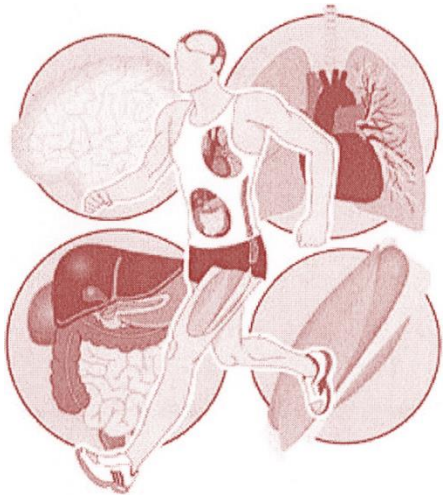
Inside Story

By Matt Barbour

What exactly is going on under your body's bonnet as you move through the 26.2 miles of a marathon?



No wonder the marathon is our ultimate yardstick - from cramps, to dizziness, to dehydration, those gruelling 26 miles 385 yards (count them) reach parts other distances can't reach. And it can pay to know exactly what parts, says Clare Lane, applied physiologist at Bath University's Human Performance Centre. "Understanding the physiological processes that occur during the different stages of a marathon gives runners a better grip of the underpinnings of strategy and training and can take their running to the next level."

PRE-START

It's now that the pre-race nerves kick in. But it's not just your incessant back- and-forth pacing that's sapping vital energy stores - sizing up the competition and playing your mile-by-mile strategy on a mental loop can be equally draining. "What most runners don't appreciate is just how much energy your brain uses, especially when it's pumped with adrenalin," says Charlie Pedlar, endurance physiologist with the English Institute of Sport (EIS).

"Your heart beats faster, and your brain, being a hugely inefficient and sizeable organ, can use up to 10 per cent of your stored glycogen energy reserves before you've even begun - you'll see the elite runners take time away from the crowds to keep calm and maintain their pulse at no more than 10 beats over their resting heart rate." That rush of 'fight or flight' adrenalin is there for a purpose -to elevate your core temperature and prime your muscles for action- but you need to control it if you're going long, says Pedlar. "Adrenaline is great for sprint events, when you want to shoot out of the blocks, but with marathons, the mantra has to be energy conservation."

0-6 MILES

An average 40-year-old male runner should have a resting pulse of about 60- 70 bpm, with women perhaps 5 bpm or so higher. "In the opening stages of a marathon, the heart rate of both men and women should climb to the plateau of about 140bpm, working at about 70 per cent of your maximum effort, a guide we use for testing new athletes' fitness," says Pedlar. "Any higher than this, and it's more than likely you'll be using the anaerobic energy system, which is up to 18 times less efficient."

Stick to your steady pace and you'll avoid exceeding your RER- or 'Respiratory Exchange Ratio' - he explains, which is when you're breathing out a greater volume of C02 than the oxygen you're

breathing in. The EIS uses state-of-the-art air analysis software to help identify an athlete's optimal aerobic pace, but it's pretty much impossible to gauge on your own in race conditions. "The rule of thumb should be 'go slower'," says Pedlar. "Even a short burst of anaerobic exercise will have an exponentially negative effect on your performance later on."

Your heart rate's not the only thing on the rise; your core body temperature should elevate quickly from around 37°C to about 39°C, prompting the hypothalamus, an almond-sized area of the brain, to flick the 'on' switch on your sweat glands to help keep things cucumber-cool. And it prompts the release of more adrenalin. "This helps the mobilisation of fat as a fuel source through your oxidative pathways, replenishing the glycogen energy stores in the liver and muscles you're tapping into," says Pedlar.

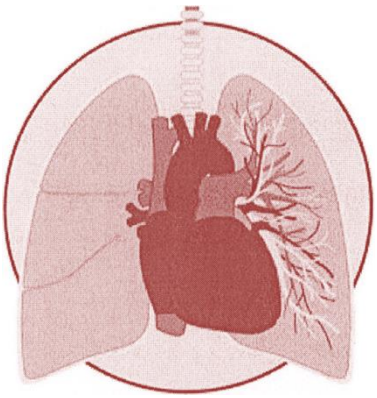
6-12 MILES

By now you're well settled into your pace, and your key readings will start to broadly plateau. From here to the end of the race, you should experience what's called 'cardiac drift'; your heart rate and core temperature steadily rise by about five per cent even though you're maintaining the same pace. Your body is finding it increasingly hard to dissipate the heat your efforts are creating.

"This makes your heart work harder to pump the blood through your system faster to cool you down," explains Dr Tom Crisp, sports and orthopaedic physician at The Royal Free Hospital, London (sportsmedicineservices.com). "It's a system that can be terminal if you lose sight of your mile splits, so I always advise marathon runners to do negative splits, speeding up in the second half of the race." Your body will still be relying on the ultra-accessible glycogen stores in your liver and muscles at this point- although increasingly sensing the need to start converting fat to replenish those stores - and your sweat output should peak.

It's now that hydration is needed. Some put it off, feeling too good in the moment to contemplate feeling bad later. But that's not wise, says Pedlar. "The fitter you are, the more efficient your body is at cooling you down with sweat, which means the well-trained are more likely to suffer from dehydration."

Use training runs to gauge personal fluid requirements. Weigh yourself before and after a run. For every kilogram of total weight lost, you need to be drinking at least one and a half litres of fluid. "That needs to be taken on board before you sense any thirst," warns Pedlar. "By that time, your metabolism and energy efficiency will be severely impaired." Typically, 150 to 300m! of fluid every 15 minutes should combat dehydration. "It's a vicious circle - you don't drink enough, your blood volume decreases, so your heart has to pump less blood faster to keep you cool, making you heat up more and making your heart beat even faster."



12-18 MILES

Your glycogen stores are now starting to run low, so your body is desperately trying to convert the more abundant and energy-rich fat stores to keep your motor running. "How efficient your body is at doing this is about 30 per cent genetic, and 70 per cent training," explains Lane. "Some people have more aerobic mitochondria that convert fatty adipose tissue to glycogen and blood glucose, but the fitter you are the better your body utilises them."

The hours of training you put in make your body better at transporting oxygen to your muscles, so you stay below your anaerobic threshold

The effects of over-exertion are kicking in as you try to maintain pace, despite the messages coming from within that something's changing. You could suffer stomach cramps, as oxygen-rich blood has been diverted away from the digestive system towards the muscles, while other runners will get diarrhoea, caused by interruption to the normal bowel movement. But it's not all doom and gloom downstairs, says Lane. "The bladder shouldn't need to be emptied. Blood is diverted away from kidneys during strenuous exercise, slowing urine production."

18-24 MILES

With glycogen stores bottoming out, it's now that you might be facing up to the dreaded 'wall'. Many runners are under the misapprehension that the fuel type you use suddenly changes at different points in the race, but that isn't the case, explains Pedlar. "It's an almost continuous transition, and when you start to run out of easily-accessible blood sugar and glycogen you're also pretty dog-tired, so there's a large mental element to it." It's now that those hours (and hours and hours) of training come into play.

"People who haven't prepared properly can start to go into anaerobic respiration, when there's too little oxygen reaching the muscles," he says. "Your body isn't efficient at taking in oxygen, so you'll hit your anaerobic threshold at very low intensity." And the killer by-product of this is lactic acid, causing acute pain and muscle cramps. Lactic acid production provides another vicious circle. "It impairs the mechanism that breaks down fat for energy," explains Pedlar.

And as if that weren't enough discomfort to be (not) getting on with, your joints should be feeling it now too. Unlike at the start, when your foot spends 200 milliseconds on the ground and 500 milliseconds in the air with each stride, these two figures will become almost equal-around the 300-millisecond mark. "Your stride becomes less efficient, so your foot spends more time on the ground, absorbing more of the two to three bodyweights you drive down with each step, often causing an intense, dull pain in the kneecaps," he says.

24-26.2 MILES

Just when you're feeling like you want to keel over and die, Mother Nature steps in. "It's often after the intense physical low and with the finishing line in sight that runners talk of experiencing a 'high'," says Crisp. "While this is no doubt a pain-management facility, it also presents real dangers as you stop listening to your body and push yourself to absolute exhaustion." The heart rate can soar to 180 and your blood pressure can shoot through the roof, while your body temperature can even rise over 41°C. "It's no surprise that over 80 per cent of all fatalities in marathons happen within two miles of the finishing line."

POST-RACE

As finishers collect their goodie bags and medals, their blood pressure plummets and can even go too low, Pedlar says, leading to fainting. Giddiness and even hypothermia. "Your internal temperature-controlling mechanisms can be shot, so it's essential to keep walking around so your heart and blood pressure can normalise in a more controlled, stable way." After 26.2 miles of pounding, there'll be significant micro-trauma damage to the musculoskeletal system, and you'll more than likely have a fluid deficit, which will inhibit recovery. The waste products of metabolism and tissue damage clog up your lymphatic channels, which can prevent fluids and minerals from entering your system and speeding repair, says Pedlar. "The best way to minimise delayed onset muscle soreness and drain your lymphatic system is ice baths, compression and massage combined with 20 to 30 minutes' light cycling or swimming in the days after your marathon."

The Wall Explained….

"Hitting the wall is about running out of energy," says Dr Tom Crisp, sports and orthopaedic physician at The Royal Free Hospital in London. We're talking about chemical energy, obtained from the breakdown (metabolism) of energy-containing fuel - in other words carbohydrates (blood glucose and glycogen, a polymer of glucose stored in the muscles and liver) and fats (free fatty acids in the blood stream and muscle triglycerides). While fat metabolism requires vast amounts of oxygen the simpler carbohydrate molecules, which eat up minimal 02 when burnt, are your fuel of choice.

"Even if you carbo-load wisely and maintain a reasonable pace, you still only have about 2,000 calories worth of glycogen stored in your muscles- enough to get most runners to about mile 18 or 20," he says. "As glycogen reserves are used up and fatty acid metabolism increases, your heart has to work harder to pump more oxygen-carrying blood to your muscles, making it difficult to maintain pace."

Add in the effects of dehydration - your blood thickens, making it harder to pump round your body - and the micro-trauma you're no doubt experiencing in your major muscle groups, and you're fighting a losing battle. "Fatty acid metabolism itself requires glucose, so you're instantly double-dipping, causing the steep drop into low energy." Non-working muscles can't even come to the rescue and transfer their un-tapped glycogen reserves to working muscles - once it's inside a muscle cell, it stays there until it's metabolised. "This is why many marathon

runners prefer courses with periodic elevation changes, which allow glycogen reserves to be shared among a larger group of working muscles."