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Hitting The Wall

If You Understand the Scientific Reasons Behind “The Wall,” You Should Be Able to Avoid It.

BY SARA LATTA

It felt like an elephant had jumped out of a tree onto my shoulders and was making me carry it the rest of the way in.”—Dick Beardsley, speaking of hitting The Wall at the second marathon of his career, the 1977 City of Lakes Marathon.

“I wasn’t wanting to talk much. And when I’m not talking, you know I’m hurting.”—Don Frichtl, a runner who encountered The Wall somewhere after mile 21 of the 2002 Chicago Marathon.

“At around mile 23, I was beginning to feel like the anchor was out.”—George Ringler, speaking of his 1991 Lake County Marathon.

“The Wall.” It evades easy definition, but to borrow from Supreme Court Justice Potter Stewart’s famous definition of obscenity, you know it when you see it—or rather, hit it. It usually happens around mile 20, give or take a couple of miles. Your pace slows, sometimes considerably. Some runners say that it feels as though their legs had been filled with lead quail shot, like the stomach of Mark Twain’s unfortunate jumping frog of Calaveras County. Others can’t feel their feet at all. Thought processes become a little fuzzy. (“Mile 22, again? I thought I just passed mile 22!”) Muscle coordination goes out the window, and self-doubt casts a deep shadow over the soul.

The bad news is that more than half of all nonelite marathon runners report having hit The Wall at least once. The good news is that more than 40 percent of all nonelite marathon runners have never hit The Wall. In other words, while it certainly doesn’t hurt to be prepared for the possibility of hitting The Wall, doing so is far from inevitable.

ENERGY DYNAMICS 101

“Hitting The Wall is basically about running out of energy,” says Dave Martin, Ph.D., Emeritus Regent’s Professor of Health Sciences at Georgia State University in Atlanta—chemical energy, that is, stored in the form of adenosine triphosphate (ATP) and obtained from the breakdown, or metabolism, of energy-containing fuel. The runner’s primary fuel sources are carbohydrates (in the form of blood glucose and glycogen, a polymer of glucose stored in the muscles and liver) and fats (free fatty acids in the bloodstream and muscle triglycerides, molecules containing three fatty acids).

Fats might seem to be the logical first choice of fuel for endurance events; not only are they the most concentrated form of food energy, but even the thinnest runners have enough body fat to get them through 600 miles. Alas, it’s not quite that simple. Fatty acid metabolism requires plentiful circulating oxygen, a precious commodity when you’re running at marathon race pace. Carbohydrate metabolism, on the other hand, requires less

oxygen. In fact, cells can derive energy from carbohydrates either aerobically (in the presence of oxygen) or anaerobically (in the absence of oxygen).

If you start your marathon at a reasonable pace for you, your fuel consumption ratio will be about 75 percent carbohydrates to 25 percent fatty acids, according to Martin. During the race, as carbohydrate supplies begin to dwindle, that ratio changes as your body begins to rely more heavily on fatty acids.

What does all of this have to do with hitting The Wall? Let's start with the pace. It's common, in the excitement of the moment, to start out at a pace that's too fast for you. Big mistake. Your heart cannot pump enough blood to ensure a steady supply of oxygen to the muscles. At this point, your muscles have no choice but to burn glucose in the absence of oxygen. The anaerobic metabolism of glucose, as it's called, is inefficient, yielding only about 1/18 as much energy (in the form of ATP) as aerobic metabolism. To make matters worse, among the by-products of the anaerobic metabolism of glucose are lactic acid and hydrogen ions. As these waste products continue to accumulate in the blood and tissue, they will not only make your muscles feel as though they are on fire, but they can also inactivate the enzymes that govern glucose metabolism. You're toast.

Even if you're racing at a reasonable pace and you've done a good job of carboloading in the days before the marathon, you still have only about 2,000 calories worth of glycogen stored in the muscles and liver; that's about enough to get you to—surprise!—mile 20. If you manage to deplete your glycogen reserves, say hello to The Wall. As mentioned before, burning fatty acids requires plentiful oxygen, so as fatty acid metabolism increases, your heart must work harder to pump more oxygen-carrying blood to the muscles. It may be difficult or impossible to maintain your pace, especially if you've lost enough water through sweat to become even slightly dehydrated (this causes your blood to become thicker and therefore harder to pump). In addition, fatty acid metabolism itself requires glucose; as someone once said, "Fat is burned in a carbohydrate oven."

Of course, you can do things to make sure you stay well hydrated and maintain an adequate supply of glucose during the marathon, and you're probably aware of most of them. Begin to carboload a few days before the race to make sure that your muscles store as much glycogen as possible. Fortunately, the old, frequently stressful and unpleasant depletion/loading program has fallen out of favor with most runners. Martin recommends eating a balanced diet with a higher-than-usual percentage of carbohydrates as you're tapering before the race. As the body increases its glycogen stores, it also increases the amount of stored water, leading to slight weight gain but also making more water available for sweat during the race.

Make sure that you are well hydrated before the race, and eat a light, carbohydrate-rich meal no later than two hours before the race. And by all means take advantage of the water, sports drinks, and other glucose-containing foods offered at the aid stations!

Many people also find that sports gels provide quick boosts of energy, although Martin admits that he is not a big fan of them. "Picture this poor soul who takes a blob of GU but doesn't quite manage to get a cup of water. Now he's got this thick 100 percent solution of stuff in his stomach that he can't absorb. I'm a firm believer in energy drinks rather than just water." Other favorites include defizzed Coke (Frank Shorter used to swear by it), which is a good source not only of carbohydrate but of caffeine as well (the role of caffeine in preventing fatigue is discussed later).

Martin also points out that nonworking muscles cannot transfer their glycogen reserves to working muscles; once glucose is inside a muscle cell, that's where it stays until it's metabolized. "This might be one reason why many marathon runners prefer a race course with periodic, slight elevation changes," he says. "This allows the glycogen reserves to be shared among a larger group of working muscles." Runners who are racing on a very flat course might consider occasionally varying their pace or stride length to mobilize unused glycogen stores.

CENTRAL NERVOUS SYSTEM FATIGUE

It should come as no surprise that the brain, as well as the muscles, can become fatigued over the course of a marathon. In recent years, J. Mark Davis and others have begun to study the relationship between changes in the central nervous system (the brain and spinal cord, or CNS) and exercise-related fatigue.

Davis, a professor of exercise science and the director of the exercise biochemistry laboratory at the University of South Carolina, suspects that CNS fatigue, the result of neurochemical changes in the brain, is very likely to be involved in a runner hitting The Wall during a marathon. In fact, he says, "I think that CNS fatigue is actually what causes most people to stop, as opposed to muscle specific fatigue." Aside from very highly motivated runners, he says, most people don't really drive or push themselves to complete muscle failure.

Davis cautions that his research is still at the preliminary stage, but his data certainly support the CNS fatigue hypothesis. During prolonged exercise, the brain's production of the neurotransmitter (a chemical that carries signals from one neuron, or brain cell, to another) serotonin increases steadily; it peaked, in his animal treadmill studies, when the animals collapsed from exhaustion. Elevated levels of serotonin have been implicated in feelings of tiredness, sleepiness, and lethargy. (The folk remedy of drinking a glass of warm milk before going to bed has a sound scientific basis: milk, as well as chocolate, is a good source of the amino acid tryptophan, the precursor to serotonin.)

The rising levels of serotonin are caused by increased delivery of tryptophan to the brain. What's interesting, Davis says, is that the increase in free tryptophan in the blood is very much related to the increase in free fatty acids in the blood. "While many people believe that the increase in free fatty acids is very important to delaying fatigue in the muscle," says Davis, "we think it has a negative effect in terms of central fatigue."

To make matters worse for the marathon runner, the brain's production of dopamine (the neurotransmitter responsible for generating feelings of excitement, reward, motivation, and pleasure) begins to drop even as serotonin levels are rising.

One experimental approach to preventing an increase in serotonin synthesis has been to give subjects nutritional supplements that include something called branched chain amino acids (leucine, isoleucine, and valine). Branched chain amino acids (BCAAs) compete with tryptophan for space on the receptors that carry chemicals from the blood to the brain. Unfortunately, while BCAAs do indeed lower the levels of tryptophan and, by extension, serotonin in the brain, they don't prevent CNS fatigue during exercise. Davis believes BCAAs' failure to prevent CNS fatigue is due to one of their side effects: an increase in the blood levels of ammonia, a brain and muscle toxin.

The best strategy for delaying both muscle and CNS fatigue, Davis says, is tried and true: eating or drinking carbohydrates. "It's well known that carbohydrate feeding blunts

the increase in free fatty acids," he says, which of course ends up blunting the increase in serotonin, "so carbohydrates cannot only delay glycogen depletion, but they also delay central fatigue." In addition, brain function in general is highly dependent upon blood glucose, as anyone who tries to calculate mile splits at mile 23 probably knows.

Davis is beginning to investigate nutritional approaches to prevent dopamine levels from dropping, including the addition of tyrosine (the precursor to dopamine as well as norepinephrine, a stress-related hormone similar to adrenaline) to sports drinks, but he cautioned that there are not yet data showing that tyrosine supplements raise dopamine levels during exercise or delay fatigue.

Runners have been using caffeine to help delay fatigue for years, the prevailing wisdom being that the substance increases the blood level of free fatty acids available for metabolism. Recent research by Davis and others, however, indicates that caffeine plays another, perhaps more important role, in delaying fatigue by increasing the levels of dopamine in the brain.

COGNITIVE STRATEGIES

Yogi Berra said that "Baseball is 90 percent mental; the other half is physical." Berra's famously charming illogic aside, the same could probably be said about any sport. Charles A. Garfield, a sports psychologist and coauthor of the book *Peak Performance: Mental Training Techniques of the World's Greatest Athletes* (Warner Books, 1985), maintains that 60 to 90 percent of success in sports can be attributed to "mental factors and psychological mastery."

Scant scientific research examines the relationship between mental strategies and hitting The Wall per se, although a body of research dating back to the 1970s documents the relationship between a runner's thought processes and performance. Faster race times are generally associated with what have come to be known as associative strategies—thinking about physical sensations, such as breathing, muscle soreness, or blisters, and other race-related issues such as pacing and competitive strategy. During competition, elite runners tend to use associative thinking strategies almost exclusively.

Athletes who achieve their peak performance usually experience something that has come to be known as "flow," a concept introduced to the world in the 1970s by psychologist Mihaly Csikszentmihalyi. Flow is "a state of consciousness where one becomes totally absorbed in what one is doing, to the exclusion of all other thoughts and emotions," according to Susan A. Jackson and Csikszentmihalyi, authors of *Flow in Sports* (Human Kinetics, 1999). "So flow is about focus." In other words, when you experience that running nirvana during which everything seems effortless, you are probably thinking associatively.

Unfortunately, most of us are not able to maintain a state of flow for an entire marathon. Slower runners tend to use dissociative strategies—thinking about things not directly related to the race—in addition to associative strategies.

"There is some reason to believe that people with different levels of running experience may benefit more from using different strategies," says Britton Brewer, associate professor of psychology at Springfield College in Springfield, Massachusetts. "People who are more experienced in the sport may be able to make better use of associative strategies, because they won't be intimidated or panicky when they experience various symptoms that they encounter while distance running."

Kevin Masters, associate professor of psychology at Utah State University, agrees, even suggesting that average runners should learn ways to distract themselves during the marathon. "The overwhelming evidence shows that [distracting yourself mentally makes] time seem to go faster, and you feel that you are exerting less energy. Overall you will run a little bit slower, but for most people that's not a big issue."

A 1998 study by Clare D. Stevinson and Stuart J.H. Biddle, published in the *British Journal of Sports Medicine*, made a further distinction in marathon runners' mental strategies, describing four types of thinking used by nonelite runners in the 1996 London Marathon.

The first type was internal association, or focusing on how the body feels while running. The second type of thinking was external association, in which the runner's attention is focused outwardly on things important to the race: calculating split times, negotiating water stations, or jockeying for position with competitors. The third mode of thinking was inward dissociation (or distraction): daydreaming, singing silently (or aloud!), or solving mental puzzles. Runners who used the fourth mental strategy, external association, tended to focus their attention outwardly on events unimportant to race performance: the scenery, the cheering crowds, other runners dressed in kooky outfits.

The researchers found that the most prevalent mental strategy for all runners, whether they hit The Wall or not, was inward association. But those runners who reported hitting The Wall tended to use inward dissociation much more frequently than their wall-avoiding competitors. The authors speculate that "It is likely that being distracted from sensory signals and important aspects of the task meant that runners were not able to judge their pace very well and failed to stay fully hydrated, contributing greatly to 'hitting The Wall.' "

While it might seem plausible that external dissociation might lead runners into a similar trap, the authors found this not to be the case, possibly because "noticing spectators, aspects of the scenery, or, in particular, other runners, made runners inadvertently aware of the speed at which they were running as they passed by them or were overtaken."

On the other hand, the researchers suggest that paying too much attention to the body (inward association) made their subjects magnify their discomfort, making The Wall seem to appear much earlier and for a longer period of time. Their advice: make brief but regular checks on your body, rather than constantly monitoring every step of the race. Focus most of your attention externally: be aware of critical race-related factors and enjoy the atmosphere of the race.

WHAT NOT TO DO: A CAUTIONARY TALE

Dick Beardsley's race strategy for the second marathon of his life—the one in which an elephant jumped on his shoulders—is a classic primer on how not to prepare for and run a marathon. He had run his first marathon on a whim when he was in junior college and finished in 2:47:14. Not too bad, especially considering that he hadn't trained for the marathon distance. Two months later he learned of a marathon in nearby Minneapolis. It was Tuesday, and the marathon was on Sunday. He decided to "prepare" himself for this one. Relying upon advice in an article he found in an old running magazine, he decided to fast until the marathon, allowing himself only Gatorade, juice, and water.

On the morning of the marathon, he put on his brand-new pair of running shoes and

went out for an eight-mile warm-up. He went out fast in the first few miles of the marathon. He bypassed the aid stations—didn't everyone know that drinking anything during a race would give you a side ache?

Beardsley was still feeling pretty good, despite the blisters on his feet, as he ran past the 20-mile mark where someone had painted the words, "You're at The Wall." And then, just past mile 23, he felt like a sledgehammer had come down on him. "I went from feeling pretty good to where I did not know how I was going to get to the next telephone pole," he said. "I was running with my eyes shut, hallucinating. Without a doubt, that was the worst wall I ever hit." He collapsed at the finish line, severely dehydrated.

It's a testament to Beardsley's superb physical abilities and mental toughness that he managed to finish the race, much less to finish seventh overall.

Mistake number one: by fasting the week before the race, he probably started off in a state of near-glycogen depletion.

Mistake number two: running in a brand-new pair of running shoes. It is difficult to maintain your cognitive focus on race-related issues as you are developing painful blisters. His eight-mile warm-up was about seven and a half miles too long. By going out too fast, he probably incurred some lactic acid buildup, which lessened the amount of glucose that he could metabolize later on. Not eating or drinking during the race was a recipe for glycogen depletion and dehydration.

Beardsley, of course, learned his lesson well, going on to become one of the best marathoners in the United States and making history in his memorable finish two seconds behind Alberto Salazar in the 1982 Boston Marathon.

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