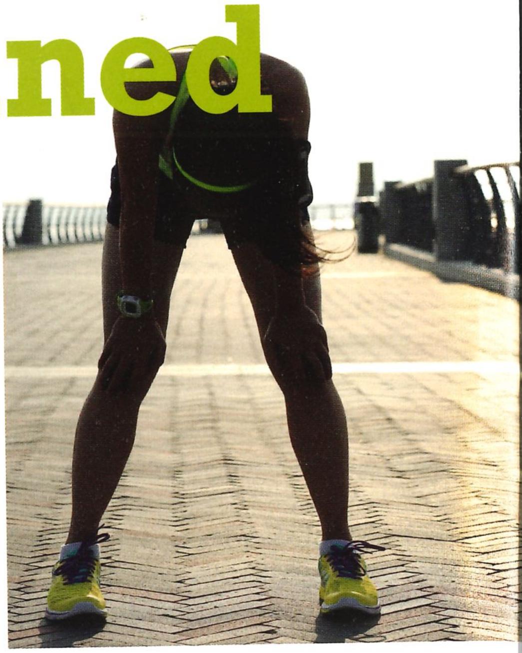
EPOC explained



Mark Thompson explains what EPOC is and how it affects the recovery process

Excess post-exercise oxygen consumption (EPOC) is the amount of oxygen we consume above what we would normally consume at rest in order to return the body to its pre-exercise state. Quite simply, when we finish a period of exercise, we experience EPOC, often as 'afterburn' and breathlessness. The level of EPOC is relative to exercise length, intensity, fitness level and gender. EPOC measures the quantity of exercise-induced disturbance of the body's homeostasis and the subsequent recovery demand (Wisbey).

> 'It generally takes anywhere from 15 minutes to 48 hours for the body to fully recover to a resting state.'
>
> Vella and Kravitz (2004)

First, we need to look at what occurs during exercise that disturbs or alters our body's homeostasis. During exercise, the following occur:

- increased body temperature
- increased metabolism
- increased breathing rate
- increased cardiac output (due to increased stroke volume and heart rate)
- increase of adrenaline
- production of lactic acid
- increased levels of carbon dioxide

We also experience an 'oxygen deficit'. As we start to exercise we first have to resynthesise ATP anaerobically as our body catches up to the realisation that we need more oxygen to cope with the demands of exercise.

All of the changes to the body that occur during exercise are returned to normal, resting levels through the process of EPOC. Whether the exercise is 10 seconds long or 10 minutes long, we will experience EPOC, but the duration and intensity will differ.

EPOC components

EPOC consists of a fast, shorter component and an extended, slower component (Foureaux et al. 2006). The fast component, also known as the alactacid stage (without lactic acid) uses the extra oxygen that is taken in during recovery to restore ATP and phosphocreatine and to re-saturate myoglobin with oxygen. Complete restoration of phosphocreatine takes up to 3 minutes but 50% of stores can be replenished after only 30 seconds, during which time approximately 3 litres of oxygen are consumed.

Myoglobin has a high affinity for oxygen. It stores oxygen in the sarcoplasm that has diffused from the haemoglobin in the blood. After exercise, oxygen stores in the myoglobin are limited. The surplus of oxygen supplied through EPOC helps replenish these stores, taking up to 2 minutes and using approximately 0.5 litres of oxygen.

The slow stage, also known as the lactacid stage (with lactic acid) is primarily responsible for breaking down and removing the lactic acid built up during exercise (lactate metabolism). This process can take a long time, as oxygen is utilised to break down the lactic acid through the following processes (Miller):

- Oxidised and removed from the body as carbon dioxide and water.
- Oxidation in the mitochondria to convert to pyruvate to enter the aerobic energy system.
- Transported in the blood to the liver, where it is converted to blood glucose and glycogen (**Cori cycle**).
- Converted to amino acids (building blocks of proteins).

Being as adaptable as the human body is, not all lactic acid is broken down and removed from the body as carbon dioxide and water. Some can be converted or 'recycled' into pyruvate, amino acids and glycogen to be utilised by the body. The majority of lactic acid is oxidised, producing carbon dioxide and water, some is converted to glycogen and stored in the liver and small amounts are converted into protein and glucose (Miller). Therefore it is not entirely correct to call lactic acid a 'waste product'. It is a waste product during exercise as it negatively affects performance levels. However, during EPOC it has some positive implications (Figure 1).

> **Key terms**
>
> **Cori cycle** The process where lactic acid is transported in the blood to the liver, where it is converted to blood glucose and glycogen.

EPOC effects

EPOC and the energy systems

EPOC is greater when we work predominantly in the lactic acid system, due to the increased levels of lactic acid produced that subsequently take longer to neutralise. There will always be some EPOC, as we have to pass through the anaerobic energy systems first (ATP-PC and lactic acid) before the body 'catches up' and settles into the aerobic system. So even light exercise will lead to EPOC.

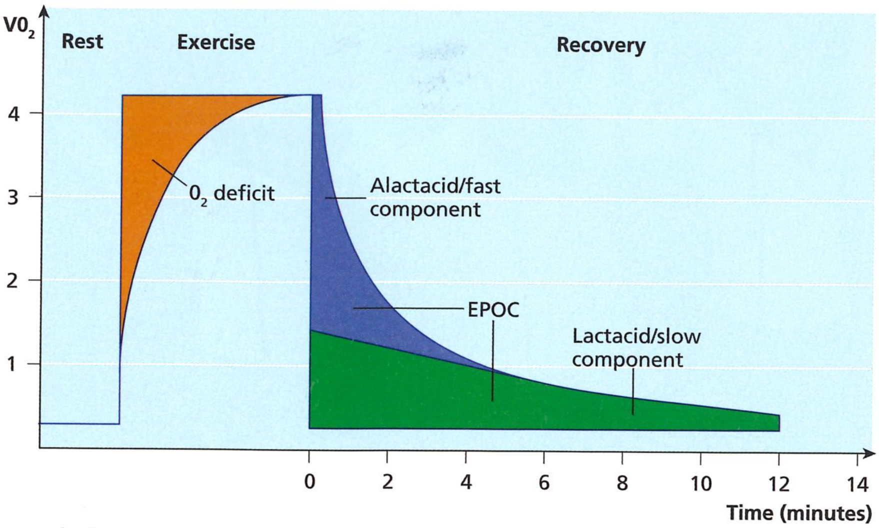


Figure 1 Excess post-exercise oxygen consumption (EPOC)

In activities where there is a mix of energy systems and phases, there may be periods when EPOC starts but doesn't finish, such as during a half-time break. The full EPOC process cannot occur until we stop exercising fully and have the time required to allow our bodies to get back to fully resting levels.

EPOC and VO_2 max

The speed and efficiency of EPOC is related to fitness levels. The fitter the individual, the more quickly they will recover after exercise. A higher VO_2 max allows a performer to utilise oxygen more efficiently during exercise, and this is the same during recovery. Recovery rate is therefore reduced.

EPOC and exercise intensity

There is no doubt that higher-intensity activity generates a larger EPOC. LaForgia et al. (2006) found that exercise at a VO_2 max of equal to or above 50–60% stimulated a linear increase in EPOC as duration increased. In other words, the harder we exercise, the longer it takes to recover.

EPOC and exercise duration

EPOC goes up linearly with duration of exercise, so EPOC will be greater after a marathon compared to a 10 km run at the same intensity — the longer we exercise, the longer it takes to recover.

In conclusion, exercise that is high in intensity and long in duration will lead to a longer EPOC process compared to low intensity and/or short duration.

EPOC and training

EPOC has important links to training, as it can help to plan effective programmes, reach the highest levels of performance and allow suitable rest periods that can minimise the risk of injuries, overtraining and fatigue. One of the key challenges in sport science is in determining an optimal training load (Wisbey).

It is imperative for athletes to train effectively if they are to reach optimal performance. Knowledge of EPOC in relation to training can support the achievement and maintenance of optimal levels, as well as support athletes and coaches in relation to training, tapering and peaking, and recovery methods/requirements.

EPOC and training type

When looking at the research available, Vella and Kravitz (2004) concluded that intermittent exercise such as interval training led to a greater EPOC response than continuous training. They also deduced that a high-intensity resistance training programme such as circuit resistance training or resistance weight training also led to a greater EPOC than aerobic training. This can be attributed to the increase in lactic acid produced and anaerobic respiration from the higher-intensity exercise.

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EPOC and metabolic rate/weight loss

Foureaux et al. (2006) say that training which can maximise EPOC and resting metabolic rate (RMR) may be an important factor in weight loss. During EPOC, our metabolism stays above resting levels, therefore we are burning more calories. This means that exercise which leads to a longer EPOC process may help with weight loss. However, it is important to remember that the most effective way to burn fat is through low-intensity, long-duration exercise where fat is the main fuel utilised.

Conclusion

EPOC is a process we all experience after exercise. Next time you finish a match or period of exercise and you are breathless, take a minute to consider why you are continuing to breathe heavily and how taking in this extra oxygen is helping to return your body to normal resting levels.

Further reading

Foureaux, G. et al. (2006) 'Effects of excess post-exercise oxygen consumption and resting metabolic rate in energy cost', *Brazilian Journal of Sporting Medicine*, Vol. 12, No. 6.

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Wisbey, B. '*EPOC — Quantify Your Training Load?*', FitSense Australia.

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