Why efficiency doesn’t matter

Or how to get more miles between knee surgeries

By John Schubert

More times than I could count, exercise physiologists have measured the efficiency of bicyclists at different pedaling cadences. By measuring the rider’s power output on a stationary bike, oxygen consumption, and anything else they can hook up to a computer, they can measure fuel (food and oxygen) consumed and foot-pounds of work produced.

Typically, these studies show that the bicyclist is “most efficient” at a cadence of 50 or 60, which sounds painfully low to accomplished riders, but user-friendly to novices or non-cyclists. Most of us have been told to work on increasing our cadence to 80, 90, or whatever number our friends think is a good cadence. And our friends are correct. But how can they be correct when these faster cadences are less efficient? The reason is pretty straightforward:

• Again, efficiency is measured in miles per fuel burned. But you don’t care, because the world has plenty of oxygen and peanut butter sandwiches for you to consume.

• A slower cadence (with, for a given power output, a higher gear and higher pedal effort) has three disadvantages when compared with the faster cadence (combined with lower gear and lower pedal effort). None of these disadvantages is labeled “inefficiency” in a strict engineering sense, but they’re all quite important, and I’ll discuss them each below.

  • Your objective isn’t to consume less peanut butter. Your objective is to feel good while riding the tour — and feel good again the next day. If you eat more peanut butter in reaching this objective, you won’t object.

  Now, here are those undesirable side effects:

  • The slower cadence is harder on your knees.

  • The slower cadence is more likely to generate lactic acid.

  • The slower cadence uses up your blood glucose faster.

The first of these side effects is obvious enough: more pressure on the knee joint. But the second and third are often not well understood, and they relate directly to the rider’s short-term comfort.

Most people understand that lactic acid is what makes your muscles ache when you climb a hill. And we also understand that lactic acid — which is essentially an IOU for the muscles to consume oxygen our bloodstream hasn’t delivered yet — isn’t produced if we exercise within our aerobic capacity.

But exercise isn’t exact, and roads are never flat, and it’s easy for an individual muscle to drift above the anaerobic threshold when we’re riding. This is particularly true when the pedal effort is high.

Here’s an example: Take two identical riders. One is riding a cadence of 90 with a gear of 60 inches. The other is riding a cadence of 60 with a gear of 90 inches. Both are going the same speed, 16 mph. For many people, this is an easy effort level on flat ground. But when the road insidiously turns into a gradual climb, the effort level increases. The 60 rpm rider is now pushing with more force on the pedals, and the 90 rpm rider isn’t.

Think this is trivial? It isn’t. A three-percent grade — so slight as to be almost invisible — requires roughly a doubling of your power output to stay at the same speed. (And many riders will attempt to stay at that speed, muscling over the slight hill.) This doubling of the pedal effort is going to bring you much closer to producing lactic acid if you start at a higher level of effort, which is what happens when you ride at the slower cadence.

Thus, the 60 rpm rider will, in the course of a normal ride over undulating terrain, get lactic acid buildup in his muscles. And it makes him feel tired. The 90 rpm rider will have less lactic acid, and feel less tired.

The blood glucose question is probably more important because it’s less easy to understand than the instant-feedback agony of lactic acid. But anyone who wants to feel comfortable riding more than an hour or two at a time should be very interested in it.

Muscles use two kinds of fuel: fat and glucose. Glucose is the muscles’ high-energy fuel. When you’re working hard, your muscles are burning glucose. In addition, glucose is the fuel that powers your body’s nervous system (including the brain) and your involuntary muscles (heart muscles, among others).

Fat is low-energy fuel. Slow, easy effort levels use fat. Your body can only store enough glucose for about two...
hours of exercise (it’s stored in the muscles, in the bloodstream and in the liver). But even a thin person has enough fat stored for days and days of exercise.

For these reasons, anything you can do to make your muscles burn fat instead of glucose is advantageous. And lower effort levels use more fat. Therefore, our 90 rpm/60-inch rider burns more fat and less glucose than our 60 rpm/90-inch rider. The faster-spinning rider will feel fresher at the end of a long ride, and fresher the next day.

And just in case you’re unconvinced about that efficiency thing, here’s another statistic: at 16 mph, it takes you something like 26 minutes to burn up the 150 calories contained in the last two double-stuff Oreos you ate. In other words, riding your bike is so efficient that you don’t need to optimize efficiency. Therefore, I conclude, that efficiency just isn’t as important as these other factors. Spin away.

Two new items on my bookshelf merit special mention:

**Optimal Muscle Recovery** by Edmund R. Burke, Ph.D. (Avery Publishing Group, Garden City Park, New York, www.averypublishing.com; 1999); $14.95. Not all of you need or want Ed Burke’s latest book, but those of you who do want it, will want it very badly.

If you describe yourself as a “flower-picking tourist,” if you don’t ever try to see how fast or far you can go, and if you have a relaxed type B personality around your bike, you probably can’t relate to Optimal Muscle Recovery.

But if you want to be a good rider — not necessarily a competitive rider, just a good one — and want to avoid making stupid mistakes that hurt your riding, you need this book.

Want to know when, how much and what kind of fluids to drink to maximize your recovery from exercise? Burke has a chapter on that. Want to know, in language that is both scientifically rigorous and easy for a layperson to understand, how muscles work, what causes injury, cramping and soreness, and how to avoid all these things? Burke has many chapters on these topics.

I was surprised to learn that one should eat bagels during or immediately after exercise, rather than apples or peaches, to maximize the body’s recovery of glucose stores and the muscles’ recovery. Similarly, it was news to me that extra Vitamin C and Vitamin E play a direct role in the muscles’ recovery from exercise, or that carbohydrates bolster the immune system’s effectiveness.

I’ve known Ed Burke for two decades now, and his credentials as an exercise physiologist are the best there is. He was instrumental in helping the athletes on the 1984 Olympic Cycling Team win nine medals. But don’t be intimidated by Burke’s cutting-edge credentials — the advice in this book is written so that it will be enormously useful for someone trying to complete his/her first half-century without undue agony, as well as for the really competitive athlete.

Burke garnered strongly worded endorsements from runners Grete Waitz and Frank Shorter, cycling coach Chris Carmichael, and other luminaries for this book.

The book includes a pitch for a commercial product — the R4 System Drink, a sports drink designed and tested to help your muscles recover from exercise quickly. Some may wrinkle their noses at this mix of journalism and product promotion. But after suffering through 30 years of Gatorade commercials, I’m delighted to see one sports drink company that thinks the public is smart enough to want to know how and why the product really works.

**The Dancing Chain** by Frank Berto, Ron Shepherd and Raymond Henry (Van der Plas publication, San Francisco, CA); $49.95.

The Dancing Chain belongs on your coffee table. Period. There, I’ve said it. Why? Admit it, you love the derailleur. This fascinating mechanism that looks so odd, moves in several directions at once, and makes such distinctive noises is at the root of many riders’ fascination with cycling.

And The Dancing Chain is an extraordinary history of the derailleur. Only 2000 were printed, and about two-thirds of them have been sold already. When they’re gone, a second printing is unlikely. Five years from now, this book will be a legendary collector’s item, and you’ll be sorry you didn’t get one when you had a chance.

Lead author Berto, who began his cycling journalism career by writing for Bicycling Magazine in 1975, assembled co-authors Shepherd from Australia and Henry from France to write this definitive history of the derailleur. It was a fitting cap to Berto’s technical writing career, which has focused on technical analysis and evaluation of derailleurs (and other drive-train components).

The book begins with the pre-derailleur, pre-everything bicycles of the 1860s, and traces the designers’ efforts to create more usable machines with belt drives, front wheel drive, different wheel diameters and other adaptations.

You’ll read a clear history, available nowhere else, of the progression from the penny-farthing style bike to the chain drive bike, the first rudimentary three-speed patented in 1869, the 1909 Sturmey-Archer three-speed hub and its 17 (!) then-contemporary British competitors, and France’s 1908 Velocio — the first item that would be readily recognizable as a conventional rear derailleur. The book goes on, incremental innovation by incremental innovation, skipping continents as appropriate, to show virtually every step in how that Velocio evolved into the derailleurs in your bike shop today. You get to look over the shoulders of these long-dead inventors and see how their thoughts evolved, and you see which evolutionary “dead ends” didn’t make the cut.

Berto assumed — wrongly, he later learned — that he could find a publisher by hawking a nearly complete manuscript and illustrations. He soon learned that was incorrect. Publishers took one look at the hundreds of illustrations, thought about the Adobe Photoshop work necessary to clean them up for publication (which later turned out to average about an hour per illustration), and all roundly rejected the project.

Undeterred, Berto pressed on. He personally funded the production costs and self-published the book (with no small amount of help from Rob Van der Plas, whose dedication to publishing bicycle titles should be richly rewarded).

“No publisher would touch it. ‘Too much print, too many pictures,’ they said,” Berto said. “It just cost an arm and a leg to take those old pictures and make them look good.”

But Berto spent the arm and the leg, and the book’s countless illustrations are clear and easy to follow. He hasn’t broken even financially yet, but he’s gotten another reward: “I have a stack of letters, about a half inch thick, thanking me for the book,” Berto said. “That makes me feel good.”

In addition to ordering The Dancing Chain through your bookstore or bike shop, you can get an autographed copy directly from Berto. To make your coffee table the envy of your block, send a check for $54.50 (which includes shipping) to Frank Berto, 70 Crane Drive, San Anselmo, CA 94960.

Technical Editor John Schubert (Schubley@aol.com) tips his hat to fellow technical writers John Forester and Han Kroom for addressing the myth of efficiency in 1983-1984 articles in Bike Tech.