EXERCISE THERAPY IN CORONARY DISEASE*

HERMAN K. HELLERSTEIN

Associate Professor of Medicine
Western Reserve University School of Medicine
Associate Physician
University Hospitals of Cleveland
Cleveland, Ohio

FOR the past few decades, work physiologists, physical educators, and human ecologists have emphasized that modern American life is hypokinetic and excessively sedentary, and that it contributes to the development of certain degenerative diseases. Man today tends to eat too much, smoke too much, and do too little physically. Such habits are probably dangerous because there appears to be a significant relation between such habits and the premature development of coronary heart disease.

The beneficial effects of exercise have been amply substantiated by reports on the training of normal fit and unfit subjects. However, physical training has not as yet found acceptance in this country as an integral part of the management of the patient with a myocardial infarct. Richard W. Eckstein[1] demonstrated that exercise induced coronary collateral circulation in dogs with minimal narrowing of the coronary arteries. In other dogs with moderate and severe coronary narrowing, greater collateral circulation developed. Similar experimental work on the beneficial effect of exercise on experimental atherosclerosis has been done on chickens and rabbits. Eckstein suggested that, by extrapolation, his findings could perhaps be applied to the treatment of patients with coronary atherosclerosis by using exercise to improve their coronary collateral circulation and thereby to enhance the adequacy of their coronary circulation.

In the past six years my associates and I have been engaged in a feasibility study to determine whether it is possible to interest habitually

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sedentary lazy, hypokinetic, sloppy, endomesomorphic, overweight males to adhere to a program of enhanced physical activity, and whether this program would be associated with evidence of some retardation of the effects of atherosclerosis, particularly in terms of the end point, death, or of reduced morbidity. In addition, we were interested in whether activity would modify the thrombotic incidence in highly coronary-prone subjects.

The purpose of our study basically was to determine whether we could add life to years and perhaps add years to life. I am paraphasing the comments made by Samuel Fox earlier in the program in regard to the importance of the *joie de vivre*. In addition, we hoped to learn how these effects were mediated—whether by direct effect on the myocardium or collateral arterial development of the heart, or by extracardiac effects on the central nervous system, hormonal balance, over-all and specific metabolic processes, or even on the skeletal musculature.

The study population included both coronary-stricken subjects and highly coronary-prone subjects, with the purpose of testing the feasibility and efficacy of a multifaceted active intervention on the progression or development of coronary artery disease and its sequelae, i.e., secondary and primary prevention respectively. The inclusion of ostensibly normal subjects, without manifest coronary disease, is predicated upon the findings of prospective epidemiologic surveys that certain host factors are consistently associated with a high risk of developing coronary disease, viz., elevated serum cholesterol, elevated blood pressure, obesity, cigarette smoking, physical inactivity, abnormal carbohydrate metabolism, and possibly psychologic patterns.

At the onset of the study we made no attempt to gather a true, random control. We were content to take a comparison group of similarly matched individuals who were studied in terms of physical fitness and who had been followed over the past years.

The design of our study was purposely comprehensive, with primary emphasis upon the enhancement of physical fitness. In recognition of the importance of nutrition, we attempted to persuade our patients to attain a normal body weight by reducing the intake of saturated animal fats. We recommended that they abstain from the use of tobacco and, more important, that they continue a normal, social, and work mode of life; lastly, that they obtain an adequate amount of rest and sleep.

METHODS

The subjects were white, middle-aged, middle and upper class businessmen, executives, managers, and professionals who were referred to the program by their physicians. They continued to look to their private physicians at least once a year for over-all medical care. In the past some individuals have been studied at the Cleveland Y.M.C.A.; however, most of the present subjects were studied in collaboration with the Jewish Community Center of Cleveland, Ohio. The subjects referred to the program were judged medically, with particular emphasis on the cardiovascular system, both physically and psychologically.

The population of the study group consisted of 656 middle-aged men, of whom 254 have coronary artery disease. The latter have been followed for a total of 697 subject years, with an average of 2.7 years. We have not accepted subjects with uncompensated congestive heart failure or severe vascular disease. In the study population there are subjects with severe angina pectoris controlled by nitroglycerin, and some with left bundle branch block. A few have complex arrhythmias, such as a Wenckebach-type second-degree block, and one has an atrially driven artificial pacemaker. The 402 normal coronary-prone subjects had an average age upon intake of 45 years. The subjects with arteriosclerotic heart disease had an average age of 49 years. A historical review indicated that since the age of 25 there had been an average gain in weight of 19 pounds. At the time of intake 28 per cent were more than 15 per cent overweight. Thirty-two per cent were professionals, 20 per cent business people, and 22 per cent of the managerial class. All were employed in sedentary occupations. Their physical fitness was low compared to Scandinavians of the same age and sex. Their lipids in general were high. They worked more than 50 hours a week. Forty-seven per cent of the subjects smoked cigarettes. In terms of personality and the Minnesota Multiphasic Personality Inventory (MMPI) scores, there was a high degree of depression, hypochondriasis, and hysteria. According to the Rosenman-Friedman classification, 72 per cent of the subjects were of the Type A variety.

There were 254 subjects with arteriosclerotic heart disease, of whom 203 had clinically documented angina pectoris, myocardial infarction, or angina pectoris and myocardial infarction. There was another group consisting of 51 subjects who have "silent coronary artery disease," who had QRS changes consistent with the Minnesota Code for myocardial infarction and abnormal exercise electrocardiographic tests with ischemia but who never had a clinically documented episode. Of the subjects with obvious coronary disease, 60 per cent had angina pectoris.

A detailed analysis of 100 subjects with arteriosclerotic heart disease will be presented in regard to the quantitative changes in the exercise electrocardiogram and in physical fitness. Data on survival and changes in lipids and other parameters will be presented for a larger segment of the study population.

Medical analysis. The study plan includes an initial study of the subjects, a period of physical conditioning, and scheduled periodic re-examination.

Medical history. Medical cardiovascular records included detailed personal history of coronary disease both in the subject and in his family. Subjects were specifically questioned about the presence of previously documented myocardial infarcts, angina pectoris, dyspnea either at rest or with exertion, ankle edema, and other signs of congestive failure. They were questioned about the presence of diabetes mellitus, gout, peptic ulcer, and hypertension both in their families and in themselves. A detailed history of cigarette smoking and other usage of tobacco was obtained.

Physical examination. Cardiovascular physical examination included examination of the ocular fundi, chest, heart, and condition of arterial pulses. At the beginning of the examination blood pressure was measured in the sitting position with mercury sphygmomanometer in the right and left arms, and in the left arm after 10 and 15 minutes. Perception of pain was estimated by response to pressure over the styloid process. Height and weight were measured, and the size of the body frame was estimated by measurements of the depth of the chest, the width of the shoulder, chest, and hip, and the girth of the ankle. The amount of subcutaneous fat was estimated by caliper measurement of vertical fat folds on the cheek, abdomen, iliac crest, buttock, posterior thigh, anterior thigh, and triceps. Somatotype was determined from photographs. The percentage of overweight was computed according to tables established by the Metropolitan Life Insurance Company.

Laboratory findings. Total and one-second vital capacity were measured on a vitalometer. A standard 12-lead electrocardiogram was taken. Electrocardiographic response to a Flack test or Valsalva maneuver was recorded. Blood was obtained and analyzed for total serum cholesterol by the method of A. Zlatkis[2] as adapted to semiautomated analysis.

Diet. Each subject completed a seven-day diet form in which he recorded an exact description of everything that he ate. Food portions were measured volumetrically or weighed on a scale by the subject. Detailed food records were analyzed by computer at the Instrumentation Field Station of the Heart Disease Control Program, Division of Chronic Diseases, U.S. Public Health Service, in Washington, D.C., and exact values of carbohydrate, protein, and fat intake were determined. The subject and his wife were then counseled by a dietician and instructed in methods of preparation of palatable, low-cholesterol meals with fat content less than 35 per cent of the total caloric value.

Physical activity. An estimate of the physical activity of each subject was made by determining the number of hours per week spent in sports, calisthenics, and running. The amount of physical activity performed by the subject during his employment was noted and determined calorically by reference to previously established tables of known requirements of energy for work.

Studies outside the laboratory. On one or two of his typical working days each subject wore a portable electrocardiographic electromagnetic tape recorder (Avionics). Dime-sized silver electrodes (Epsco) were fastened to the subject's chest in the V-4 and V-4 R positions in the fifth intercostal space and the electrocardiogram was monitored over a 24-hour period. The subject concurrently kept an exact journal of the nature and times of his daily activities and his attitudes toward them.

Evaluation of coronary proneness. The extent of coronary proneness of each individual was assessed by noting the number of "coronary-prone" characteristics which he possessed. These included documented past history of coronary heart disease; present history of angina pectoris and signs of congestive heart failure; hypertension; high-fat diet; cigarette smoking; obesity; degree of endomesomorphy; personal or family history of diabetes mellitus, peptic ulcer, or gout; unexplained abnormality of vital capacity; nonspecific changes in the resting electrocardiogram; ischemic ST-T changes in the exercise electrocardiogram; and serum cholesterol (greater than 250 mg. per 100 ml.).

Evaluation of coronary arterial circulation. A select number of subjects have been studied in collaboration with Eugene Z. Hirsch and Cathel MacLeod; myocardial oxygen consumption, coronary artery flow, and lactic acid production were measured before and after training. In addition, triglyceride and cholesterol turnovers are being evaluated.

Determination of physical fitness. Physical fitness was assessed with a modified von Dobeln bicycle ergometer. A blood pressure cuff attached to a mercury sphygmomanometer was placed on the upper left arm. The subject sat on the bicycle for at least three minutes; after this three blood pressure readings were recorded in rapid succession. The subject then underwent a 45-second period of hyperventilation during which the electrocardiogram was recorded. Each subject then pedaled for a period of six minutes and rested for four, beginning at a level near 300 kilopond meters per minute (KPM/min.) and increasing by increments of 150 KPM until a heart rate of 150 beats per minute was reached. A subject who was considered relatively physically fit initially underwent a period of empty exercise, i.e., pedalling against no resistance for at least four minutes, after which he began exercise at either 450 or 600 KPM. Electrocardiograms were taken at intervals of a minute, both during work and rest. Blood pressure was measured in the left arm during the first and fifth minute of work and during the third minute of rest.

Physical fitness was characterized by the physiological variables: heart rate, blood pressure, and their derivatives HR $\times$ SBP (heart rate times systolic blood pressure), Work Load 150, and predicted maximal oxygen uptake. Predicted maximal oxygen uptake per kilogram of body weight (ml.O_2/kg. B.W./min.) was calculated according to the methods of Astrand and L. Anderson. Work Load 150 per kilogram body weight (WL 150 KPM/kg. B.W./min.) was calculated according to methods previously described. A minimal heart rate of 135 was used to extrapolate to Work Load 150. An indirect measure of myocardial oxygen consumption was obtained from the product of heart rate (HR) and systolic blood pressure (SBP), HR $\times$ SBP, which was computed for the last minute of exercise at each work level and expressed in units times 10^2 power.

Our experience indicates that untrained normal subjects and untrained cardiacs have higher blood pressure for the same level of work than trained normal subjects. This constitutes the entity called "exertional hypertension." Thus untrained normals and untrained cardiacs have a higher blood pressure for the same work load, which indicates that the myocardial oxygen demand is greater than that which is imposed

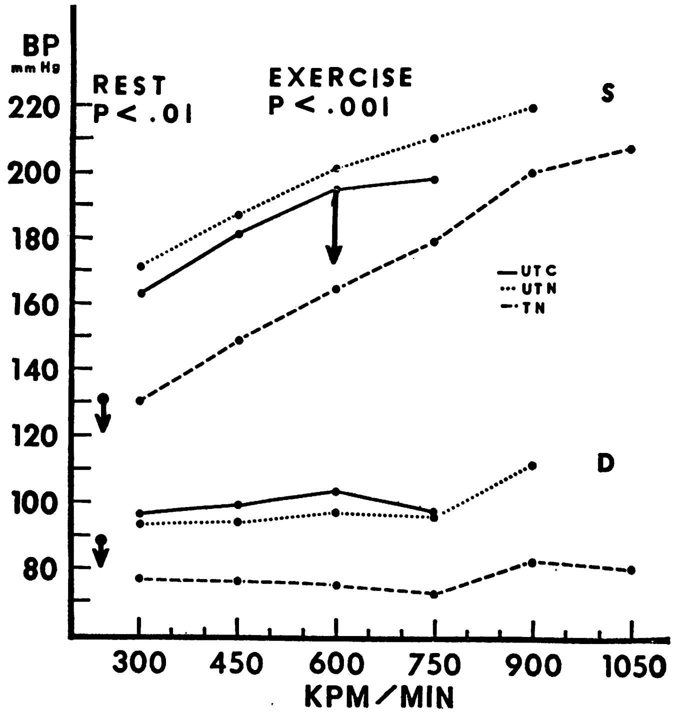

Fig. 1. Blood pressure during steady state exercise is lower in trained normal subjects than in untrained subjects (N = normal, C = cardiacs). The vertical arrow shows the improvement of blood pressure after participation in a conditioning program.

by the same work load on a trained subject (Figure 1).

The exercise electrocardiograms were analyzed according to the method of Lester *et al.*, namely, in terms of ST-J displacement and the slope of the first 0.08 seconds of the ST segment. A small transparency (Figure 2) placed over the electrocardiographic record facilitated the measurements of ST-J displacement (in millimeters) and slope of the ST segment in (millivolts/second).

Electrodes for electrocardiographic monitoring were arranged according to a modified system of Arbaquez *et al.* with the right arm electrode placed on the forehead, the left arm electrode at the ensiform process, the left leg electrode at the V-6 position, the chest electrode at the V-4 position, and the right leg ground electrode at the V-4-R position. Electrocardiograms were taken with the unipolar leads aVR, aVL, and V and bipolar lead CR.

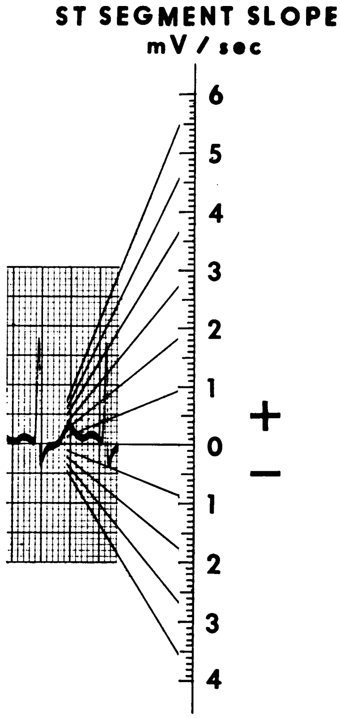

Fig. 2. Technique to measure displacement of the ST junction and the slope of the 0.08 second ST segment—according to the method of F. M. Lester *et al.*[7]

Standard plate electrodes were used and the recordings made on a Sanborn 500 Viso-cardiette with a time constant of three seconds. Electrocardiograms were recorded at a paper speed of 25 mm./second. The sensitivity was usually 1 cm./mv.; if not, the appropriate values were corrected to that sensitivity. The leads used for analysis were C4V, CH6, and C4R. A single complex during exercise which was picked for analysis was typical of those complexes during a period of several seconds. On no occasion was a single unusual beat measured. The measured complex was one showing the greatest ST-J displacement and the least positive ST segment slope for the given work load. This usually occurred during the last minute of exercise. The criteria for judging the exercise electrocardiograms are displayed in Figure 3. The abnormal category included a ST-J displacement of 0.01 mv. or more with a zero or negative slope. Each lead for every work level was categorized as

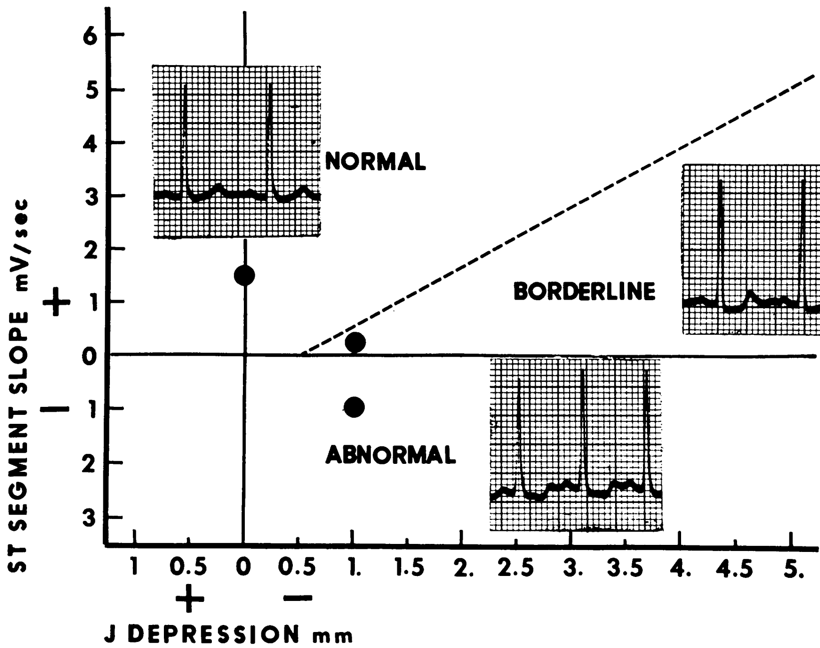

Fig. 3. Distribution of ST junction depression and of slope of 0.08 second ST segment in normal, borderline, and abnormal responses to exercise.

being normal, borderline, or abnormal. The EKGs of follow-up tests were evaluated in the same manner, and comparisons between tests were made for the same lead at identical external work loads. Improvement or deterioration of the exercise EKG was judged by a change of EKG category.

Psychological evaluation. Psychological evaluations have included a structured interview by a trained staff member, and the Holzmann ink-blot test and the MMPI. Special attention was paid to the level of the score on the Depression (D) scale and the relationship of the scores on the Hysteria (Hy) and Hypochondriasis (Hs) scales to the D score.

Subjects with coronary disease were found to have a high degree of depression as judged by the MMPI profile. Our subjects had an average profile similar to those of Class II-C and II-B subjects with arterio-sclerotic heart disease studied in the Cleveland Work Classification Clinic between 1950 to 1963 (Figure 4). It was apparent that the more serious the coronary artery disease, the higher were the depression

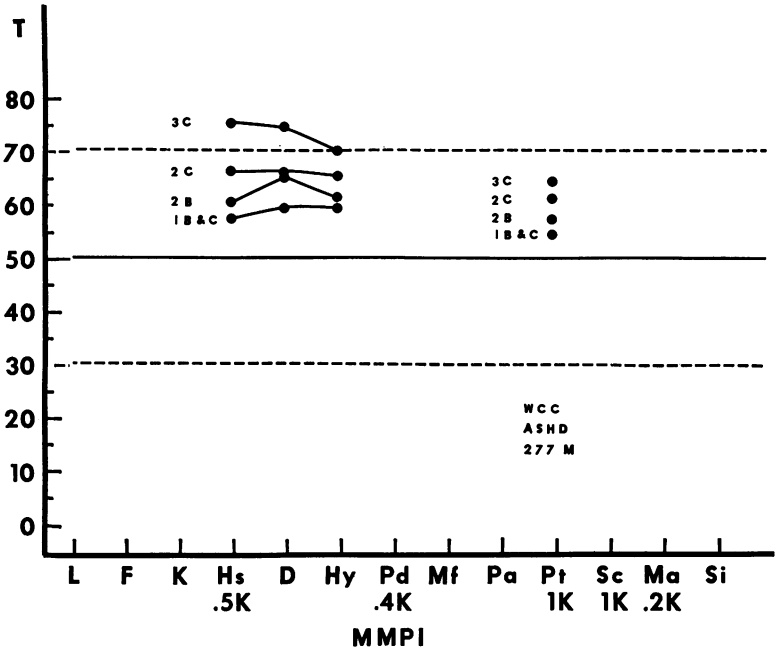

Fig. 4. Relation of therapeutic and functional classification of 277 ASHD men to 4 scales of the Minnesota Multiphasic Inventory—namely, Hypochondriasis, Depression, Hysteria, and Psychasthenia.

scores (Figure 5). The subjects who had angina pectoris and myocardial infarction had a higher depression score than those who had infarction or angina pectoris alone. This relation also held true for the psychasthenia scale.

Methods of conditioning. After each patient had been studied, a program was formulated to enhance his over-all fitness. Physical reconditioning was a part of a comprehensive positivist program, which included improvement of nutrition, attainment of normal body weight, adequate rest, abstinence from the use of tobacco, and continuation of gainful employment and of a normal social mode of life.

After the analysis each subject was counseled by a study physician, a dietician, and a physical educator. A specialized program involving exercise, weight reduction, diet, and abstinence from smoking was formulated for each subject, with the approval of his personal physician.

Exercise prescription. The general principles of reconditioning that can be applied at all ages and in all states of health were followed. An

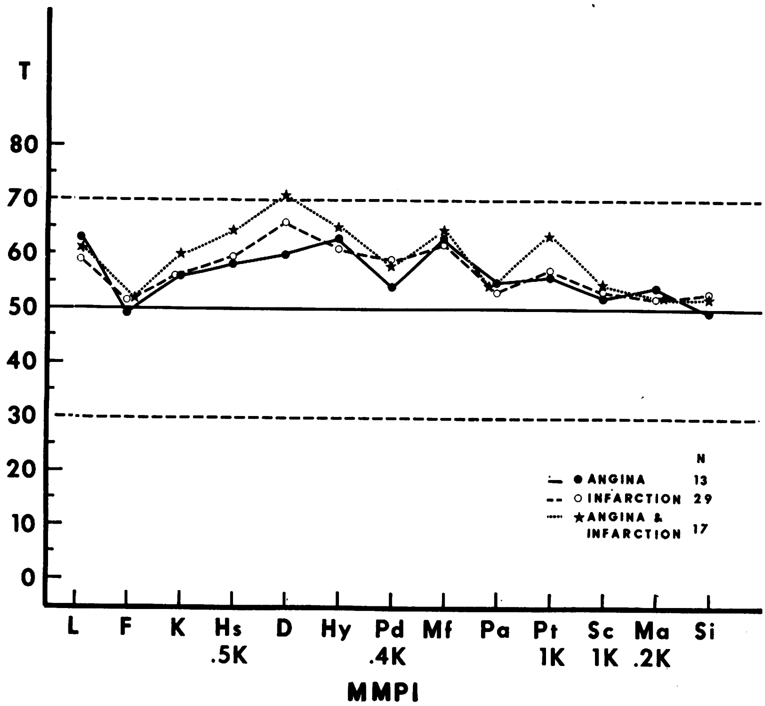

Fig. 5. Relation of scores on the MMPI to severity of arteriosclerotic heart disease.

exercise prescription was compounded to stress each subject to approximately 60 to 70 per cent of his aerobic capacity.

Exercise began gradually at a level commensurate with the subject's state of physical fitness and progressed slowly over a period of months to more physically taxing levels. The levels of physical fitness initially were low in both the normal coronary prone subjects and in those with arteriosclerotic heart disease (Figure 6). The exercise prescription consisted of calisthenics for strength, run-walk sequences for endurance, and recreational exercise for fun. The calisthenics consisted of warm-up exercise involving the shoulders and arms; strenuous high-oxygen cost activities, i.e., hops, leg exercises, sit-ups and push-ups; and cooling-down arm and shoulder exercises. Upon entering the program most individuals began by performing one-half to two-thirds of each series of exercises. Exercises necessitating straining and the Valsalva maneuver were proscribed for men with coronary heart disease or documented hyperactive carotid sinus reflexes.

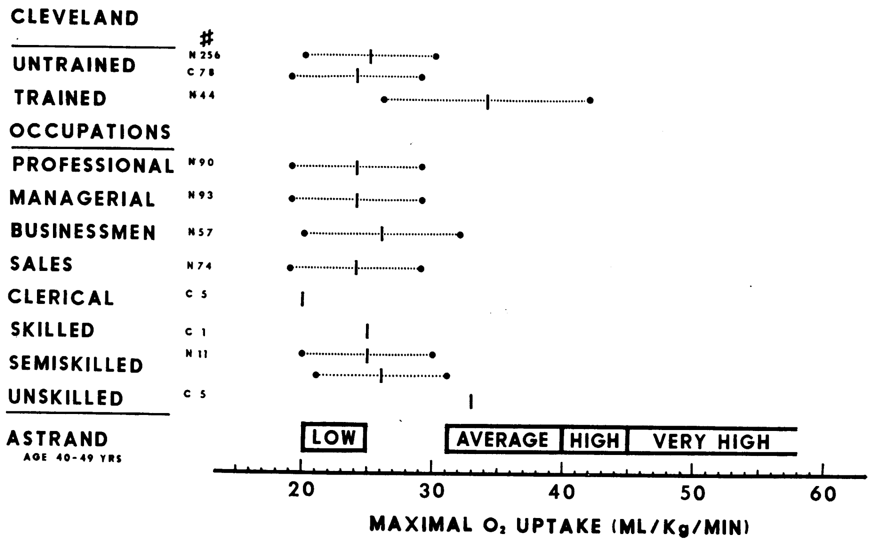

Fig. 6. Maximal oxygen uptake of study subjects on intake in the conditioning program was low compared with Astrand's Swedish males.

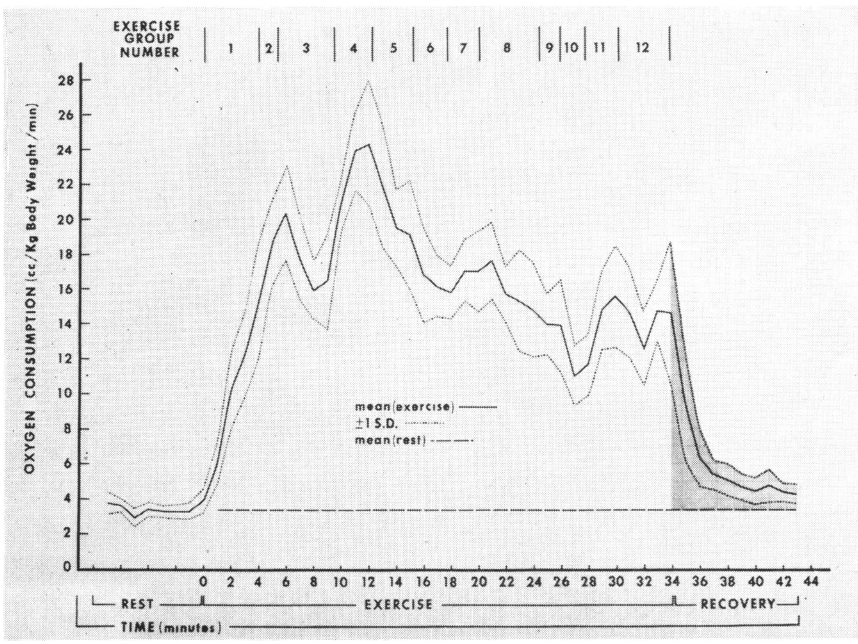

Fig. 7. Oxygen cost of consecutive performed calisthentics done routinely in the Western Reserve Physical Fitness Program. Exercise numbers signify performance of the following exercises: 1) shoulder exercises, standing, warm-up; 2) hops, walk steps; 3) arm sweeps, standing; 4) hops, sailor's hornpipe; 5) body bends; 6) leg exercises, supine; 7) leg-arm-hip exercise, sitting on floor; 8) leg exercises, lying on side; 9) leg exercises, bicycle movements, supine; 10) sit-ups; 11) push-ups; and 12) shoulder exercises, standing, cool off.

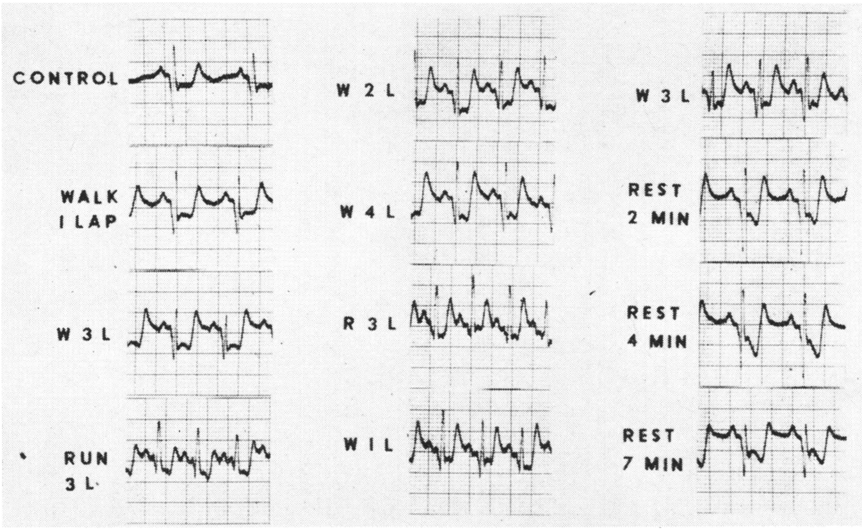

Fig. 8. Radio-transmitted electrocardiograms recorded during walking (*W*) and running (*R*) of a cardiac subject. Note that ST displacement decreases when the subject runs and recurs at rest. (*L* indicates 1/18 of a mile.)

Run-walk sequences were initially prescribed at low levels of work and were gradually increased until a subject could run a mile. Recreational activity, i.e., basketball, volleyball, swimming, bag punching, etc., was advocated but highly competitive games demanding sudden spurts of energy were proscribed.

The caloric expenditure of full participation totaled approximately 400 calories per hour. Calisthenics required 200 calories over a 30-minute period (Figure 7); run-walk sequences 120 calories over a 15-minute period; and recreation, 80 calories, over a 15-minute period.

Monitoring the subjects with electrocardiographic telemetry has provided valuable information regarding the individual's fitness and the validity of the prescription for exercise based on performance on the bicycle ergometer. Initially many ASHD subjects showed arrhythmia, or displacement of the ST segment, often of great magnitude. These usually subsided during continued effort; they demonstrated the walk-through angina pectoris described by A. Kattus (Figure 8). The prophylactic use of nitroglycerin was encouraged in symptomatic subjects.

Monitoring of blood pressure after exercise also has been informative in confirming the presence of exertional hypertension.

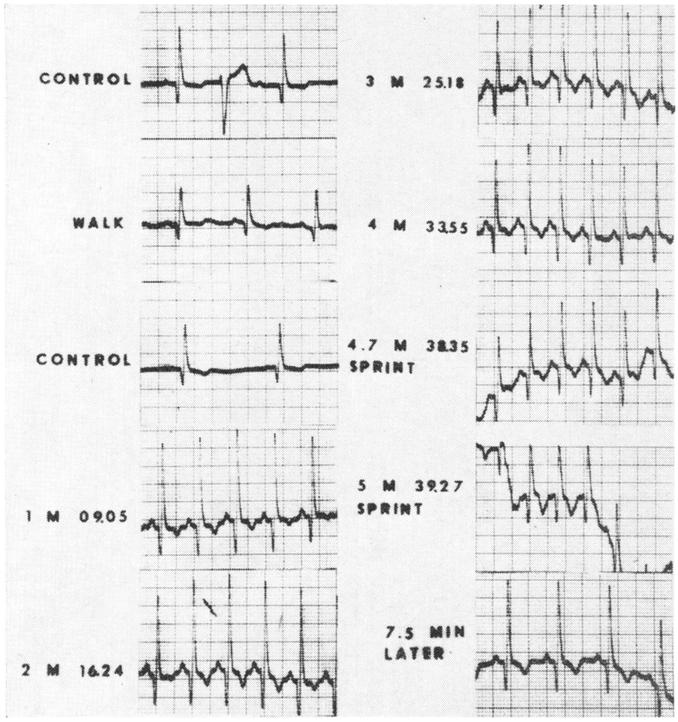

Fig. 9. Radio-transmitted exercise electrocardiograms of a physically trained 42-year-old business man with a posterior myocardial infarct. During a 5-mile run in 39 minutes there were no significant changes in the electrocardiograms.

Supervision and follow-up. Each subject attended exercise classes at the Jewish Community Center of Cleveland at least three times a week. The subject kept a record of his attendance and made a note of comments or reactions to the program of exercise. A staff physical educator examined the records kept by the subject at monthly intervals and determined whether he was ready to progress to a more strenuous level of work, Exercising subjects with heart disease were carefully supervised by trained physical educators. Complete rexamination of subjects with heart disease including bicycle ergometry and psychological testing were carried out at six-month intervals, and progress was assessed.

Representative examples of monitoring are presented in Figures 8 and 9. Figure 9 shows the performance of a 42-year-old subject, a business man, who has a documented myocardial infarct. This patient has trained to the point that he is able to run five miles in 39 minutes without

TABLE. WRU-JCC FITNESS STUDY OF ASHD

Item	*Initial*	*Follow-up*	*P<*
Cholesterol (mg./100 ml.)	263.5	242.1	0.01
Blood pressure (mm. Hg)	s 129.9	121.7	0.01
At rest	d 86.8	84.3	0.05
During exercise	s 191.3	171.6	0.001
Maximal 0_2 uptake (ml. 0_2/kg. BW/min.)	23.2	28.9	0.01
Work Load 150 (kpm./kg. BW/min.)	8.1	9.8	0.01
SBP x HR x 10^2 During exercise	248.3	192.7	0.001

ischemic changes or discomfort.

Another example demonstrates the blood pressure lowering effect of effort. This is quite similar to the observations of Jiri A. Kral *et al.* in Belgrade.[3]

RESULTS

Of the 656 subjects in the program, 254 were categorized as having coronary heart disease (angina pectoris, documented myocardial infarction, or both). These 254 subjects have been followed for 697 subject years with an average follow-up of 2.7 years.

The results of an active conditioning program on a subgroup of 100 of the 254 men with coronary disease were analyzed in greater detail. The average age was 48.8 years and the average weight 81 kg. The subjects were followed for a period of 305 subject years with an average follow-up of 36 months. Seventy-five per cent of the subjects adhered to the program. There was an average weight loss of 2.5 kg. of body weight, which was not considered biologically significant.

Physical fitness was significantly improved and sustained during this period in 65 per cent of the subjects. In the subjects who initially had abnormal electrocardiograms, 63 per cent improved their exercise EKG. The electrocardiographic responses to exercise improved in 79 per cent of the subjects who improved their physical fitness.

The changes in Work Load 150, maximal oxygen uptake, and blood pressure at rest and during exercise are listed in Table 1. The WL 150 and maximal oxygen uptake rose significantly and the exercise systolic blood pressure decreased.

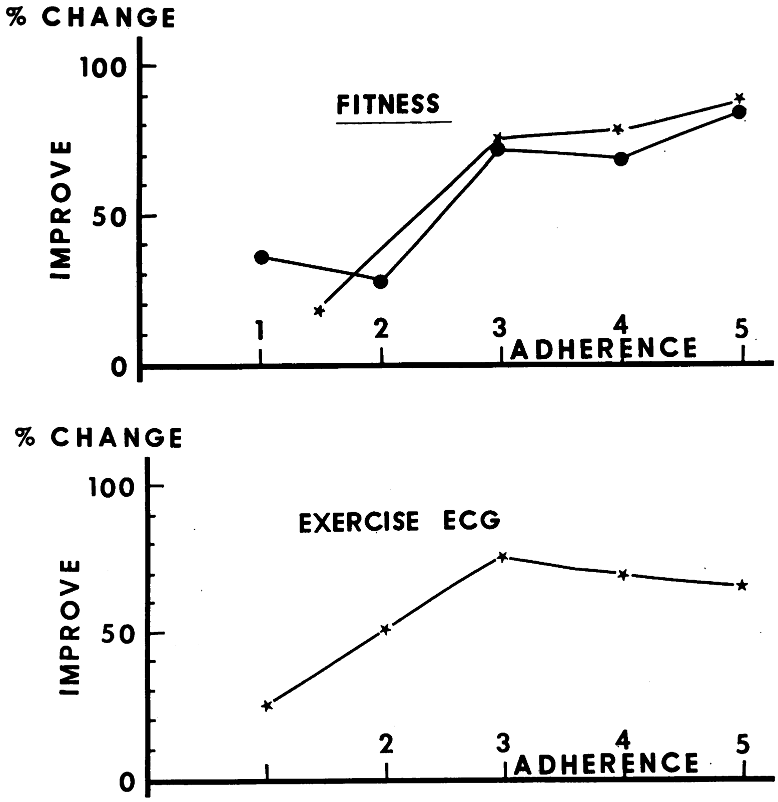

Fig. 10. Relation of adherence to training program to improvement in physical fitness (*A*), and in the exercise ECG (*B*). The stars indicate subject with abnormal exercise electrocardiograms on entry into the program. The solid dots represent the total ASHD population.

Sleeping pulse rate. The average heart rate was not only lower in the more fit subjects during exercise, but also during sleep. The average heart rate during sleep was approximately 20 beats per minute lower in the most fit subjects than in the least fit subjects, 52 and 72 beats respectively.

Adaptation to training was not always associated with changes in exercise blood pressure and heart rate; the majority of subjects improved in both parameters. There were many subjects who improved in only one parameter.

Heart rate $\times$ systolic blood pressure product: Estimated myocardial oxygen requirement. The improvement of this product in the subjects who adhered to the training program indicates that after training a subject can perform more external work before the oxygen consumption of his heart attains a given level. Put differently, since a given work load can be performed with a lesser myocardial oxygen consumption after training, performance of the heart may be "more efficient." In addition to the reduction of the product, there is also a significant reduction in exercise blood pressure. Since the cardiac output does not change significantly after training, and since the heart rate is lower during exercise, the stroke volume increases significantly. In addition, arterial-venous oxygen extraction by the skeletal musculature also increases.

Adherence. From the over-all results, it was quite apparent that adherence to the training program played an important role in the response in the electrocardiographic, heart-rate, and blood-pressure parameters. Adherence to the training program was judged independently by the physical educators. Performance records were kept for each attendance, so that it was possible to judge the subjects objectively. As indicated in Figure 10, significant improvement in exercise EKG and in fitness developed in subjects graded 3 to 5 adherence (2.2 to 3 hours per week of faithful attendance in the physical training program). The subjects who improved their physical fitness enhanced the likelihood of improving their exercise electrocardiogram. We reasoned that this occurred because trained subjects have a lower blood pressure and heart rate for the same work level and hence the oxygen demand (systolic blood pressure × heart rate product) is lessened. Sufficient data are not available to determine whether the development of inter-coronary collateral channels also contributes to the improvement of cardiac function.

Psychological changes. Psychologically the group as a whole appeared to improve, subjectively and objectively. The spouses of the subjects were enthusiastic because of the change in the personality and the greater ease of cohabitation. The decrease in the D score was significant at the 1 per cent level. On a subjective basis, many subjects insist that they can "think" better, sleep better, feel less tense and fatigued and, in general, have more pep and zest for life. Improvement of the psyche after physical training has also been noted by other investigators.

Mortality rate. The usual mortality rate of comparable coronary subjects treated in the traditional manner ranges from 4.5 to 6.0 per hundred patient years. In the present study the death rate is lower.

Eleven subjects with coronary disease have died; the death rate was 1.95 per 100 per year. At present we do not attempt to attribute statistical significance to these results because in the feasibility study no attempt was made to randomize the subjects. However, we can say with reasonable certainty that the mortality rate of physically conditioned coronary patients is not greater than subjects who do not undertake such a program.

Discussion

The present study demonstrates that an active intervention program of conditioning including exercise, weight reduction, diet therapy, and cessation of smoking is feasible, reasonably acceptable, and appears to be of benefit in the treatment of patients with coronary heart disease.

The improvement in the parameters indicates that the subjects with coronary artery disease who participate in an exercise program can be trained to do more work with fewer heart beats, lower heart rate and blood pressure, and greater stroke volume. Further, even during sleep fewer heart beats are required. The adaptation of untrained and of coronary subjects therefore appears to be similar qualitatively but not quantitatively.

The mechanisms of the benefit of physical conditioning of coronary subjects have not been clarified adequately. It is probable that similar adaptations occur in normal persons and cardiacs. Some of the metabolic changes include a reduction in serum triglyceride levels and an increased permeability of the skeletal muscular membrane for glucose (J. A. Holoszy and H. T. Narahara).[4] The effects on glucose tolerance are disputed. The findings of P. C. Davidson *et al.*[5] that drastic physical training of five subjects impaired glucose tolerance have not been corroborated by our studies (with J. Radke), and are at variance with the clinical observation that diabetic subjects who exercise require less insulin.

Other studies have shown that ASHD subjects have higher serum and urinary catecholamines after effort or emotion. The higher exercise heart rate and blood pressure of our subjects before training confirm this finding. The changes in the circulatory parameters after training suggests that a profound alteration of the catecholamine stores or availability has occurred. Whether these changes are confined solely to the heart—labeled recently as an "endocrine organ"—or also involve the central nervous system is speculative at this time. J. J. Schildkraut and S. S. Kety[6] have recently reviewed the role of cerebral biogenic amines and emotion. An attractive hypothesis has been presented that mood is determined in large part by the catecholamine content of important adrenergic receptor sites in the brain; the depression occurs when depletion or inactivation occurs, and elation when the opposite prevails. In the subjects of our study, depression played an important role. The score of the D scale was elevated on intake into the study, and varied directly with the severity of the disease. After training the D score decreased.

The changes in the mood and the cardiovascular system suggest that the training program with its many facets (psychologic, nutritional, physical conditioning, group participation, etc.) has produced significant changes in both the cardiovascular and nervous systems.

There are many unsolved problems in the training of coronary subjects. These include: 1) selection of subjects—especially criteria for exclusion; 2) scientific bases for prescription or proscription of exercise; 3) enhancement of adherence and motivations; and 4) evaluation of structure and function of the coronary arterial circulation.

Summary

Six hundred and fifty-six middle-aged men, of whom 254 have coronary heart disease, have been studied as part of an active conditioning program involving weight control, diet therapy, cessation of smoking, and regular performance of exercise. Detailed evaluation of a subgroup of 100 men with coronary disease revealed that they were able to perform muscular effort more efficiently than before training, i.e., with fewer heart beats, lower blood pressure, and greater aerobic capacity. Ischemic ST-T changes in the exercise electrocardiogram decreased in two thirds of the subjects after a conditioning program. Adherence to the training program played an important role in the response in the electrocardiographic, heart-rate, and blood-pressure parameters.

Although the study program is considered to be still in the experimental stage, it appears that an active, supervised, conditioning program can be used safely in the treatment of selected subjects with coronary heart disease, infarction, and angina, but not in congestive failure.

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