Train Your Brain

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Runner's World
As any runner who's ever felt his legs turn into lead anvils at the end of a hard workout or race knows, running farther or faster all boils down to a battle against fatigue. And so you train to increase either the distance or the pace-or both-you can sustain without tiring. But hold on just a second: Fatigue might not be what you think it is. According to the latest exercise science, that dead-tired feeling could be all in your head. What's more, the way you've been training to prevent fatigue in your legs may not be the best way to train to prevent it where it really starts: in your brain.

Throughout most of the 20th century, the prevailing theory of exercise fatigue was the so-called "catastrophe" model. According to this theory, fatigue is an involuntary drop in performance caused by the loss of homeostasis (or balance) somewhere in the body. For example, due to lactic-acid buildup, the muscles lose pH balance and become too acidic to function properly, causing you to slow down. Or the muscles become depleted of glycogen (their primary fuel source), so there's no longer sufficient energy available to sustain performance.

But in the 1980s, a new generation of exercise scientists, led by Tim Noakes, M.D., of the University of Cape Town, South Africa, began to poke holes in the catastrophe model. First, they found that the common functional breakdowns-things like lactic-acid buildup and glycogen depletion-don't always occur as we tire. Studies, in fact, showed that fatigue often develops before the muscles reach a level of acidity that would cause direct muscle dysfunction, and that you can feel tired even when there is still muscle glycogen available in the working muscles.

What's more, these researchers also argued that the old catastrophe model couldn't account for the peculiar phenomenon known as the "end spurt" - you know, the guy who elbows past you in the last few yards of a marathon. If fatigue was always caused by direct physiological events within the muscles, then runners who began to slow down during the latter stages of a race couldn't possibly sprint the last 100 yards or so. "Athletes can often surge during the latter stages of a race, knowing that they won't have to continue once they cross the finish line," says Chris Abbiss, Ph.D., a biomedical and health-science researcher at Edith Cowan University in Western Australia.

In one 2001 experiment on end spurts, Australian researchers put a group of subjects through a 60-minute simulated time trial on stationary bikes. They interspersed six all-out sprints throughout the hour-long effort. The results showed that maximum power output began to decline in the second sprint, indicating a very early onset of fatigue. Maximum power continued to decrease through the fifth sprint, but then suddenly shot upward in the sixth and final sprint. If the fatigue that began to set in as early as the second sprint had been caused by a catastrophic loss of homeostasis in the muscles, where did the cyclists find the energy for the final surge?

Are We Done Yet?

As more research challenged the catastrophe theory of fatigue, an alternative emerged, suggesting that fatigue is a protective mechanism that the brain uses to prevent a catastrophic breakdown. Feedback signals from the body to the brain indicate the imminent likelihood of a physical crisis if exercise continues at the current intensity level. In response to these signals, the brain decreases muscle activation and produces feelings of discomfort and loss of motivation, resulting in reduced exercise performance. That is, your brain tells your body to quit working so dang hard.

The new, brain-centered model of exercise fatigue-called the "central governor" theory-also explains the end spurt. Proponents of this model believe that, throughout exercise, the brain continually reads feedback signals from the muscles, blood, and elsewhere in order to answer the question: "How much longer can my body go at the present work level before something terrible happens?" When the answer received is "not much longer," the brain reduces motor output to the muscles and generates those familiar feelings of suffering to reinforce the need to slow down. But when the finish line is within sight, your brain allows you to pick up the pace, knowing it will all be over with soon.

"The brain diminishes muscle activation during the middle of the race in anticipation of calling in a reserve toward the end," says Frank Marino, Ph.D., head of the School of Movement Studies at Charles Sturt University in Australia.

Studies involving simulated races (usually on stationary bikes) have shown that a decline in performance due to fatigue almost always coincides with a drop in electrical activity in the muscles. "This suggests that the brain reduces the drive to the muscles as a means of protection," says Marino.

The Power Of Thought

If fatigue really does start in your head, how do you train to delay its onset? By doing workouts that will convince your central governor that you're capable of achieving your goal times without suffering bodily harm. Such workouts should be highly race specific-simulating both the pace and distance of your goal event-so that your brain will be less likely to feel endangered during the race and won't put the brakes on motor output to your muscles, causing you to bonk.

The perfect example of a highly race-specific workout for a 5-K runner is an interval session of 5 x 1000 meters at 5-K race pace with a three-minute jog recovery between. Because the workout entails running 5-K at 5-K goal pace, it serves as proof to the brain that your body can handle the workload. If you're training for a longer race, such as a half-marathon or a marathon, you need to alter this approach by running only about half the race distance at goal pace, since not even the toughest elite could recover quickly enough from a workout totaling 26 miles of race-pace intervals.

Most runners can't jump right into demanding race-specific workouts without first developing the speed and distance components of race fitness individually.

So start by doing one challenging speed workout and one challenging distance workout each week, along with however many easy runs you want. Early on, most of your speed training should be much faster and your distance training much slower than goal race pace. As your body adapts, your speed efforts should become longer and slower, and your distance efforts should become longer, then faster, until your workouts closely simulate the upcoming race experience. Once you've proven to your brain that you can complete these race-specific workouts, come the big day, it should respond to your efforts with a "been there, done that, no problem."