Food for thought - marathons and fat burning

An observation was made by a seasoned club runner that regular marathoners don't lose weight or get thinner. The conclusion was drawn that those marathoners can't be burning fat when they run marathon distances, else they would get thinner. There are two responses to this assertion. The first, simply, is that to lose weight one must expend an amount of energy that is greater than the amount consumed. It's a simple equation between energy in and energy out. The balance can be influenced by what we eat, by activity levels (running and day to day activities) or by both these factors. If we increase our running and increase our eating, however, there's likely to be no net weight change.

If the balance shifts and marathoning does result in overall energy expenditure exceeding consumption, the deficit will be supplied from body fat reserves, leading to weight loss. The relationship is a little more complex in that exercise training tends to increase muscle mass as well as to decrease body fat. Muscle is more dense and weighs more than adipose tissue (fat), so the true loss of body fat may actually be underestimated by the bathroom scales.

We use energy constantly throughout the 24 hour period however we eat periodically and our energy usage per hour will vary depending upon our activity. Resting uses a minimal amount of energy to support life whereas running uses an extra amount to support muscular activity on top of the basal rate.

Whilst running, it's very difficult to consume energy at the same rate as it is being used. Many of us can't tolerate the ingestion of sports drinks whilst running, let alone more concentrated forms of energy. So we rely on our body's energy stores to fuel the run. The energy that is consumed by our muscles, or 'burned', originates from two sources: glucose / glycogen and fat / fatty acids. (There are additional metabolic sources which fuel sprint activity, known as anaerobic energy, but we're considering endurance running here rather than sprinting.)

Most of us, for most of the time, are burning a combination of carbohydrate (glucose / glycogen) and fat fuel while we run. How can we be certain of this? Received wisdom is based on considerable scientific study.

To go back to the beginning, the principle of conservation of energy was established in the late 19th century. Using a carefully controlled chamber in which a subject could eat, sleep and exercise (i.e. live for several days), scientists were able to measure the total energy expended by the subject as all metabolic processes within the body ultimately result in heat production. These elaborate calorimetry experiments provided data to show that, when body weight remains constant, all the energy consumed is used up by a combination of basal metabolism and activity (including exercise).

Experimental calorimetry equipment is complex and expensive to run however all of the metabolic processes that release energy also depend on oxygen. Measuring oxygen consumption during physical activity provides an indirect, but very accurate, method of estimating energy expenditure.

If you've heard about VO_{2max} in connection with exercise performance, this is a similar measurement. VO_2 is oxygen consumption. The VO_2 assessment involves the subject breathing in ordinary air, where the composition of the standard atmosphere is relatively constant. Measurement of the volume and composition of the expired air allows a calculation to be made in order to work out the volumes of oxygen and carbon dioxide in the expired air, and hence the amount of oxygen used. Actually, the calculation is a whole series of equations, but the use of spreadsheets and computer processors allows the calculations to be done in real time in the laboratory. The important values are the volume of oxygen used and the volume of carbon dioxide produced and these figures are used to calculate the Respiratory Quotient ($RQ = VCO_2 / VO_2$).

There are inherent differences in the molecular compositions of carbohydrate, fat and protein. This means that each requires different amounts of oxygen for the complete oxidative breakdown into the end products of carbon dioxide and water which occurs as energy is released. The mix of carbohydrate, fat and protein fuelling exercise will determine the ratio of carbon dioxide produced to oxygen used, i.e. the RQ. In practice, the contribution of protein as an energy source is very small and so we focus on the relative proportions of carbohydrate and fat.

Simple organic chemistry tells us that the complete oxidation of one glucose (carbohydrate) molecule requires six oxygen molecules and produces six molecules of carbon dioxide. So, when we are burning carbohydrate as a fuel for exercise, the RQ equals 1.00. Fats have different compositions and the RQ for fat fuels ranges from 0.69 to 0.73 but a value of 0.70 is considered to be representative.

This means that burning 100% fat as fuel will result in a RQ of 0.70 whereas burning 100% carbohydrate as fuel will result in a RQ of 1.00. These data can be used to construct a table relating the proportions of fuel to the measured RQ as it is found that the relative percentages of the fuels providing energy approximate to a straight line function of RQ. For example, RQ = 0.85 represents 50:50 fat:carbohydrate.

In practice, almost all exercise is fuelled by a combination of carbohydrate and fat fuels. The greater the intensity of the exercise, the higher the proportion of carbohydrate and the lower the exercise intensity, the greater proportion of fat as fuel.

Returning to the marathoners, we can assume that they are exercising at a lower intensity than if they were running a 10km race. Therefore their fuel is made up of a higher proportion of fat than if they were running flat out for 5 or 10km. The amount of body fat available as fuel is more than adequate to fuel a marathon but runners still ‘hit the wall’.

The strategy employed to deal with ‘the wall’ is to take on carbohydrate because it is this fuel component that will be exhausted at that point and cause the runner’s performance to drop dramatically when their fuel mixture changes to be predominantly fat. It’s worth noting that taking on board fat whilst running doesn’t work in the same way because fat digestion doesn’t release useful forms of fat directly into the bloodstream whereas simple carbohydrates such as those provided in sports drinks, gels and jelly beans provide almost instant glucose.

Few runners have the opportunity (or the cash) to have VO_2 measurements made, unless perhaps they are close to a university or laboratory and able to volunteer for experimental studies. VO_2 measurements show a strong correlation with heart rate during exercise and so it is heart rate that provides the simple proxy measurement. This is where the popular figure of 60 – 70% maximum heart rate as the fat burning zone originates. It is relatively easy to establish your maximum heart rate, either directly while exercising or as an age-based calculation, and then work out the fat burning range. This represents the exercise rate at which you will use the greatest proportion of fat, compared to carbohydrate, as fuel. So, as long as your total energy intake is less than your total energy expenditure, you will start to reduce your body fat stores in the most effective way.

Age-based calculation for maximum heart rate: Subtract your age from 220 (226 for women) to calculate your maximum heart rate.

So, if your maximum heart rate is 180, then your greatest rate of fat burning occurs when exercising below 126 beats per minute.

In conclusion: yes, club level marathon runners will be burning fat while they run however they won’t lose weight as a result of their marathons unless their overall energy intake is less than the energy they expend.

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