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ABSTRACT

This speech begins with the presentation of a conceptual scheme of the physical working capacity of a person starting a training program. The scheme shows that after exercise, when recovery begins and sufficient time elapses, the individual recovers and adapts to a level of physical working capacity which is higher than his starting level. From this scheme it is shown that a light workout produces faster recovery but a lesser degree of adaptation to a higher level; a strenuous workout that allows insufficient time for recovery before exercising again might impair the individual's physical working capacity. For an exercise session for cardiopulmonary conditioning for deconditioned or pathological adults, the following is recommended: a warmup, a stimulus period, and a cool-down composed for the most part of aerobic exercises (exercises which utilize energy which is liberated mainly through aerobic rather than anaerobic pathways). It is stated that during the stimulus period the individual should moderate his heart rate so that his heart stays within the "target zone"; the use of the heart rate in this manner provides a built-in barometer of relative exercise stress that is independent of the person's fitness level and requires the individual to perform a higher intensity of work to achieve his heart rate as his fitness improves. Charts and diagrams are referred to in the text and appear as appendixes. (JA)

Exercise Programming for Cardiacs - A New Direction for Physical Therapists

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This is a transcript of a taped lecture broadcast on WAMC, the FM radio station of Albany Medical College, on December 4, 5, 6, 1974. This lecture, and the related lecture by Dr. Lenore Zohman of Montefiore Medical Center, were followed by two-way question and answer periods.

This presentation deals with the role of exercise in cardiopulmonary rehabilitation and reconditioning. We shall begin by having Dr. Zohman tell us what she might say to a patient who has approached her for advice concerning a personal exercise program. Then I shall delve a bit further into the physiology underlying some of her recommendations.

(Dr. Zohman's presentation)

Thank you Dr. Zohman. I'm sure that it is now clear to the audience why your cardiopulmonary rehabilitation program is so well known for its high quality.

I should like to begin my remarks by referring to the general conditioning scheme which is Figure 1 on printed visual number one. Then I will discuss more specifically the factors involved in prescribing exercise for cardiopulmonary conditioning.

At the left of Figure 1 we see the physical working capacity of a person starting a training program. As he participates in exercise of sufficient intensity and duration to constitute an overload on the systems underlying physical working capacity, his capacity for continuing the exercise diminishes until he reaches fatigue and stops exercising. For example, a person might run three miles at a pace which exhausts him completely when he is finished. The overload is a function of both the intensity and the duration of the exercise. Then recovery begins and, if sufficient time elapses, perhaps a day or two, he recovers and adapts to a level of physical working capacity which is higher than his starting level; that is, he shows a conditioning or training effect. Of course, if he does not undertake another exercise session for a long time, let's say two weeks or more, his physical working capacity will regress back to and perhaps below his starting level. Naturally, one exercise session is not going to produce much of a training effect, but if the overload is repeated at regular intervals, the person will gradually "get in shape."

This conceptual scheme allows us to see the relationships among several factors involved in conditioning. For example, Figure 2 shows what might occur if the overload is reduced. If the person stops exercising after a relatively light workout then he will recover faster, but the degree of adaptation to a higher physical working capacity will be reduced. If he increases the frequency of his workouts, then he might still obtain a training effect. For example, the overload might be so minimal that the individual might need to work out twice a day to obtain a training effect.

On the other hand, if the overload is very great, then several days might be required for full recovery and adaptation to take place. If the person undertakes another strenuous exercise session before recovery is complete, he might find that his physical working capacity is impaired in comparison with what it had been. This point is especially important for clinicians who work with older and deconditioned patients since the recovery processes seem to be slowed down in these kinds of people. This idea is illustrated in Figure 3 on your printed visual. For a given overload, the time required for recovery is greatly increased. Thus it is very important in working with such people that we remember to keep the overload at a moderate level and/or reduce the frequency of the exercise sessions. As the individual improves his condition, the overload and/or the frequency of the exercise sessions may be increased. Thus it seems that two or three strenuous exercise sessions per week is optimal for adult fitness programs. If the overload is moderate, then three to five sessions per week may be optimal.

At the other end of the fitness spectrum are well-conditioned young athletes who seem to be able to profit from as many as two very strenuous workouts per day.

Now, I should like to go into some more specific information concerning the prescription of exercise for cardiopulmonary conditioning in deconditioned adults and patients with coronary heart disease.

First we might ask what kind of exercise is appropriate in order to produce a training effect in the circulatory and respiratory systems, the exercise utilized must place a stress or overload upon the systems. Since these systems are responsible for bringing oxygen into the body and for transporting it to the working muscles, any exercise which is dependent on large amounts of oxygen will stimulate the circulatory and respiratory systems, which collectively are called the oxygen transport system. The maximal amount of oxygen which a person can take in, transport and utilize during strenuous exercise is called his maximal oxygen consumption or maximal aerobic power. This parameter is widely used by physiologists and physicians as a measure of cardiopulmonary fitness. Activities which call upon the individual to utilize large portions of his maximal aerobic power would include walking, jogging, cycling, swimming, crosscountry skiing, tennis, golf, squash, basketball and handball. The key factor is that the activity should engage large amounts of muscle mass and be continued for upwards of two minutes or so to allow the oxygen transport system to become mobilized. The diagram on printed visual number two illustrates that an activity must continue for two to three minutes before the transport system can be adequately mobilized. Exercise which is very localized, such as weight lifting or very short duration such as sprinting, would utilize energy sources which would be largely "anaerobic" and would fail to utilize large amounts of exygen.

While sports such as basketball, handball and tennis can provide a cardiopulmonary training effect, the competition involved in these sports may encourage a deconditioned or pathological adult to push himself to exhaustion, perhaps resulting in a period of several hours and even days in which he feels debilitated, until his recovery processes are completed. Of course it is also possible that such severe stress might exacerbate any pathology which might be present. It is important for us to remember that exercise is a very potent stressor which can produce ill effects as well as beneficial ones, if it is inappropriate for the individual involved. Therefore, it is essential that each individual gain some understanding of his own needs and capacities and be prepared to moderate or cease his activity when appropriate.

Activities such as isometrics, heavy lifting and sudden bursts or all-out effort are generally contra-indicated for adults because they tend to raise the blood pressure and heart rate markedly and dangerously.

It is always sensible to begin an exercise session with very low intensity exercise to allow the muscles literally to "warm-up" so they can work more efficiently. Even more important, the gradual increase in exercise intensity allows the circulation to the skeletal muscles and the heart muscle to be increased. This increase in circulation to the heart muscle is especially valuable because it can help to prevent the hypoxic condition which often occurs in the heart when a strenuous bout of exercise is undertaken suddenly.

It is also wise to "cool down" gradually toward the end of the exercise session since during the exercise the large amount of blood which has been diverted from other organs to the legs is helped in its return to the heart by the squeezing action of the muscles against the veins. If large muscle exercise, especially exercise using the legs in an upright position such as walking, jogging or cycling, is stopped suddenly, much blood may pool in the legs, thereby reducing the venous return and the cardiac output. This may lead to a precipitous drop in blood pressure and the individual might feel dizzy and faint.

So we see that an exercise session for cardiopulmonary conditioning should include a warmup, a stimulus period and a cool-down composed for the most part of aerobic exercises, that is, exercises which utilize energy which is liberated mainly through aerobic, rather than anaerobic, pathways. And you recall that Dr. Zohman explained that during the stimulus period the individual should moderate his exercise so that his heart rate stays within the "target zone."

The use of heart rate as an index of exercise intensity is predicated on several well-known concepts which are illustrated on printed visuals three and four. Printed visual three shows that as the workload increases in intensity, the oxygen consumption increases in a linear fashion until the person reaches his maximal oxygen consumption, the maximum amount of oxygen that his respiratory, circulatory and muscular systems can take in, transport and utilize per unit of time. Once the individual reaches his maximal oxygen consumption, or aerobic power, any further increment in work can only be accomplished by supplying energy anaerobically, leading to the production of lactic acid, a drop in muscle pH, and exhaustion. Before training our fictitious subject reached his maximal oxygen consumption of three liters/minute at workload three and was able to perform one more workload before exhaustion. After six months or so of training he had increased his maximal oxygen consumption to four liters/minute which was attained at workload four, and he still could perform one "supra-maximal" workload by resorting to anaerobic energy release. Please note that the oxygen consumption at any given sub-maximal workload did not change with training; only the maximal oxygen consumption changed. It generally true that in well-learned tasks such as walking or jogging, the energy required for any given amount of mechanical work is unaffected by training and is very similar from person to person. Therefore, throughout the range of submaximal aerobic effort there is a constant relationship between workload and oxygen consumption and they both may be put on the same axis, as shown in printed visual four. If this is done and heart rate is plotted against workload and oxygen consumption, we see that a linear relationship is obtained, both before and after training. The maximal heart rate doesn't change with training but the heart rate at any given sub-maximal workload and at rest usually drops substantially, because any given oxygen consumption not constitutes a smaller percentage of the individual's maximum.

We know that in normal adults workloads which maintain the oxygen consumption at sixty percent or more of maximal oxygen consumption, for at least several minutes, are sufficient to elicit a training effect. Therefore we can feel confident that if a person brings his heart rate up to a level which corresponds to sixty to eighty percent of his own maximal oxygen consumption, a training effect will result. This is how the lower limit of the heart rate target zone is determined. The upper limit is roughly the level of work at which some amount of anaerobic metabolism and lactate production seems necessary, making it very difficult for the person to continue the exercise long enough to get a training effect. Furthermore, if the individual pushes himself very hard, this degree of overload often results in feelings of debilitation and very long recovery periods, as I mentioned earlier in this presentation. As a rough guide, if one still feels tired several hours after exercising, it is likely that the exercise was too strenuous for him.

The limits of the target zone in persons with coronary heart disease of course must take into account the patient's pathology. In such a patient the zone is usually set at 70-85 percent of his clinical maximum heart rate; that is, the heart rate at which he exhibits symptoms such as anginal pain, electrocardiographic changes signifying oxygen insufficiency to the heart muscle, or other clinical signs indicating that the exercise should be terminated or moderated.

The beauty of using target heart rate to determine exercise intensity is that it is easy for the person to measure and it provides a built-in barometer of relative exercise stress which is independent of the person's fitness level. That is, as the person improves his fitness and his maximum exercise capacity, he will have to perform a higher intensity of work to achieve his target heart rate. This concept is illustrated in printed visual four where you can see that at workload 2, our subject reached a heart rate of approximately 140 beats per minute before training and 120 after training. Thus he will need to increase the intensity of his exercise in order to reach his target heart rate, which might conceivably be around 140 beats per minute. For example he might now need to jog rather than simply walk in order to reach his target heart rate.

This built-in progression when using target heart rate as a guide to exercise intensity is very useful in working with cardiac patients because heart rate is the best single indicator of myocardial oxygen consumption, which is in turn an indication of physiological stress to the heart.

A cardiac patient will generally exhibit his clinical symptoms, for example, anginal pain or electrocardiographic changes, at about the same heart rate. So as he progresses in an exercise program, using a target heart rate which is below his clinical maximum, that is the rate at which his symptoms usually appear, he can exercise safely and effectively, gradually increasing the work he does in his workouts as his heart rate for any given workload is reduced due to his improved fitness. Incidentally, this reduction of heart rate at rest and while performing submaximal workloads is one of the most important training effects of aerobic training, since it signifies a lesser physiological strain on the heart during most of the day when the person is not actually performing his exercise regimen, assuming that the individual maintains the same life activities he took part in before starting to exercise regularly. Of course, he can instead increase the amount and/or intensity of his daily activity without necessarily increasing the physiological strain on his heart. This latter alternative is especially valuable for cardiac patients whose daily activities have had to be reduced due to the appearance of overt symptoms.

Before finishing this section of training I should like to mention a few of the factors which may influence training response. First, the degree to which one can improve seems closely related to how unfit the individual is. Therefore, working with very deconditioned people is relatively satisfying since large training effects are often found.

Secondly, good training effects have been produced in people as old as 80 years, showing that exercise training can be helpful even at a ripe old age. The magnitude of response in very old age seems to be somewhat reduced, but this may be because the intensity of training for these people is usually not as high as it would be for younger people.

Thirdly, the adaptation of women to the kind of training we have been discussing is very similar to that of men, even though the absolute levels of performance may be somewhat lower due to a variety of cultural and physiological factors.

And fourthly, the maximum capacity of an individual is limited to a large degree by his heredity -- therefore, most of us could not be champions in events based on cardiopulmonary fitness no matter now hard and long we trained. So the success of a training program for an adult should be measured in terms of an individual's <u>own improvement</u> toward <u>his own maximum capacity</u> rather than by reference to some set of absolute standards derived from measurement of large numbers of people.

Thank you.

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Figure 1 - Conditioning schema

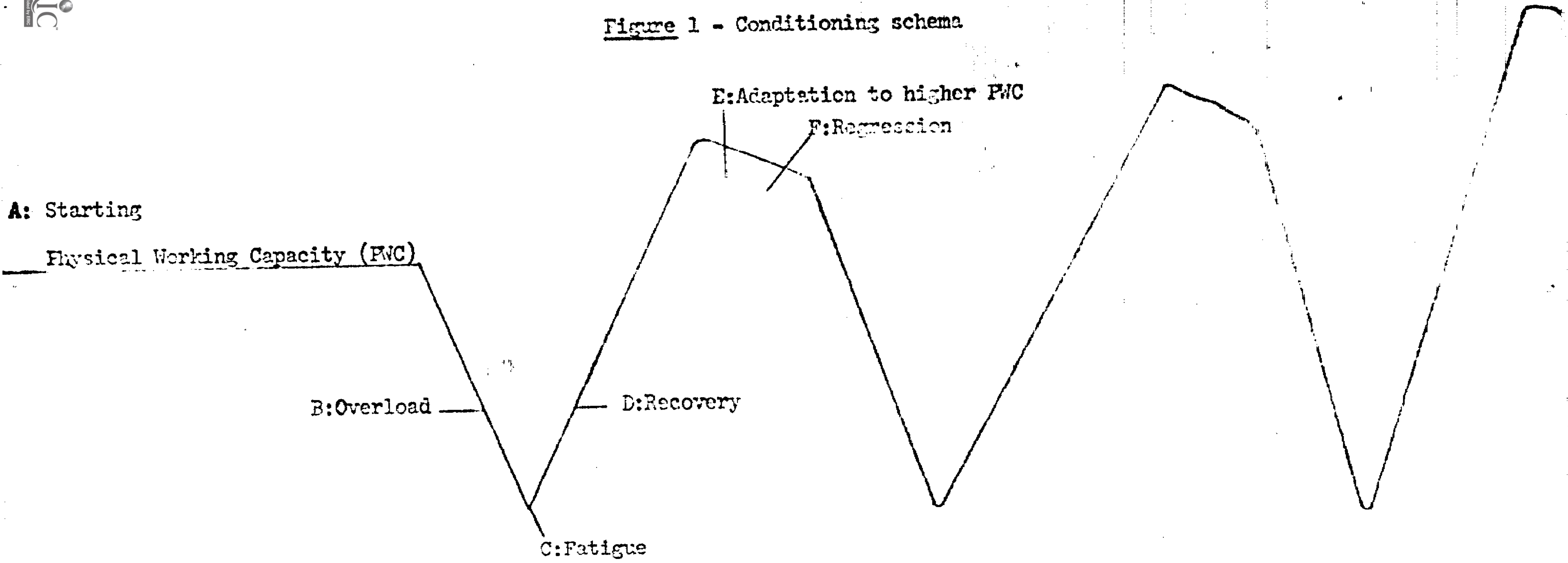

Figure 2 - Conditioning schema in which overload is decreased and frequency increased

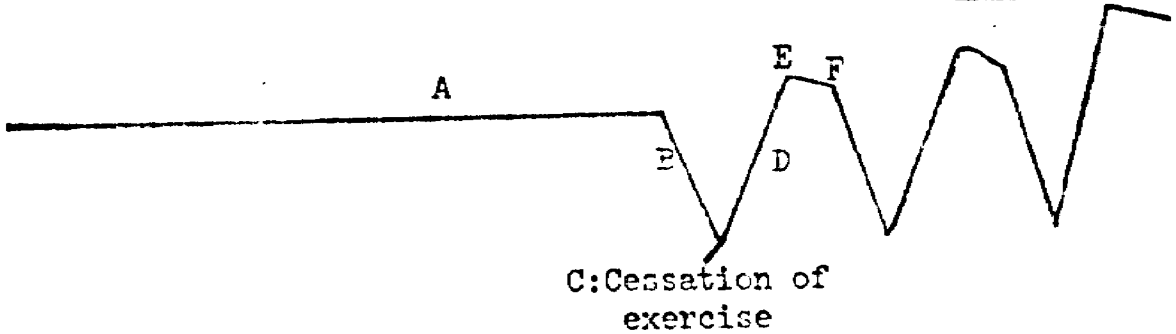

Figure 3 - Conditioning schema for older or deconditioned persons

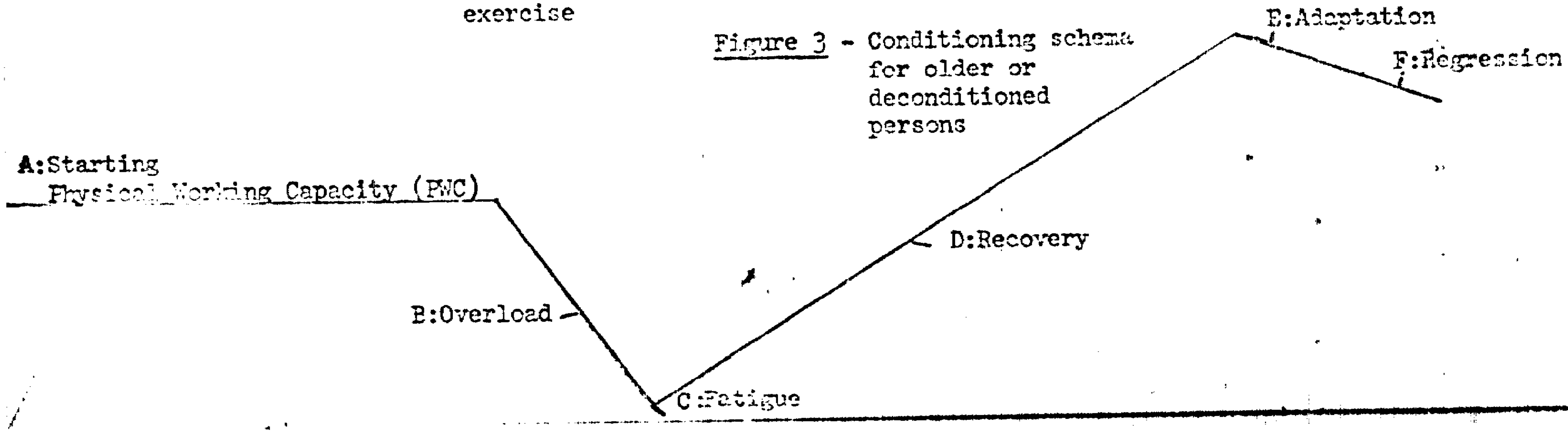

Figure 4 - Time pattern of aerobic and anaerobic energy release in a moderately strenuous, large muscle exercise, such as running.

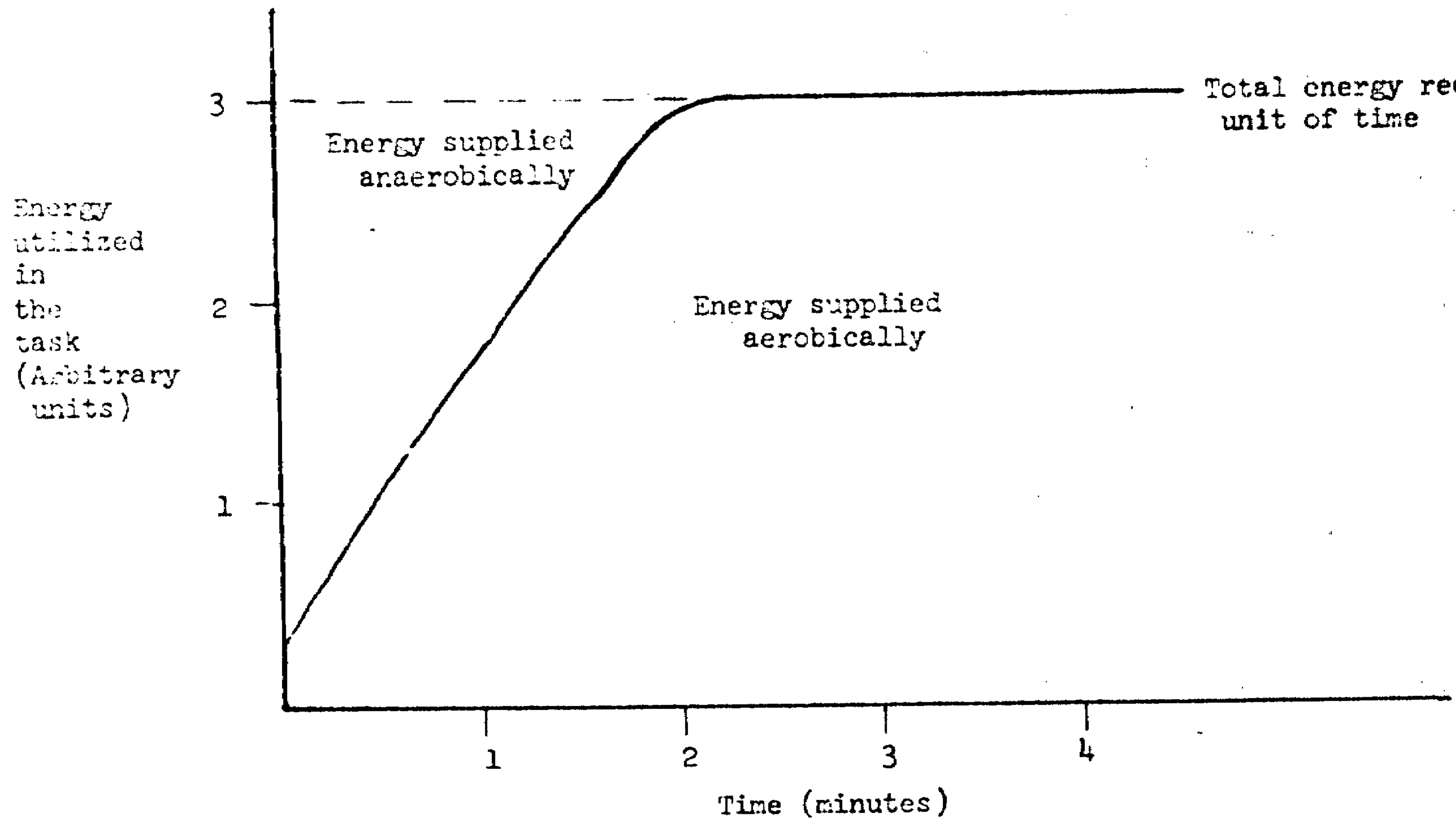

Figure 5 - Relationship between workload and oxygen consumption in aerobic exercises for a subject with a maximal oxygen consumption of 3 liters/minute before training and 4 liters/minute after training.

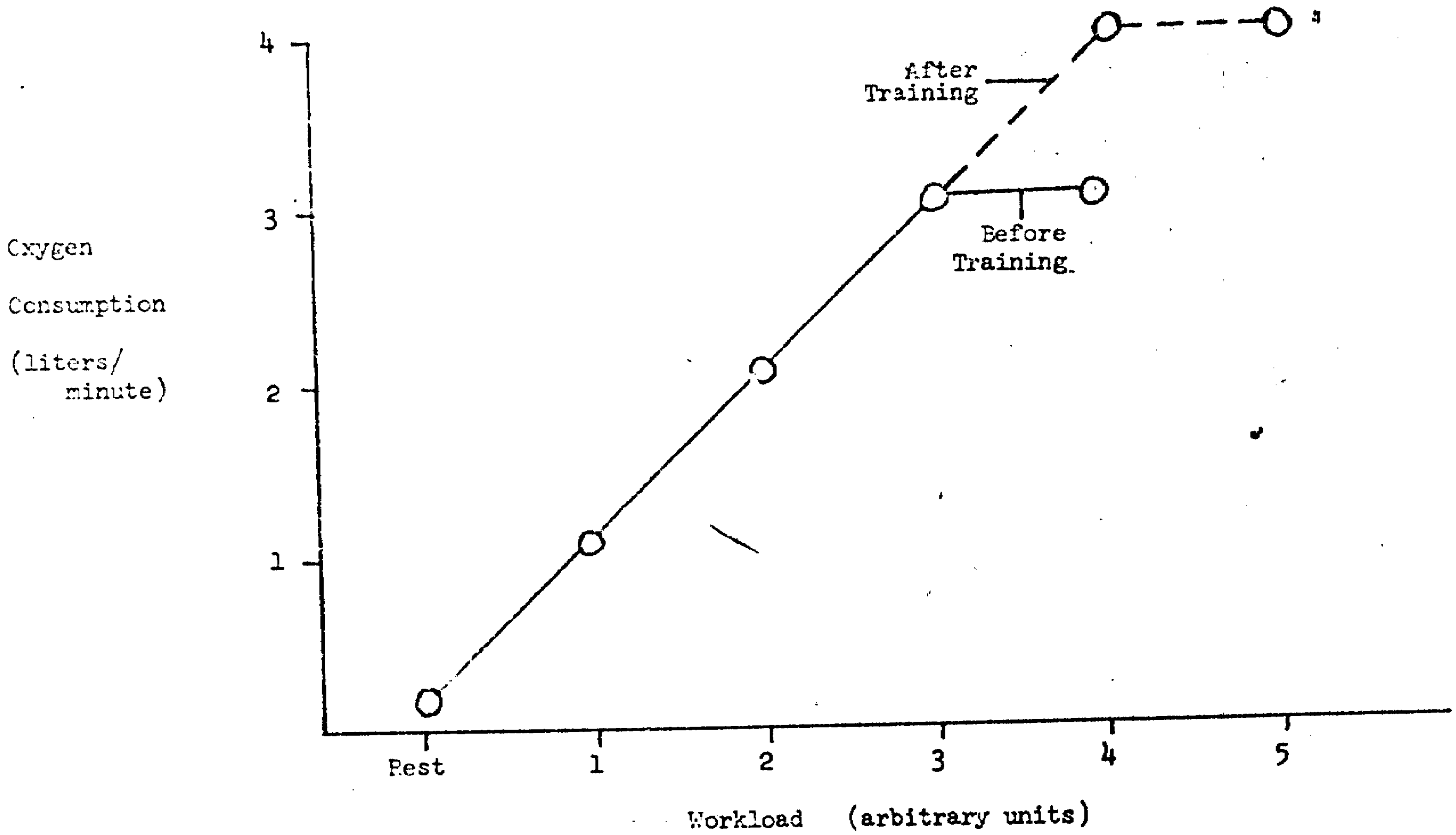

Figure 6 - Relationship for one subject pre- and post-training between workload and oxygen consumption, both on the horizontal axis, and heart rate, on the vertical axis.