



The importance of physiology in distance running

International 5,000m, 10,000m, marathon and cross-country runner Sonia Samuels takes us through her journey to find the best methods to improve running performance

As an international distance runner, I have been privileged to both compete and train with many of the world's top athletes. I am constantly looking for new ways to improve my performances.

I currently live in Loughborough, having been a student at the university, and I have been fortunate enough to be able to take a career break from teaching to concentrate solely on my sport. It is a rigorous regime to get to peak fitness and it's not all about the running. There is diet to think about, equipment, recovery/massage and even altitude adjustment. This can seem glamorous when it involves travelling to faraway destinations with high peaks, but perhaps less so when it involves sleeping in a specialised altitude simulation tent at home.

LT, RE and VO_2 max

Running is not simply putting one foot in front of the other. When done correctly, it is a scientific endeavour to maximise speed and endurance. We can learn a lot from physiology and how it can make us run faster. In my quest to achieve success as a long-distance runner it is important to know which physiological elements are involved and how to train and develop them. Therefore, it is important to understand how the body functions at rest and how these functions change when the body is working at a high intensity. Every athlete has their own strengths and weaknesses, and training programmes should be structured to meet each athlete's individual needs, using the scientific knowledge and experience available.

Lactate threshold (LT) and running economy (RE) are more important than VO_2 max. VO_2 max (the maximum volume of oxygen that can be taken in and used by your muscles per minute) has received most of the attention among runners and coaches, but a high VO_2 max alone is not enough to attain elite-level performances. While you can improve your VO_2 max, it is largely genetically determined. Lactate threshold and running economy have a much



An altitude simulation tent replicates the low oxygen conditions of altitude and aims to increase the athlete's oxygen-carrying capacity by increasing red blood cell volume

greater influence on performance and are more responsive to training.

Laboratory tests have shown that although athletes might have an elite-level VO_2 max, they are not necessarily capable of running at the elite or even sub-elite level because they do not have a high LT or are not very economical. In 2009, I spotted a similar trend in my own scientifically observed results. I made changes to my training to improve my LT and RE, and almost immediately my races improved, taking large chunks of time out of my personal bests.

Improving LT

Research has shown that LT is the best physiological predictor of distance-running performance. This threshold defines the transition between running that is almost purely aerobic and running that includes significant oxygen-independent (anaerobic) metabolism. It represents the fastest speed you can sustain aerobically. Since LT represents your fastest sustainable pace, the longer the race, the more important your LT.

I have found tempo running — also known as threshold running — to be

a key part of the training programme in terms of raising lactate threshold. Generally this is a continuous run at LT pace, starting at about 3 miles and increasing up to 8 miles (or for about 45 minutes). I perform this type of workout at least once every 2 weeks when training for distances of 5,000m and above.

In preparation for the marathon, I build these runs up to a maximum distance of 15 miles. My tried and tested interval session to improve LT is 6 x 1 mile at LT pace with 1 minute rest. These types of workouts are the bread and butter of base fitness. They take a lot out of the body but when I'm laid out on the sofa later in the afternoon I always get an immense feeling of satisfaction that my fitness is improving.

Key term



LT pace For highly trained and elite runners, LT pace is about 25–30 seconds per mile slower than 5,000m race pace (or about 15–20 seconds per mile slower than 10,000m race pace) and corresponds to about 85–90% max HR. The pace should feel 'comfortably hard'.

Improving RE

Running economy is the volume of oxygen consumed at submaximal speeds. Laboratory tests have shown marked differences in the amounts of oxygen that different athletes use when running at the same speeds. These differences in economy of oxygen use are a major factor in explaining differences in running performance between athletes with similar VO_2 max values. For example, research has shown that while Kenyan runners have VO_2 max and LT values similar to their US and European counterparts, the Kenyans are more economical. This could be due to their light, non-muscular legs. The heavier your legs, the more oxygen it takes to move them.

RE is probably even more important than LT in determining distance-running performance because it indicates how hard you are working in relation to your maximum ability to use oxygen. For example, if two runners (Nick and Tom) have a VO_2 max of 70 ml of oxygen per kilogram of body weight per minute and an LT pace of 6 minutes per mile, but Tom uses 50 ml of oxygen and Nick uses 60 ml while running at 6:30 pace, the pace feels easier for Tom because he is more economical. Therefore, Tom can run faster before using the same amount of oxygen and feeling the same amount of fatigue as Nick.

Despite its importance, running economy seems to be the most difficult of the three physiological elements to train. There is a misconception among many runners and coaches, who think that RE is a reflection of running form. However, it is more influenced by the microscopic structures that affect oxygen delivery to, and use by, the muscles: capillaries and mitochondria. The densities of the capillaries and the mitochondria are enhanced with high mileage. Research has shown that runners who run high mileage (more



A young Kenyan developing her running economy to match mine!

than 70 miles per week) tend to be more economical. The more you run the more the body adapts and efficiency improves. Running is a technical skill that can be learned and improved; all wasteful movements need to be eliminated.

Training in Kenya

Other forms of training, such as intervals and tempo runs, can also improve RE. As VO_2 max and LT improve, the oxygen cost of any submaximal speed is also likely to improve. However, it is possible to become more economical without improving VO_2 max or LT. Strength

training and plyometric work (the stretch shortening cycle) have both been shown to improve running performance and economy. The key items are high intensity drills that include bounding, hopping, sprinting and jumping. This is achieved by improving energy returns from muscles and tendons. The best runners spend less time in contact with the ground, not more.

Having spent time at Iten in the Rift Valley, I have observed the best Kenyan athletes going through their paces. Interestingly, they do a lot of short hill sprints and bounding exercises. Kenyan

runners have strong ankles and feet with spring-like qualities that allow the body to bound along. Many young Kenyans can be seen walking barefoot, which also encourages springy levers.

I found many of the Kenyan trails quite rocky and uneven in comparison to the grassy and flat paths I am accustomed to in the UK. Perhaps growing up running barefoot and having to avoid rocks not only develops strong feet and ankles but also an ability to spend less time on the ground. In many ways, Kenyan athletes are the perfect example of an efficient running machine.

In the words of Alberto Salazar (coach to double Olympic champion Mo Farah), 'learn to run like a sprinter and you'll be a great distance runner.' Ryan Hall, US record holder for both the half-marathon and marathon, advocates the importance of performing some short sprinting repetitions. As part of my quest to improve my own marathon performance and improve RE, I have incorporated sessions of short hill and flat sprinting into my training

programme. Hopping and eccentric calf loading are also a twice weekly part of the programme. Sessions could include:

- hill sprints of 50–80 m
- high knee drills
- bounding
- single leg hops
- eccentric calf loading off a step

Key term

Eccentric When a muscle lengthens under tension.

Back to VO_2 max

While LT and RE are the most important physiological elements, you don't want to ignore your VO_2 max entirely. VO_2 max is important in reaching your running potential and is largely dictated by stroke volume and cardiac output. Long intervals provide the heaviest load on the cardiovascular system because of the repeated attainment of the heart's maximum stroke volume and cardiac output (and, by definition, your VO_2 max).

Key term

Stroke volume The amount of blood your heart pumps with each contraction of its left ventricle.

Cardiac output The amount of blood pumped by your heart each minute.

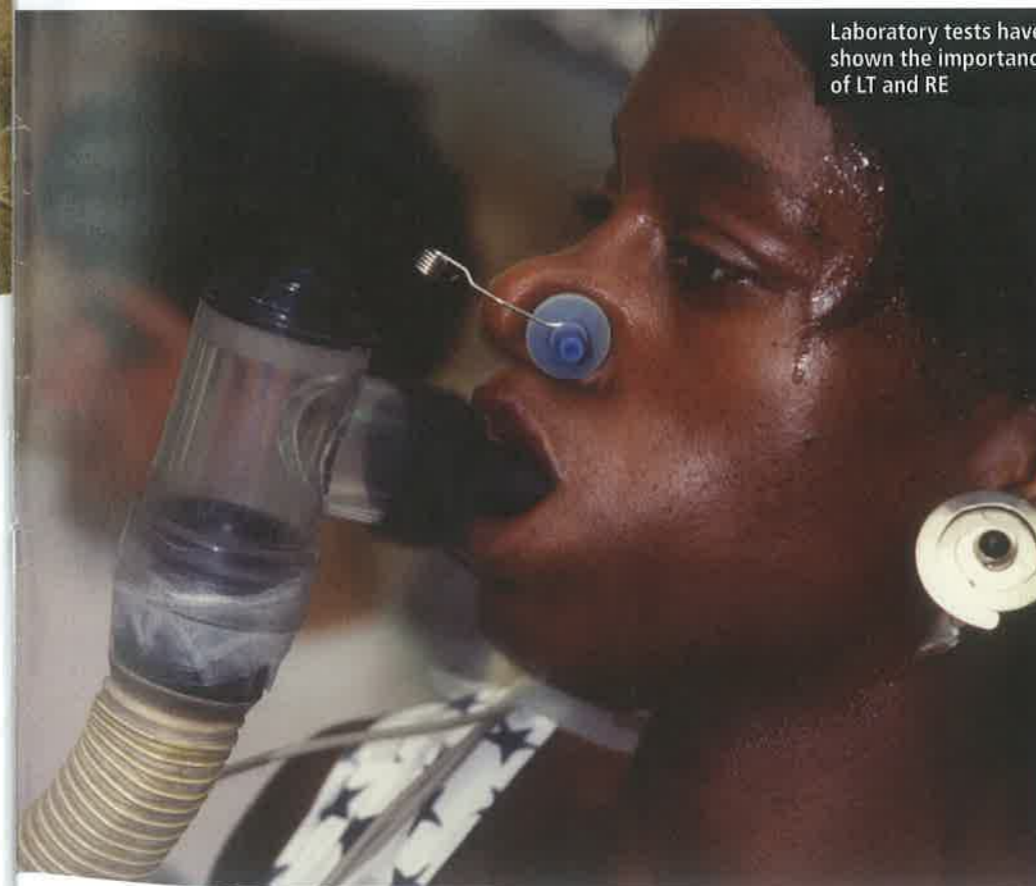
You can use current race performances or heart rate to tell you the velocity at which VO_2 max is achieved (vVO_2 max). vVO_2 max is close to 1-mile race pace for recreational runners and close to 2-mile race pace (10–15 seconds per mile faster than 5,000 m race pace) for highly trained runners. You should be within a few beats of your maximum heart rate by the end of each interval.

I have found altitude training to be a great boost to my VO_2 max value. The set-up at the High Performance Centre at Loughborough University means that we can have our VO_2 max tested in the laboratory frequently. My own personal results have shown a marked increase in VO_2 max after spending time at altitude. This was highlighted in 2010, when I improved my VO_2 max from 70 ml/kg/min to 74 ml/kg/min during a 4-week spell in the French Pyrenees.

Sessions to enhance my VO_2 max also include short repetitions (between 2 and 4 minutes) and with adequate recoveries. A sample session would be 8 × 3 minutes with 2-minute recoveries. This allows me to run close to my maximum.

Over many years of training as an elite-level athlete, I have constantly been striving to find new ways to raise my threshold, improve my economy and boost VO_2 max. Although physiology plays a huge part in defining the success of a distance runner, it is definitely less of a contributing factor than I once thought — the rest is all in the mind.

Sonia Samuels is an international long-distance runner.



Laboratory tests have shown the importance of LT and RE

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