BRITISH PILOT STUDY OF EXERCISE THERAPY

II. PATIENTS WITH CARDIOVASCULAR DISEASE

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ABSTRACT

Two groups of middle-aged men, one with and one without overt cardiovascular disease, were studied while they were taking part in a specially designed course of exercise therapy in a gymnasium. The "patients" group had at least two months pre-treatment to allow physical recovery and mental re-education before their initial very small test dose of exercise. Using short periods of progressive, mainly weight-loaded, isotonic exercises carefully regulated by control of pulse rate and avoidance of symptoms of over-exertion, both groups showed large increases in effort capacity and reductions in resting pulse rate, blood pressure and plasma lipid levels within two months.

The safety of this particular form of exercise was shown in this high-risk population by the low drop-out rate and the absence of cardiovascular accidents in the gymnasium over a ten year period. It is suggested that, given suitable training of the staff and using the safeguards described, the presence of doctors and a cardiac resuscitation team is unnecessary in a gymnasium specializing in cardiac rehabilitation. This makes it possible for rehabilitation and physiotherapy departments throughout the country to carry out this effective and positive form of exercise therapy.

INTRODUCTION

"The wise for cure on exercise depend"
(Dryden, circa 1675)

The prescription of exercise for various forms of cardiovascular disease is not new, as testified by Heberden's famous reference in 1818 to his patient with angina who was "nearly cured" by the task of sawing wood for half-an-hour every day. Again, Stokes in 1854 (1) suggested that "The symptoms of debility of the heart are often removable by a regulated course of gymnastics or by pedestrian exercise". As a treatment for "soldier's heart" gymnastic activity was successfully introduced during the First World War by Sir James Mackenzie. This was such a novelty that half the cardiological establishment of the day attended the first exercise session, and were impressed by the efficacy of the treatment and absence of fatal side effects.

After a period of nearly 50 years, during which vigorous physical activity was regarded as unsuitable for patients with cardiovascular disease, there was a re-awakening of interest during the nineteen-sixties. This happened simultaneously in many parts of the world, including Germany (2), Scandinavia (3, 4), America (5, 6), Israel (7) and the UK (8, 9). The regimens used and results obtained have been reviewed by Kellerman (10), Raab (11) and Sanne (12). Except for the work of Groden (13) and Carson (14), there has been a remarkable absence of practical work in cardiac rehabilitation in Britain, although the joint working party on this subject set up by the Royal College of Physicians and British Cardiac Society may help to establish the recommendations of the World Health Organization (15).

The subjects chosen for this British study were two groups of middle-aged men, one with and one without cardiovascular disease, who were undergoing exercise therapy in a gymnasium. The purpose of the exercise therapy was to obtain maximum fitness rapidly and safely. It had been felt that this combination of exercise and informal group therapy would appeal to the noradrenaline-addicted coronary-prone individual whose restless, driving predisposition to over-activity could be harnessed to the creation of positive health in place of destruction from fatigue and tension (16).

There are several reasons for choosing this particular gymnasium for the study. Firstly, the principle of "do no harm" was a major concern. The gymnasium chosen offered personal supervision by an experienced remedial gymnast, Alistair Murray, who had already developed a carefully regulated and progressive exercise system for

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cardiac patients under the responsibility of one of us (P.N.). The system enabled patients to relate their monitored progress to causes of fatigue and anxiety in their daily lives. Secondly, it was a system amenable to study and quantitation in relation to established physiological methods (17).

SUBJECTS AND METHODS

The subjects studied undertook a course of exercise at the gymnasium, lasting at least two months. They were divided into two groups:

(a) "Volunteers" – Of a total of 1535 middle-aged men attending the gymnasium, not on medical advice, but because they wished to become fitter, 71 volunteered for this part of the study. Their ages were 35-60 (mean 44.2) years. The consent of their general practitioner for them to take part in the study was obtained prior to the first examination. Each attended the Cardiac Department at Charing Cross Hospital for history-taking, clinical examination, electrocardiography at rest and after exercise, and for assessment of left ventricular function by phonocardiography and apexcardiography (18, 19). Fifty-four (76%) were considered to be normal, 10 (14%) to be hypertensive and 7 (10%) had abnormal left ventricular function without hypertension.

At the gymnasium, 63 of the "volunteers" had monthly readings of resting pulse rate and blood pressure, measured with a Hawkesley Zero Muddling Sphygmomanometer recorded for up to six months from starting the training programme.

(b) "Patients" (excluding above). These were a total of 248 males, referred by a consultant cardiologist (P.N.), their ages being 22-74 (mean 52) years, of whom 17 (7%) had cardiac neurosis, 18 (7%) were hypertensive (BP 150/90 or above), 74 (29%) had pre-infarction syndrome i.e. the behavioural changes and progressive painless or painful cardiac disability associated with signs of left ventricular dysfunction (usually a palpable and audible atrial gallop rhythm) that characteristically occur in the six to twelve months before a sudden coronary illness (20, 21). 66 (28%) had ischaemic heart disease without infarction and 73 (29%) were post-infarction patients.

THE PREPARATIONS FOR GYMNASIUM EXERCISE

"Volunteers" usually had begun exercise before tests started, and with two exceptions, those in whom the tests revealed hypertension or early ischaemic heart disease continued to exercise, but were managed as "patients". "Patients", before they visited the gymnasium, underwent at least two months pre-treatment. This period was regarded as a most important part of the rehabilitation programme which, as well as allowing time for recovery from infarction and the rich development of the coronary collateral circulation (22), permitted considerable patient self-examination and education; and taught them techniques for avoiding the overstrained state preceeding breakdown in health in general (23) and regarded as preceeding coronary illness in particular (21). This involved control of anger-provoking situations, and where these could not be avoided, the use of diazepam to remain calm during the day and to obtain adequate sleep at night. Apart from thiazide diuretics in a few patients, no further medication was used.

Although walking at gradually increasing pace and for progressively increasing distances was encouraged during this period, patients were trained to avoid both the physical and the emotional triggers of cardiac pain. Practical experience of rehabilitation quickly taught the lesson that great expansion of cardiac performance was possible only where the patient disciplined himself to avoid producing this pain in his daily life, usually by paying attention to time pressures and sources of anger, frustration, resentment or righteous indignation. We agree with the proposition that conflicts at work and in the family, changes in working conditions, life events of especial importance and absence from work through illness, namely the conditions that predispose to high levels of catecholamine secretion, are especially related to the onset of myocardial infarction and sudden death (24).

Patients were required not to use β-blockers or coronary vasodilators, e.g. trinitrin. They were not nagged to stop smoking or to lose weight until they had recovered from the overstrained state and were actively engaged at the gymnasium. Once there, control could usually be achieved by maintaining a constant calorie intake in the presence of increased energy expenditure. The desires to eat and drink excessively and to smoke subsided as fitness waxed and strain waned.

Towards the end of the pre-treatment period, the patient visited the gymnasium with his wife or another relation. This provided an overall impression of the gymnasium and the chance to discuss any anxieties with the gymnasium staff: The visit allayed fears that the gymnasium activity might be uncomfortable or too strenuous.

When the patients began to attend the City Gymnasium regularly, they were exposed to three influences: Firstly, lessons from the medical and gymnasium staff about the effects of emotional stress and fatigue on cardiac performance. Secondly, informal "group therapy" where new patients and older members could communicate with one another over a cup of caffeine-free coffee in the gymnasium. Thirdly, the influence of the exercise itself.

INITIAL EXERCISE SESSION

After the "volunteers" and "patients" had changed into gym kit, the pulse rate was taken. If this "arrival" pulse rate was over 90 beats per minute, the subject was asked to sit and rest until it had fallen below this level. Then the test dose of five light, mobilizing exercises illustrated in fig. 1 were carried out to ease all the major

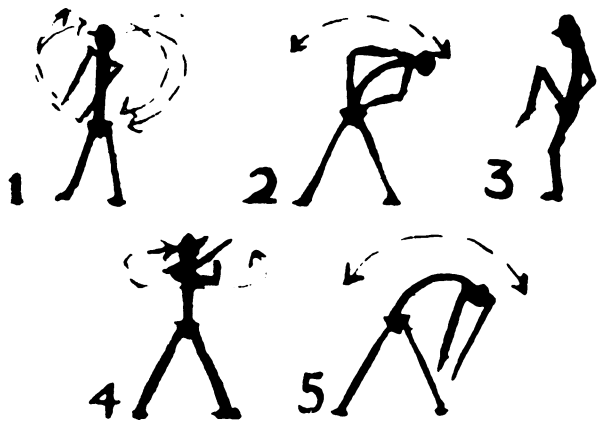

Fig. 1. Test dose of Gymnasium exercise.

muscles and joints over their full range of movement. Each exercise was performed 12 times, and the test dose ended with one minute on a lightly loaded cycle ergometer. The subject was closely watched throughout for the onset of discomfort, distress or pallor, which would be taken as a signal to stop the test. It was undesirable for the pulse rate to be more than 110 at the end of these exercises. The response to the test dose enabled the therapist to choose an exercise programme which fitted the patient's age and observed condition, or revealed that he was not ready for exercise therapy.

EXERCISE PROGRAMME

All exercise sessions began with the mobilizing exercises of the test dose, taking less than five minutes, and continued with the 10 separate exercises described and characterized in physiological and biochemical terms in the previous paper (17). The system used was the "Murray Method of Progressive Exercise by Pulse Control" with measurable work intensity. All subjects started with very low work intensities using weights of only 2-3 lbs. They were taught to count their pulse rate by palpation at the wrist, but during the exercise programme it was quicker and more convenient to use an ECG-heart-rate meter* activated by grasping two electrodes.

**Murray Pulse Monitor M.I.E. Ltd.*

By means of this schedule of 10 different exercises graded in "Repounds per minute", the subject's pulse rate was kept within the "pulse range" appropriate to his age and condition, as indicated in fig. 2, for the 10 to 15

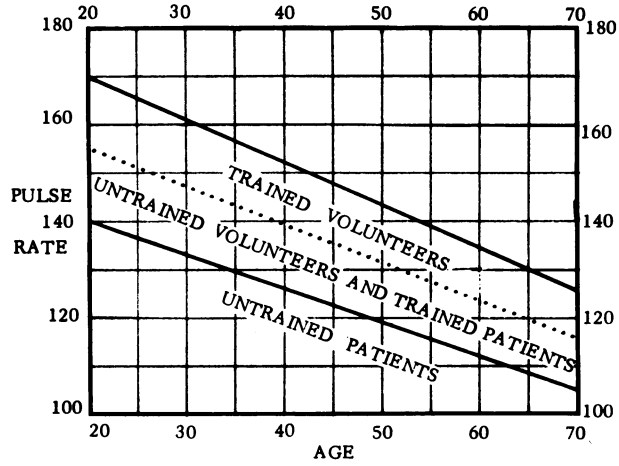

Fig. 2. Pulse rate ranges for patients with cardiovascular disease at different stages of Gymnasium training.

minutes of the active exercise period. Exercising week by week, without exceeding the prescribed heart rate, and without creating sensations of more than moderate effort, the subject was able to accomplish this programme with slower pulse rates and greater ease. As his physical condition improved the intensity of the work was increased by raising the rate of movement, the number of repetitions, and reducing the rest pauses between exercises. When the rest pauses had been eliminated, and the number of repetitions raised to a maximum of 20 to 30 for each large muscle group exercise, the subjects were allowed to increase the weights used by a small amount. Whenever the weight was increased, the rate of movement and number of repetitions were reduced, the rest pauses reintroduced, and the progression was repeated.

Subjects recorded the intensity of their exercise in "Repounds" per minute at weekly intervals. Usually a plateau of fitness was reached by patients after two to three months. Important advantages of this self-assessment of exercise intensity was the measurable progress in the first two to three months of exercise, and the ability of the subject to demonstrate to his own satisfaction that a morbid life-style, produced for example by over-work, anger, frustration, could predictably reduce his capacity for physical exertion.

Although isometric work is avoided, exercises which are largely isotonic are also unsuitable for cardiac patients when the resistance to be overcome is so great that the movement can be repeated only a few times.

Examples include an overweight person attempting full knee bends, "sit-ups" from a horizontal position, or press-ups from the floor. Similarly, even away from the gymnasium, patients were warned against such mainly isometric exertions as pushing a car, pulling on the wheel of a heavy car when parking, undoing stiff bolts or screws or, as was reported to have brought on one of Churchill's heart attacks, straining at a jammed window.

Thirty of the normal "volunteers", and all the patients with cardiovascular disease, returned to the Cardiology Department of Charing Cross Hospital for repetition of the full range of cardiological tests. Serial lipid estimations were carried out weekly on 12 of the patients with coronary heart disease, cholesterol and triglyceride being measured by the standard AA11-24 method, and free fatty acids by a fluorescence method (25).

RESULTS

The drop-out rate during the first two months in both "volunteers" and "patients" was low (5%). The reasons given for discontinuing included transport problems in attending the gymnasium, and temporary exacerbation of pre-existing musculo-skeletal disabilities. In approximately 500 "patients" there were no cases of cardiac arrest, infarction or collapse in the gymnasium and none suffered any form of cardiac emergency. This also applies to the total of over 2,000 other members attending the gymnasium during the past 10 years. Of the 248 patients with cardiovascular disease studied, nine (3.6%) died during the three year period of the study, none during their initial two month term of rehabilitation. Of these, one died of pneumonia, one of sub-acute bacterial endocarditis, one of carcinomatosis, one, aged 74, of a cerebrovascular accident, one of congestive heart failure, and two of unknown causes some months or years after finishing a course of rehabilitation at the gymnasium. The remaining two patients suffered sudden cardiac arrest during periods of emotional disturbance: In one, the arrest occurred while watching the World Cup match on television, and in the other while he was visiting his mother in hospital.

Of the 30 normal "volunteers" who were re-examined after an average of a year's exercise, no significant change in the more detailed cardiological indices were found. However, there were progressive reductions in resting pulse rates and blood pressure with training (figs. 3 and 4). In the 248 "patients", gallop rhythms faded, blood pressures approached normality and minor E.C.G. abnormalities often resolved during the pre-treatment phase. In no case did the course of exercise result in any deterioration in the objective tests of left ventricular function.

The reduction in plasma lipid levels during a two

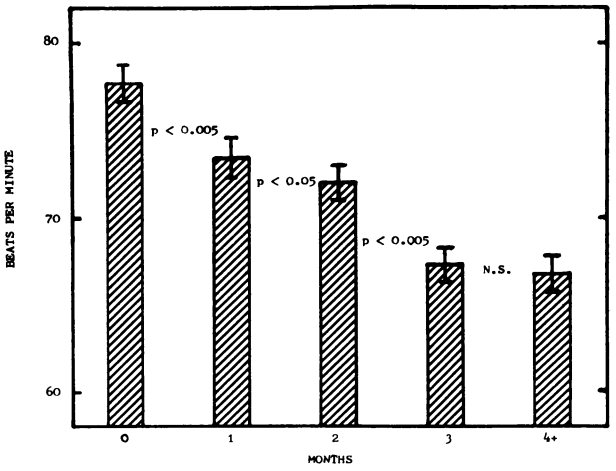

Fig. 3. Resting pulse rate (mean ± S.E.) at different times during Gymnasium training in 30 "volunteers".

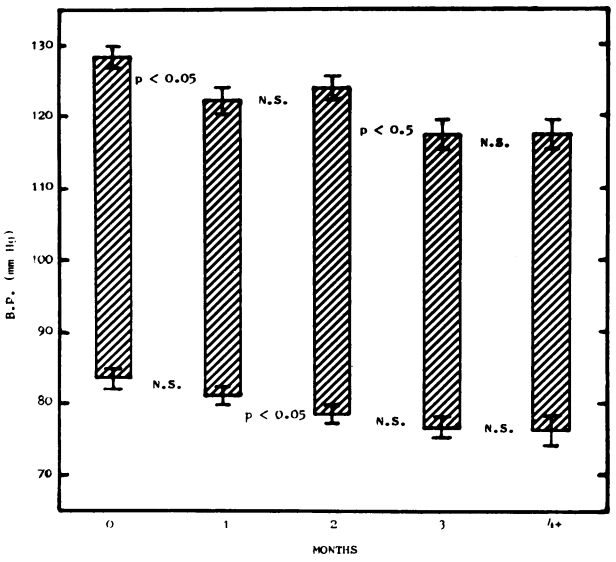

Fig. 4. Blood pressure (mean ± S.E.) at different times during Gymnasium training in 30 "volunteers".

months period of exercise in 12 patients with I.H.D., together with the increase in the intensity of the exercise which they were able to perform, is shown in fig. 5.

DISCUSSION

In this study, exercise was found to be very safe, probably on account of the emphasis given to the "pre-treatment" and the precautions taken during the build-up in physical activity. It also maintained the improvement in cardiac condition which had begun during the pre-treatment phase. This was in contrast to other simi-

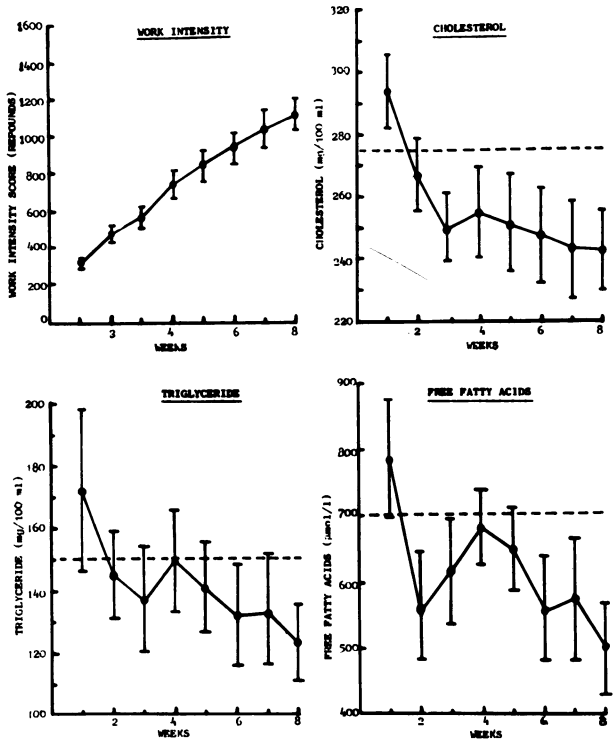

Fig. 5. Work intensity, cholesterol, triglyceride and free fatty acids (mean ± S.E.) in 12 "patients" at different stages in Gymnasium training.

lar but undisciplined and non-exercising patients of the Cardiac Department, who appeared to have higher relapse rates as measured by re-admission, persistent or recurrent pain, deterioration of left ventricular function, or the need either to continue or augment hypotensive regimes. The increase in effort capacity of these patients treated by exercise therapy was clinically far more impressive than that obtained by either β-blockade or surgery.

Some "patients" did relapse, usually a year or so after ceasing exercise, and responded well to a further course of rest, pre-treatment and gymnasium attendance. The decreases in resting pulse rate and blood pressure in the "volunteers" were similar to those usually reported with other physical training programmes using dynamic (isotonic) exercises (26). An important feature of the schedules carried out in this gymnasium is that they were light "weight loaded" rather than severe "weight lifting" exercises, as the latter involve static (isometric) muscle contractions which are dangerous in hypertensive subjects (27) and those who may be approaching cerebral or coronary vascular illness.

There is considerable variability in the evidence on the changes in plasma lipids which occur during prolonged exercise programmes. Reductions in cholesterol reported in some studies (28, 29, 30) were not found in others (6, 31, 32). These conflicting results may be partially explained by the work of Taylor (33) which indicated that exercise reduced serum cholesterol most markedly when people on a high fat intake lost weight or when only the carbohydrate content of the diet was increased to keep the weight constant.

Similarly, reports of lowering of plasma triglyceride by exercise (30, 31) were not confirmed by Mann *et al.* (34) whose subjects, however, increased the amount of carbohydrate in their diet. No previous observations on changes in free fatty acids during a period of exercise could be found in the literature.

The results of this study indicated that, given a constant dietary intake with regard to carbohydrate and fat, significant and clinically potentially useful reductions in all three of the lipid fractions measured were obtained using this exercise regime (fig. 5). The decreases began within three months and were maintained, except during gross emotional upheavals, for as long as the exercise was continued.

These effects on the plasma lipids were probably brought about by a combination of factors. Although the reduction in total body weight was small, averaging 0.5-1 kg per month in the majority of cases, there was a considerable decrease in body fat as measured by estimations of skinfold thickness. This suggests that the amount of metabolically active muscle in the body was increasing in relation to body fat. This would explain previous reports that the fit can oxidise fatty acids more effectively than the unfit (35), and even at rest mobilize and utilize more fat (36).

The consequent reduction in the amount of free fatty acid available for triglyceride and cholesterol synthesis can also account for the lowering of both these lipid fractions, and the failure of triglyceride levels (36) and cholesterol levels (37) to increase with age in groups maintaining a high level of physical activity, and hence remaining lean and muscular.

In addition to the somatic effects of exercise therapy, attendance at the gymnasium appeared to provide psychological benefit. Apart from health education provided by the gymnasium staff, the patients were encouraged to discuss their problems and successes among themselves in informal group therapy. In reply to a questionnaire given to men who had completed two months exercise, the majority reported that they felt they were coping better with problems at work and at home, were less tired at the end of the day, and slept better at night, in addition to having a greater capacity for physical work. Similar mood chances in response to a course of exercise in cardiac patients are commonly

noted (5, 6) and, by reducing catecholamine secretion rates, may contribute to the lowering of plasma lipids.

During this study of carefully supervised gymnasium activity, several principles have emerged which we believe are of importance in the prescription of exercise therapy for unfit individuals and those with cardiovascular disease. Above all, there is the need for safety precautions in any course of exercises for unfit adults or patients with cardiovascular disease, particularly in the early stages. This need is underlined by the presence of unsuspected abnormalities in nearly a quarter of the group of self-selected "volunteers". The precautions include an initial cardiologiological examinations, adequate pre-treatment, provision of suitable conditions for exercise, skilled supervision, individual self-regulation of the intensity of the exercise at each stage, the avoidance of anything approaching maximal or isometric exercise, and the prevention of competition with other gymnasium members (38).

Pre-treatment as a literally vital preliminary to a course of vigorous exercise for patients with cardiovascular disease has been described earlier in this article. "Volunteers" more than 20% over their ideal weight are generally advised to get within this limit before vigorous exercise is undertaken. The more unfit and elderly people should also gradually prepare themselves over a period of about two months by graduated walking, going on to stair climbing or stepping on and off a box a foot high for periods increasing to several minutes each day.

If the subjects are to relax and enjoy the exercise, the conditions under which it is carried out must be comfortable. In particular, cold must be avoided because it has a marked pressor effect in many individuals, increases the likelihood of muscle stiffness, and is conducive to angina. Timing of the exercise session is also important, as most people derive more benefit from exercise in the mid-morning or before lunch, rather than at the end of a heavy day at work.

By convention, the duration of an exercise session is usually three-quarters of an hour or more. This study, and those of Sanne (12) and Nordesjö (39), suggest that given a suitable work intensity, the period can be shortened to between 15 and 30 minutes without loss of training effect, providing the frequency is three times per week. Such a reduction lessens the demands on the subject's time and motivation, lowering drop-out rates. It also means that the three shortened exercise sessions each week pioneered 10 years ago by Alistair Murray, and regarded as optimal in the later Scandinavian studies, can be fitted comfortably into a normal lunch-hour break, and still leave time for a shower, changing and light refreshments. The creation of pleasant conditions is of great importance in making exercise sufficiently addictive to become a life-long habit. Just as the majority of benefits in terms of increased physical fitness and reduced lipid levels appear within two or three months of starting exercise, so they disappear within two or three months of stopping. Spartan gymnasium conditions and group exercises may revive unpleasant memories of compulsory physical training at school or in the Army. Similarly, attending a hospital gymnasium (14) may be unacceptable to some of the anxiety-driven patients who may be most at risk from recurrence of coronary illness.

The system of gymnasium exercise taught the patient to vary the intensity of his exercise, within the prescribed margins, according to fluctuations in his general condition, by heightening his awareness of fatigue and dyspnoea, and teaching him to make use of his pulse rate. The lessons did not increase anxiety and introspection, but provided a biofeedback and control system that increased confidence and satisfied the patient's need to play an active part in the regulation of his recovery. They were most useful in helping the patient to understand the effects of changes in life-style upon his physical condition.

Instead of stopping increasingly frequently to check pulse rates, as the course continued the subjects generally begin to rely more on their subjective sensations, with only occasional measurements to confirm that they were staying within the prescribed pulse rate zone. We suggest that other forms of exercise for unfit middle-aged people, such as cycling, swimming and jogging could also be made safe by training people to regulate the intensity of exertion according to subjective sensations and pulse rates.

Competition between members is discouraged, as it results in noradrenaline secretion and its undesirable circulatory and metabolic side effects (40), and may also lead to over-exertion (38). This point is also emphasized by Sanne (12), but is not a feature of the regime described by Gottheiner (7), whose article showed four of his fitter post-infarction patients competing in a 60 metre sprint race, or Kavanagh *et al.* (41) whose patients took part in marathon races. Group work is undesirable in comparison to individual supervision because it must encourage over-activity in some and under-activity in others.

If supervision is not provided the patients own choice of exercise after myocardial infarction is usually inappropriate in intensity, frequency, duration and type. Some remain as invalids unnecessarily. Others endanger themselves by adopting a "paradoxical and blatantly illogical" denial of obvious disability (42, 43) and by attempting unrealistic achievements.

Intensive courses of cardiac rehabilitation in residential centres are offered by the Royal Air Force to

Servicemen, but are not yet generally available within the N.H.S. They may be of especial value where the main causes of the breakdown in health are in the home.

The absence of cardiovascular accidents in this series suggests that the presence of doctors and a cardiac resuscitation team is unnecessary in a gymnasium specializing in cardiac rehabilitation if the safeguards described are followed. It should be possible for patients with cardiovascular disease to obtain a three month course with three sessions each week at a specially organized "school" within the physiotherapy department of their district hospital, and then "graduate" to join their non-medical friends in a gymnasium run by the local health authority or privately, providing they have been specially trained in this type of work and that strict adherence to these principles of safe exercise continues (44). A trial of introducing this system of training in the physiotherapy department of an N.H.S. hospital is currently in progress. Another novel feature of this type of exercise is that it would enable some patients to continue "extramural" studies at home, encouraged by audiovisual aids such as records and tapes, together with brief refresher courses at the hospital training school.

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