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EXERCISE: A PRESCRIPTION FOR HEALTH?

Self-medication: The benefits of Exercise

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Is it wise to draw a close analogy between the prescription of exercise and the prescription of a pharmaceutical medicine? In the present context the analogy is useful because it encourages the logical examination of the role of regular physical exertion in promoting good health. However, there has been a resurgence of interest in exercise, and, if this achieves the proportions hoped for by its protagonists, the individual doctor will need to work together with professionals in sport and physical education to provide general advice and guidance rather than to write "exercise prescriptions" for individual participants. One purpose of the meeting last May was to furnish a balanced account of the benefits of exercise. There is need for this; the style of the media has been to mock and even to ridicule recently introduced health education programmes; at other time it has chosen to be alarmist in its comment.

The benefits of exercise are not restricted to those who engage in national athletic competition. Physical exertion at work or during leisure time can bring benefits for health; walking, swimming or jogging, for example, can have a training effect for the middle-aged person who has previously followed a sedentary and inactive lifestyle.

The test seems to be whether exercise, as a self-administered medicine, can be shown to enhance normal health, to prevent disease or to ameliorate the effects of disease. There is evidence that it can help in each of these three ways.

It comes as a surprise to many that certain important details concerning the physiological changes which follow regular exercise have only recently been described. These advances in our understanding of the training process are based on two kinds of investigation. Studies involving the biopsy of human muscle have extended our knowledge of the biochemical changes; whilst a series of elegant studies by Clausen (1977) and by Saltin (1977), involving the selective training of one leg or of one pair of limbs, have helped to distinguish those changes in general cardiovascular function which are central effects, that is direct results of training on cardiac function, from those which are peripheral effects and secondary to the changes in the trained muscles.

Previous accounts have not emphasised sufficiently the importance of the changes which take place in the muscles themselves. The primary changes involved in the training process are local to the trained muscles. These changes include improvement in the metabolic preparedness of the muscle cells. This is the result of an increase in the cellular content of those enzymes which are involved in the utilisation of substrates and the release of energy. At the same time there are increases in the density of the capillaries supplying these muscles. The scale of the change in oxidative enzymes in muscle is impressive. Andersen and Henriksson (1977) demonstrated a 40% increase with two of these, succinic dehydrogenase and cytochrome oxidase, with 8 weeks' training.

Comparison of the metabolic response to exercise in two legs of the same individual when only one leg has been trained for 8 weeks (Henriksson, 1977) demonstrates some of the metabolic consequences of training. There is an increase in the amount of fat oxidised by the trained muscles and a corresponding reduction in the amount of carbohydrate oxidised. Lactate is released by the untrained muscle, this represents a loss of energy substrate as well as the appearances in the untrained muscle of a substance which limits the amount of exercise taken by the untrained leg and probably plays a part in the production of symptoms. During the formal exercise tests the subject used his untrained leg less than his trained leg as he cycled on the ergometer.

Thus the primary changes involved in the training process are improvements in the metabolic preparedness of the muscle cells and in the capillarity of the muscle. These adaptive changes in the cells of trained muscles ensure that the cells can extract the oxygen from the circulating blood more completely. Accordingly there is a smaller volume of blood flowing to trained limbs and the arterio-venous oxygen difference is correspondingly greater. Because there is a lower muscle blood flow the cardiac work is reduced. The work load for the heart is smaller because neither the heart rate nor the arterial blood pressure rise so high.

The overall improvement in circulatory function can be measured as an increase in maximal oxygen uptake during work of short duration and therefore as an increase in maximal work capacity. At levels of exertion below maximum, it can be demonstrated that the amount of oxygen for a given level of work can be distributed with a lower heart rate: for example a task which previously required a heart beat of 150 beats/min can be achieved with a rate of 130 beats/min. It is difficult to measure endurance very precisely, yet the improvement in endurance achieved by prolonged training is very dramatic. The personal records of cardiac patients and others who have trained themselves over 4 or 5 years to run the Boston marathon (Kavanagh, Shephard and Kennedy, 1977) demonstrate that some achieve an 80% improvement in maximal oxygen uptake. The significance of this is best seen as an improvement in endurance, — they have lifted their performance from an inability to run or jog to a level when they can run continuously for 4 hours. Thus the overall effect apparent to the individual who trains is increased work capacity, improved exercise tolerance and decreased fatigue. Regular exercise makes it possible to work harder, work longer and do the work with less effort.

Individuals are acutely aware of changes in their state of health if these occur quickly, say in a matter of weeks; they are less aware of changes which occur more slowly. Taken together with the rapidity with which the biochemical effects of training occur this explains why those who train are aware that they feel better. Most describe a subjective improvement in well being and a reduction in the discomfort which occurs during exercise, especially if they have previously led very sedentary lives. Thus the physiological changes, their nature and time course, may largely explain the sense of well-being which follows a change to regular exercise.

If the effects of exercise are generally beneficial the questions "who needs the medicine?" and "how badly do they need it?" become important.

Various surveys have demonstrated that the greater proportion of the general population of Europe and North America follow an inactive lifestyle and this seems to be true for all age groups except very young children. The Framingham study (Kannel, Sorlie and McNamara, 1971) and the study mounted by the Irish Heart Foundation (Hickey, Mulcahy, Bourke, Graham and Wilson-Davis, 1975) and other studies have all demonstrated the extent of the physical inactivity in various groups of people. Those who are sedentary have very much less in hand when they take exercise than they believe possible. Even walking at a normal pace may produce excessive physiological demands after quite a short time. The extent of the incapacity is obscured by the existence of anaerobic mechanisms of energy production. Sedentary individuals attempt heavy exercise very rarely, but when the do they still find it possible only because they can draw substantially upon their anaerobic reserves. They may only work hard for a matter of a minute or two and are never brought to realise that their endurance for hard work is very limited though when questioned they would expect to be able to work hard. Fig. 1 serves to reinforce this point. In estimating a man's capacity for sustained work lasting more than half an hour or so then the energy cost of the exercise must be compared with the magnitude of that fraction of his maximal capacity which can be used without discomfort and symptoms and not compared with his total capacity. An individual's ability to undertake sustained exercise is influenced by the magnitude of his work capacity and this becomes smaller the longer the exercise, certainly if the duration exceeds half an hour. Work in excess of 70% of maximum capacity will produce symptoms, either aching in the legs, or true breathlessness, symptoms which experienced athletes are used to ignoring but which usually stop the untrained. Work in excess of about 50% of maximum capacity will lead to lactate accummulation in the exercising muscles; mention has already been made of the limiting effect of this metabolic change. In untrained individuals the level at which lactate accummulation occurs may be as low as 30% and this will represent a smaller fraction of a much smaller maximum capacity. The figure shows that for sedentary individuals the capacity which is at or just below their lactate threshold is barely sufficient to allow a long walk at normal walking speed on level ground, that some anaerobic energy production will be required and that symptoms of fatigue can be expected early. An increase in speed, the added load of a hill or head wind will produce symptoms much more rapidly.

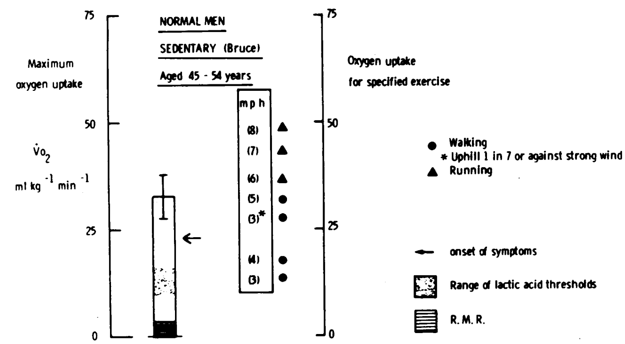

Figure 1. The left-hand half of the figure shows the $\dot{V}O_2$ max. in ml.kg^{-1}min^{-1} ± 1 S.D. for normal sedentary men aged 45-54 years residing in Seattle, USA (Bruce 1978) (n = 556). The block has been subdivided to show the approximate magnitude of the resting metabolic rate (R.M.R.) (horizontal cross-hatching) and the range of lactic acid thresholds (stippling). The arrow indicates the level of exercise at which the subject will experience some symptoms. The right-hand half of the figure shows the energy cost of various speeds and conditions based on values from Åstrand and Rodahl (1977).

Exercise is particularly benefical for those who are already incapacitated. The elderly and patients with cardiac, respiratory and muscle dieseases can undertake training with advantage. The gain in effort tolerance and work capacity from training are worth relatively more to them. The maintenance of reasonable physical fitness in such people may avoid or delay the necessity for institutional care.

The obese can also benefit from regular exertion. Exercise has a place in regimes for weight reduction as an adjunct to dietary control. The increase in energy expenditure which occurs with extra exercise is small but significant in the long term, especially if exercise is taken daily. Perhaps of greater significance is the recent finding that exercise has a stimulating effect on energy utilisation which continues long after the exercise has finished. This extra metabolic activity leads to the loss of appreciably more fat than would have been predicted for the exercise undertaken.

Various recommendations have been made regarding "safe" levels of exertion during training. The provision of "safe" guidelines is particularly important if the "medicine" is to be self-administered and if mishaps are to be avoided in the unfit. Åstrand (1972) recommended a maximum heart rate in beats/min^{-1} of 195 – age in years, Carruthers, Nixon and Murray (1975) suggested 200 – age in years –20 for the untrained. Fig 2 illustrates the heart rates found when a number of untrained individuals undertook a Cooper self-administered test while wearing a body-borne tape recorder and ECG electrodes. All the subjects except two exceeded the level believed to be safe for them. Alternative bases for advice must be sought which help subjects keep to these levels.

My conclusions are as follows:

Physical activity is of considerable benefit to everyone and should be seen as a necessary element in the pattern of daily living at all ages. Very many individuals have a greater need, than they realise for the physiological improvements which derive from training.

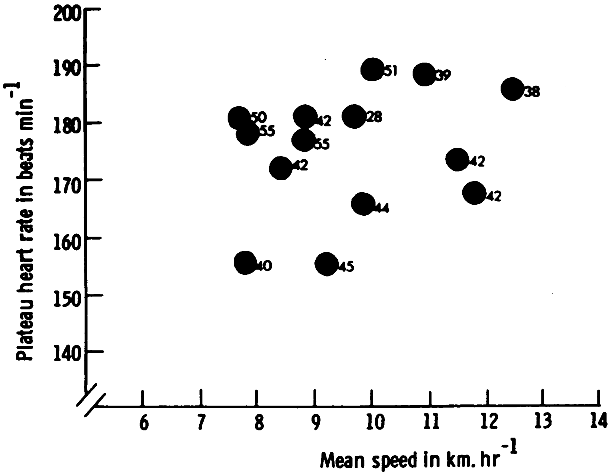

Figure 2. The values for the plateau heart rate measured using body-borne tape-recorders during self-paced fitness tests in men of different physical conditions. These values have been related to the speed at which the men walked or ran during the test. The age of the men is indicated by the number next to each symbol. All the subjects were instructed to complete the distance as quickly as possible. They ran/walked 1.6 km. They had prepared by walking regularly for 6 weeks, otherwise they were untrained.

These improvements are of special importance to the elderly and to many with chronic diseases. There is still a need for improvements in and attention to the advice provided for those who are keen to seek these improvements and who wish to administer the "medicine" safely to themselves.

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