IOCCC

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THE ROLE OF EXERCISE IN DIET

1. INTRODUCTION

It is widely recognised by health authorities that an increase in physical activity would be beneficial for most people. Exercise, while not guaranteeing longer life, can improve its quality and delay deterioration due to age and inactivity, as well as reducing the likelihood of becoming overweight. Exercise can improve cardiac, respiratory and muscular functions. It is now widely recognised that diet can have an influence on the ability to perform exercise, and this is particularly true in the case of endurance sports.

2. FUELS FOR EXERCISE

Exercise is a significant challenge to energy metabolism, and results in increased rates of utilisation of the two main metabolic fuels - fat and carbohydrate. The relative contributions of fat and carbohydrate to muscle metabolism received attention as early as 1887, when Chauveau, as a result of his studies, concluded that glucose was the immediate and preferred substrate for muscle metabolism. Although it was recognised that blood-borne fat made a contribution, it was believed that this was a precursor to muscle glycogen formation. The idea that glucose was the only fuel used directly by the muscles persisted into the early 1920's, and it was not until 1958 that there was clear evidence that fat contributed significantly to muscle metabolism.

During exercise, energy must be supplied to the muscles at the same rate that they use it, otherwise the exerciser is forced to slow down. Any mismatching of the rate of energy expenditure and the rate of energy replacement represents an 'energy crisis' in the working muscles and is generally referred to as 'fatigue'.

The generating of energy occurs in the mitochondria or the 'micro-power stations' in the muscle cells. This occurs when either carbohydrate or fat is metabolised or 'burned'. These two fuels are metabolised to produce a usable form of energy. This usable form of energy is a substance called adenosine triphosphate or ATP. The ATP is the common energy source which is used in all cells of the body for all biological activities.

3. THE IMPORTANCE OF OXYGEN

The two fuels, fat and carbohydrate are stored in the body and are recruited when required, but oxygen has to be transported from the atmosphere via the lungs and blood to the working muscles. The combustion of fat and carbohydrate dependent on oxygen is called aerobic metabolism.

The aerobic production of energy does not produce any toxic waste products and so is the preferred system for prolonged exercise.

If the intensity of exercise is increased beyond a certain point, aerobic metabolism alone cannot supply energy at the rate needed. As this happens, energy is no longer obtained from fat, and is supplied exclusively from carbohydrate through anaerobic metabolism.

This is an energy system which does not depend on oxygen, but is only available for a short period of time as it rapidly causes fatigue. One of the reasons for this fatigue is the accumulation of lactic acid which quickly reduces the ability of the muscles to contract effectively. Lactic acid in the muscles can cause discomfort both during and after exercise, and total recovery will not occur until the excess lactic acid produced during exercise has been fully degraded.

Sports such as marathon running and long distance cycling or swimming rely almost exclusively on aerobic metabolism, whilst short, intensive sports such as sprinting or weightlifting are largely anaerobic. However there are many sports which consist of a combination of aerobic and anaerobic exercise. These often involve intermittent bursts of anaerobic exercise which are separated by less intensive periods of recovery. Such sports include team games like soccer, rugby and basketball, as well as individual sports such as tennis and squash. Sports which rely on a combination of aerobic and anaerobic metabolism will, of course, utilise both carbohydrate and fat as fuels for exercise.

4. ENERGY STORES

The carbohydrate used by the muscles during exercise is mainly stored in the muscles themselves, close to the site at which it is to be used. The stored form of carbohydrate is glycogen a substance consisting of a large number of glucose molecules joined together.

There is also a carbohydrate store in the liver which amounts to about 100g of glycogen. This liver glycogen is responsible for providing glucose to maintain the normal blood glucose concentrations so that the brain (the largest consumer of blood glucose, needing 130g of glucose per day) has a sufficient and constant supply. Muscles do not use blood-glucose directly. If they did, it would be used up more rapidly than it would be replenished, during intense exercise.

There is approximately three times more carbohydrate or glycogen stored in skeletal muscles than in the liver. However, glycogen stores are finite, and inevitably become depleted during long continous exercise lasting in excess of 70-92 minutes (the more intensive the exercise, the quicker the glycogen is depleted). This applies not only to endurance events, such as marathon running but also to intermittent exercise sports such as soccer and rugby. When glycogen stores have been used up, the muscles attempt to cover their energy needs from fat metabolism. Unfortunately, because fat cannot supply energy at as rapid a rate as carbohydrate, the competitor is forced to slow down or reduce his/her rate of work to the level at which energy expenditure and energy synthesis are matched.

This situation is made worse by the fact that when glycogen stores in the muscles are used up, blood glucose (hypoglycaemia) reduces the supply of glucose to the brain, contributing to the feeling of exhaustion and causing a decrease in technique and the ability to make correct decisions.

5. TRAINING

Training allows the muscles to use more of the oxygen offered to them by the circulatory system, so that the energy expenditure of the muscles can be more adequately covered by aerobic metabolism. This means that for a given level of exercise, more of the energy needs of the muscles can be met by the aerobic breakdown of fats, so reducing the demand on the limited carbohydrate (glycogen) stores.

Training therefore allows the muscles to work at greater intensity; i.e. more speed/power for the same amount of carbohydrate breakdown as would have been needed before the training period.

6. DIET FOR EXERCISE

One of the main objectives of any person involved in medium to long-term exercise should be to have an efficient aerobic system, which will help to ensure that fat is utilised as much as possible, thus sparing the limited stores of glycogen. The glycogen stores can then be preserved for as long as possible so that optimum work rates or running speeds are maintained. In view of this, appropriate training is one of the most important areas which a competitor can control to influence the standard of his or her aerobic system.

The second area which a competitor can influence is diet. Numerous researches have shown that the ability to exercise for a prolonged period of time will be significantly reduced if the glycogen stores are not full at the start of the exercise. Endurance capacity - or the ability to continue exercising at a constant rate - has been shown to increase if a person consumes a diet which is high in carbohydrates prior to exercising. In a study of endurance runners their ability to continue running at a constant pace was improved by 25 % after consuming a high carbohydrate diet for three days beforehand. When a similar group of runners ran a 30 km distance as quickly as possible, their performance times were approximately two and a half minutes quicker after eating a diet high in carbohydrates for seven days before the run. In a study of soccer players, it was found that those players who started the match with the highest muscle glycogen stores were able to sustain the highest rates of work during the second half, and were also able to maintain their technique more effectively. In contrast, those players, whose work rates dropped in the second half were those who had the lowest pre-match muscle glycogen stores. The fact that diet can also influence anaerobic performance was emphasised in a recent Swedish study, where the subjects' capacity to perform repeated bouts of anaerobic exercise was 250 % greater after consuming a high carbohydrate diet than it was after consuming a low carbohydrate diet.

7. RECOVERY FROM EXERCISE

After endurance exercise, the carbohydrate stores in the liver and muscles are depleted and need to be replaced before the next bout of exercise. If glycogen stores have become fully depleted, it may take up to 48 hours for the stores to become fully repleted and even longer if the diet is low in carbohydrate. The most rapid rate of resynthesis is during the first one or two hours after exercise, when the enzymes in the body are most receptive to converting carbohydrate to glycogen. During this period it is vital that plenty of carbohydrates are consumed, which can be either in solid or in liquid carbohydrate form. Clear evidence of the value of carbohydrates in improving recovery came from a recent study at Loughborough University in England, which involved two groups of subjects running to exhaustion on a treadmill at a constant speed. After the run, one group consumed a high carbohydrate diet for 24 hours, whilst the second group consumed a 'normal' diet. Both groups then repeated the run. The group on the 'normal' diet ran for only 71 minutes on their second run, compared to 86 minutes on their first run. In contrast, the group on the high carbohydrate diet ran for 83 minutes on their first run and for 92 minutes on their second run, an improvement of 9 minutes. This shows that even after a relatively short period of time, consumption of a high carbohydrate diet results in an enhanced rate of recovery.

The ability to recover after exercise is vital in all sports, and does not just involve recovery from or for competitions. Most top level sports people expend as much if not more energy when training as they do when competing, so it is vital that carbohydrates are also consumed to support the energy demands of training.

Individuals in sports such as athletics and swimming often only have to 'peak' for one or two major events each season. In contrast, for many team sports, each match is equally important, and many matches are played in a short space of time. Recovery time is therefore limited, so the consumption of a correct diet is crucial. Team sport competitors should start preparing for their next match as soon as they are off the field of play following the preceding match. The first stage of this recovery should be the replacement of the body's carbohydrate and fluid stores.

8. IOCCC PRODUCTS AS A CARBOHYDRATE SOURCES

Carbohydrate foods come in two basic forms - either as complex carbohydrates ('starches') or simple carbohydrates ('sugars'). Whilst some people suggest that complex carbohydrate is preferable to simple carbohydrate as a fuel source for exercise, the available evidence does not support this. For example, in a study to compare the ingestion of simple carbohydrate in the form of chocolate confectionery, with the ingestion of complex carbohydrate such as pasta and potatoes, it was found that both forms of carbohydrate were equally as effective in improving endurance performance. The groups who supplemented their diets with either complex or simple carbohydrate improved their endurance capacity by 26 % and 23 % respectively.

In comparison, a third group who did not consume any additional carbohydrate failed to show any significant change in endurance capacity.

The essential point is that once glycogen has been stored in the muscle, it has no recollection of where it originated from. Glycogen will make an equal contribution to improving aerobic or anaerobic performance, regardless of whether it came from a complex or simple source.

9. IOCCC POSITION

IOCCC supports an increase in exercise and encourages research into the relationship between diet and exercise performance. IOCCC products have a useful role to play in the diet of athletes as a contributor of essential energy and carbohydrate in a convenient and palatable form. Sugars and starches make an equal contribution to physical performance.

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