

Tired of slowing down?

EXERCISE PHYSIOLOGIST **DR JASON KARP** EXPLAINS HOW TO FEND OFF FATIGUE AND GET THOSE PBS DOWN

“**F**ATIGUE”, defined as the inability to maintain or repeat a given level of muscle force production, is not something specific to slow or average runners. Even world record-holders fatigue – they just do it later in a run and at a much faster pace than the rest of us. Indeed, fatigue is necessary to protect our bodies from damage. However, the only way to get faster is to cause some damage so the fatigue occurs at a faster pace. To do that, you must repeatedly threaten the body’s survival with training stimuli so that your body adapts and physiologically overcompensates. When the same stress is encountered again, it does not cause the same degree of physiological disruption. In other words, the body adapts to be able to handle the threat. Below are the main causes of fatigue for different races, with advice on how to combat them.

800m/1500m

FATIGUE in the middle distance races is primarily caused by a high rate of anaerobic metabolism, which occurs when your heart cannot provide oxygen to your muscles. When you exceed your aerobic metabolic capacity to produce energy (ATP) for muscle contraction, a number of problems begin to arise inside your muscles. Your muscles lose their ability to contract effectively because of an increase in hydrogen ions, which causes the muscle pH to decrease, a condition called acidosis. Acidosis has a number of nasty side effects: (1) it inhibits the enzyme that breaks down ATP inside muscles, which decreases muscle contractile force, (2) it inhibits the release of calcium (the trigger for muscle contraction) from its storage site in muscles, and (3) it inhibits the production of ATP from the metabolic pathway glycolysis by inhibiting glycolysis’s most important enzyme.

In addition to hydrogen ion accumulation, other metabolites accumulate when running fast, including Pi, ADP, and potassium, each of which causes a specific problem inside muscles, from inhibition of specific enzymes involved in muscle contraction to interference with muscles’ electrical charges, ultimately leading to a decrease in muscle force production and your running



Fatigue in middle-distance events occurs when the body cannot get oxygen to its muscles quickly enough

speed. Limitations in aerobic metabolism also cause fatigue in the middle-distance events by limiting the pace that you can maintain aerobically. Your legs feel like lead during these short races because you’re not getting enough oxygen to them. That’s why it’s so important to run lots of miles even if you’re a middle-distance runner – you have to develop yourself aerobically to delay the acidosis and the accumulation of metabolites. To combat fatigue in the middle distances, run short intervals (45 seconds to about 2 minutes) at 800m to 1500m race pace to improve your ability to buffer acidosis and increase anaerobic capacity by increasing the number of enzymes involved in anaerobic metabolism.

3000m/10,000m

THE 3000m to 10,000m events are primarily aerobic races. So limitations in aerobic metabolism, due to inadequate blood flow to and oxygen use by the muscles, are the major causes of fatigue. However, since any race that is run faster than lactate threshold pace includes a significant anaerobic contribution, metabolic acidosis and accumulation of metabolites also contribute to fatigue in these longer

distances because they are run faster than lactate threshold pace. That’s why it’s important to also do anaerobic work for these longer distances. Here’s how to combat fatigue in the 3000m to 10,000m:

» VO2max intervals

VO2max intervals increase the heart’s stroke volume (amount of blood pumped by the heart per beat) and cardiac output (amount of blood pumped by the heart per minute), leading to an increase in VO2max, the maximum volume of oxygen your muscles consume per minute. High-intensity training (95-100 per cent VO2max) is the optimal stimulus to increase VO2max. VO2max pace corresponds to 1500m-3000m race pace for recreational runners and 3000-metre race pace for highly trained runners.

» Tempo runs

Tempo runs improve your lactate threshold, the fastest speed you can sustain aerobically, above which acidosis occurs. Increasing your lactate threshold pace allows you to run faster before you fatigue because it allows you to run faster before anaerobic metabolism begins to play a significant role. The longer the race for which you’re training,

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the more important it is to train your lactate threshold because the closer the race pace will be to your lactate threshold pace and the more important it becomes to be able to hold a hard pace for an extended time.

Lactate threshold workouts include: 1) continuous runs at lactate threshold pace; 2) intervals run at lactate threshold pace with short rest periods; and 3) shorter intervals run at slightly faster than lactate threshold pace with very short rest periods. Lactate threshold pace is about 10 to 15 seconds per mile slower than 5km race pace (about 10km race pace) for recreational runners and about 25 to 30 seconds per mile slower than 5km race pace (about 15 seconds per mile slower than 10km race pace) for highly trained runners. The pace should feel comfortably hard.

» High mileage

HIGH mileage (greater than 70 miles per week) improves running economy, the oxygen cost of maintaining a given pace, by increasing capillary and mitochondrial density, the former increasing the speed that oxygen can diffuse into your muscles, and the latter increasing your muscles' capacity to use oxygen. High mileage may also result in optimized biomechanics and muscle fibre recruitment patterns. Additionally, economy may be improved by the weight loss that usually accompanies high mileage, which leads to a lower oxygen cost; the hypertrophy of slow-twitch skeletal muscle fibres, which are more suited for aerobic metabolism; and a greater ability for tendons to store and utilise elastic energy.



Last stand: races will be 'easy' if you train hard enough



Running lots of miles in training will improve your cardiovascular system and running economy

Marathon

FATIGUE in the marathon is due primarily to running out of fuel rather than by-products of metabolism. You have enough stored carbohydrate (glycogen) to last slightly more than two hours of sustained running at a moderate intensity. Glycogen depletion and the accompanying low blood sugar (hypoglycemia) coincide with hitting the infamous wall.

Given the length of the marathon, there are other things that cause fatigue that don't play a major role in shorter races.

When you sweat a lot, you become dehydrated, which causes a decrease in the plasma volume of the blood, decreasing the heart's stroke volume and cardiac output. When these key characteristics of the heart decrease, oxygen flow to your muscles is compromised, and the pace slows.

The relentless pounding on the pavement also causes muscle fibre damage, which decreases muscle force production. Since your muscles produce heat when they contract, running for long periods of time is a threat to your body temperature – the resulting hyperthermia decreases blood flow to the active muscles (since more blood is directed to the skin to increase convective cooling), reducing the ability to regenerate ATP via aerobic metabolism. Finally, running

for so long can cause psychological or neural fatigue, the latter of which is due to changes in the levels of brain neurotransmitters. Here's how to combat fatigue in the marathon:

Run long

REPEATEDLY running for long periods of time (longer than two hours) or running for slightly less time but with a portion at lactate threshold pace, during which carbohydrates are used at a faster rate (what I call LT/LSD combo runs), presents a threat to the muscles' survival by depleting their storage of fuel. When you consume carbohydrates following a long run, the skeletal muscles respond rather elegantly to the empty tank by synthesising and storing more glycogen than what was previously present, thus increasing endurance.

Ingest carbs during the race

THAT muscles prefer carbohydrate as a fuel is so fundamental to exercise metabolism, research examining supplementation with carbohydrate during prolonged exercise has shown that fatigue can be delayed. Begin ingesting glucose about 30 minutes before you hit the wall so the glucose has time to be absorbed into your blood where it can be used for energy.

Workouts to combat fatigue

800m/1500m	3000m-10,000m	Marathon
<p>Anaerobic capacity:</p> <ul style="list-style-type: none"> • 6-8 x 400m at mile race pace with a 1:1 work-to-rest ratio. • 2 x 4 x 300 metres at 800m race pace with a 1:2 work-to-rest ratio and 5 minutes recovery between sets. <p>If you run 800m in 2:00 or 1500m in 4:13</p> <ul style="list-style-type: none"> • 6-8 x 400m in 67.5 seconds with 67.5 seconds recovery. • 2 x 4 x 300m in 45 seconds with 90 seconds recovery and 5 minutes recovery between sets. <p>If you run 800m in 2:30 or 1500m in 5:09</p> <ul style="list-style-type: none"> • 6-8 x 400m in 82.5 seconds with 82.5 seconds recovery. • 2 x 4 x 300m in 56 seconds with 2 minutes recovery and 5 minutes recovery between sets. <p>Aerobic metabolism: (See training for 3 000-10,000m).</p>	<p>VO2max:</p> <ul style="list-style-type: none"> • 5 x 1000m @ VO2max pace with a 1:<1 work-to-rest ratio. • 6 x 800m @ VO2max pace with a 1:<1 work-to-rest ratio • 40 x 200m @ VO2max pace with a 1:<1 work-to-rest ratio. <p>If you run 3000m in 9:00</p> <ul style="list-style-type: none"> • 5 x 1000m in 3:00 with 2½-3 minutes jog recovery. • 7 x 800m in 2:24 with 2 minutes jog recovery. • 40 x 200m in 36 seconds with 20 seconds jog recovery. <p>If you run 3000m in 12:00</p> <ul style="list-style-type: none"> • 5 x 1000m in 3:53 with 3½ minutes jog recovery. • 6 x 800m in 3:07 with 2½ minutes jog recovery. • 40 x 200m in 46.75 with 25 seconds jog recovery. <p>Lactate threshold:</p> <ul style="list-style-type: none"> • 4-6km (or 20 to 25 minutes) @ LT pace, up to 9-11km (or about 45 minutes). • 4 x 1500m @ LT pace with 1 minute rest. • 8 x 1200 @ LT pace with 1 minute rest. • 2 x 4 x 1000m @ 5-10 seconds per mile faster than LT pace with 45 seconds rest and 2 minutes rest between sets. <p>Running economy: High weekly mileage (>110km).</p>	<p>Running economy: High weekly mileage (>110km)</p> <p>Long run Building up to at least 2 hours.</p> <p>LT/LSD Combo Run:</p> <ul style="list-style-type: none"> • 19-25km with the last 3-6km @ LT pace. • 8km easy + 5km @ LT pace + 8km easy + 5km @ LT pace. • 16 km easy + 6km at LT pace.

Drink fluids with sodium

SINCE your sweat rate exceeds your ability to ingest fluid while running, dehydration is difficult to prevent and because endurance performance declines with only a two to three per cent loss of body mass due to fluid loss, you want to minimise its effects. During the marathon, drink fluids with sodium, which stimulate your kidneys to retain water.

Run long on pavement

UNLESS you're planning on running a trail marathon, do all of your long runs on pavement to prepare for the muscle fibre damage you'll sustain in the race.

Acclimatise to the heat

IF YOUR marathon is going to be in hot, humid weather, prepare yourself

by acclimatising to those conditions beforehand. While cardiovascular adaptations to running in the heat are nearly complete within one week, the sweating response takes about two weeks, so give yourself at least two weeks of slowly introducing yourself to the heat.

The next time you train for a big race, ask yourself what causes fatigue at that distance, and then provide the right training stimulus to combat it. And if you train smart enough, not only will you increase your fitness, you may even be able to chase down some of those seemingly indefatigable world record-holders.

» Dr Jason Karp PhD is a recognised speaker, writer, author and exercise physiologist. For more information see www.runcoachjason.com

What's up, doc?

» I have a history of injury and was wondering about the main injury-prevention actions to be taken in terms of weights, core stability, stretching and other options.

» WARM-UP is the single most important activity for injury-prevention. Increasing the core temperature improves the pliability of the muscles and tendons, making them more readily able to cope with forceful stretching.

With regards to weights it is important to have balance. Many concentrate on the large muscles and forget about the small muscles which provide fine control. For example, in the shoulder a well conditioned rotator cuff (supraspinatus, subscapularis, infraspinatus and teres minor) is essential, but it can't be seen because it is deep to the large deltoid. These muscles can be trained with a Theraband using internal and external rotation exercises.

In the back a good core is important, so many athletes now practise the plank, bridge and side-bridge exercises during their circuit sessions, but don't forget to do sit-ups and back extensions also.

For the knee it is important to have strong quadriceps, particularly the vastus medialis oblique. It is also worthwhile doing single-leg squats. When doing these, the knee must go straight down over the foot; a common error is for the knee to internally rotate towards the midline.

For the ankle you can practise balance on a wobble board. It is also important to train your ankle invertors and evertors with Theraband exercises. This will make you more resistant to ankle sprains.

Eccentric loading is worth a mention. The Nordic exercise is excellent for hamstring injury-prevention, and eccentric lowering exercises are used to treat the Achilles and patella tendons.

Stress fractures are very common and nutrition is all important, along with a good energy intake and a supply of calcium and vitamin D. Build up your mileage over time and never ignore bone pain.

» Dr Leon Creaney is a consultant physician in sport and exercise medicine. Send your questions to him at david.lowes@athleticsweekly.com. Please note that answers cannot replace face-to-face consultation with a sports physician, so only general guidance is given above.