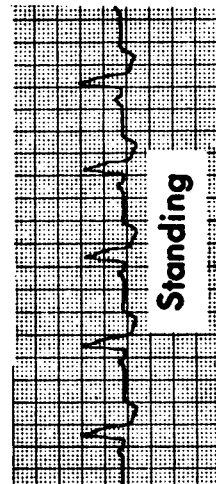
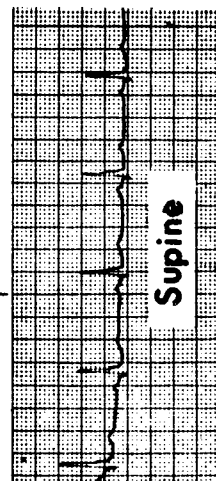
TABLE 3. All patients had electrocardiographic evidence of myocardial infarction. Additional abnormalities during exercise testing were recorded in three patients.

Patient	Area of infarction by electrocardiogram	Additional ECG changes during exercise or recovery
R. C.	Inferoseptal and lateral	Ventricular extrasystoles
T. B.	Inferoseptal	None
D. C.	Anteroseptal and anterolateral with peri-infarction block	None
L. P.	Posterior	None
W. G.	Inferoseptal	None
A. B.	Inferoseptal	Intermittent
C. D.	Inferoseptal	complete LBBB
H. B.	Anteroseptal and anterolateral	None
C. Y.	Anteroseptal and anterolateral	None
U. R.	Posterior	None
R. G.	Anteroseptal	None
W. S.	Anterolateral and high lateral	None
L. G.	Posterior and posterolateral	"Infarct PVC"
G. H.	Anteroseptal and anterolateral	None
L. J.	Inferoseptal	None
A. O.	Anteroseptal and anterolateral	None
W. E.	Anteroseptal	None
P. E.	Anteroseptal and anterolateral	None
H. S.	Inferoseptal	None
L. C.	Anteroseptal	None

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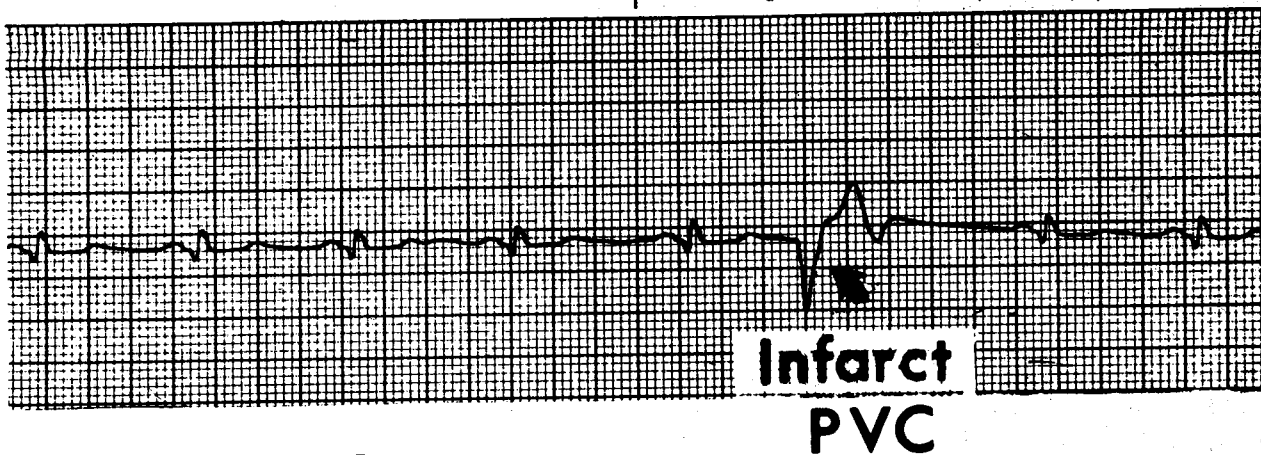


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C.D. 43 w m

Figure 1. This representation of the oblique-lead ECG recorded during exercise demonstrates a regular rhythm with QRS complexes compatible with an old posterolateral myocardial infarction. A single ventricular extrasystole was recorded had the configuration of an "infarct PVC".



L.G. 43 w m

FIGURE 2. The oblique-lead ECG was compatible with a moderately recent inferoseptal myocardial infarction. In the June 2, 1964, evaluation, the patient maintained a similar ECG complex without any alterations in the rhythm during the test. Immediately after exercise, he developed a widened QRS interval with depression of the ST-junction and inversion of the T-wave. This was interpreted as a complete left-bundle branch block and as representing a possible ischemic response. The abnormality persisted for 47 seconds before his normal ECG pattern returned. In February, 1965, the QRS interval was normal at rest. On standing, a complete LBBB configuration developed and persisted throughout exercise and during the first 2 minutes of recovery. Later, the normal QRS configuration returned, and it was observed that the complete LBBB complex could be induced by the patient tilting his head forward while he was supine.

The time interval from the date of myocardial infarction to the onset of physical conditioning varied widely (Table 1). One patient (R. C.) began a program of gradually increased daily activity 9 weeks postinfarct, while there was an interval of at least 3 years in three of the patients (D. C., A. O., and H. B.). The remaining 16 patients entered the program from 3 to 13 months after infarction.

All the subjects performed the exercise test without experiencing angina pectoris. The most common reasons for terminating testing were dyspnea and fatigue. In addition, none of these men have experienced angina while participating in the exercising sessions. One patient (R. C.) once ingested three nitroglycerin tablets during the hour prior to exercising. He had a syncopal episode following exercise. This episode was attributed to vasodilatation with pooling of blood that was potentiated by a combination of drug therapy and exercise.

Very few additional electrocardiographic abnormalities were recorded during exercise in the group (Table 3). Two subjects did have ventricular extrasystoles, one of which was characteristic of an "infarct ventricular extrasystole" 9

(Figure 1). One patient had an episode of intermittent complete left-bundle branch block that followed exercise on one occasion and that was associated with postural changes on another occasion (Figure 2).

The anticoagulated patients did not experience any episodes of hemorrhage or bruising during participation in the program. One patient (L. G.) did sprain his ankles easily but he did not have any hemarthroses.

All the patients performed work-capacity tests without complications. The mean exercise time before physical conditioning was 12 minutes at an energy demand approximately 5 times the work of rest. Two patients did not complete the entire 18-minute test after 3 months of conditioning while the remaining 18 did.

The original volunteer has participated for 2 years. Ten patients remained in the program in excess of 4 months. Of those patients who have discontinued physical conditioning (Table 4), four moved to other communities; one discontinued at the request of his supervisor; one took a 3-month leave of absence because of family commitments; and three have died. One patient terminated conditioning be-

TABLE 4. Ten patients have discontinued their conditioning program for a variety of reasons.

Patient	Reasons for discontinuing program
T. B.	Moved
D. C.	Job conflict
L. P.	Moved
C. D.	Job conflict
H. B.	Depression
W. S.	Suicide
L. G.	Sudden death
A. O.	Joint pain
W. E.	Moved
H. S.	Supervisor's request

cause he was depressed. The first death occurred suddenly in T. B. 7 weeks after he discontinued the program; the second was a suicide (W. S.); and the third patient (L. G.) died suddenly while he was still an active participant. The two sudden deaths were attributed to acute myocardial infarctions. Unfortunately, post mortem examinations were not performed.

The attendance varied from 38% by W. S. to 98% for R. C. The average attendance was 76%.

Three of the patients have been rehospitalized five times. R. C. was hospitalized for 1 week following his syncopal episode, during which his ECG and serum enzyme determinations were normal. L. P. was hospitalized twice for short intervals for treatment of acute peptic esophagitis. A. B. was hospitalized once for acute renal colic and once for surgical excision of a benign breast mass.

Nineteen of the twenty patients returned to full-time employment. One patient T. B., was an unskilled laborer who could not find new employment. U. R. was eventually retired from the civil service because of age and service. At least two of the subjects have returned to jobs that were more physically demanding than those they held prior to the onset of the illness.

V. Discussion.

This study was designed so that cardiac patients could be evaluated over an extended period of time under relatively controlled conditions in an attempt to assess the effects of regular physical conditioning on their clinical courses. These patients have been matched for age with another group of sedentary cardiacs so that their long-term clinical courses can be compared. The approach used in this study has several advantages. The oxygen requirements for the work-capacity test can be quantitated

enabling the investigator to compare the intraindividual and interindividual observations over time. The amount of energy expenditure required in performing the activity program can be estimated or quantitated, and an assessment can be made of the minimal amount of conditioning necessary to produce a desired physiologic response. The program serves as a source of motivation and initiative for the patients to condition themselves.

Even though it is too early to arrive at any definite conclusions concerning the role of physical conditioning for the nonsymptomatic cardiac patient, several interesting observations have been recorded. Many patients who recover from myocardial infarctions are sufficiently motivated to enter a long-term physical-conditioning program. The incidence of complications has been relatively low during the first 2 years. Although all the patients reported a subjective feeling of improvement and benefit, it is likely that physical conditioning may not benefit every nonsymptomatic cardiac patient. The ability to develop improved cardiopulmonary efficiency through conditioning is probably limited by the severity of the underlying atherosclerotic process and by the ability to develop interarterial coronary anastomoses and collateral circulation. It is anticipated that with further experience the pattern of the physiologic response recorded during the work-capacity test will make it possible to distinguish between subjects who might be, versus those who might not be, physically conditioned.

VI. Summary.

Twenty men who have recovered from well-documented episodes of myocardial infarction have participated in a physical conditioning program for 3 months or longer. Their

physiologic adjustments were evaluated with a work-capacity test before and periodically during the program. One patient has participated regularly for 2 years and has been demonstrated to have a higher peak-oxygen intake after conditioning than he possessed before suffering a

myocardial infarction. Three patients have been rehospitalized a total of five times for minor problems. Nineteen patients returned to full-time employment. Three patients have died, two of recurrent myocardial infarctions and one of suicide.

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