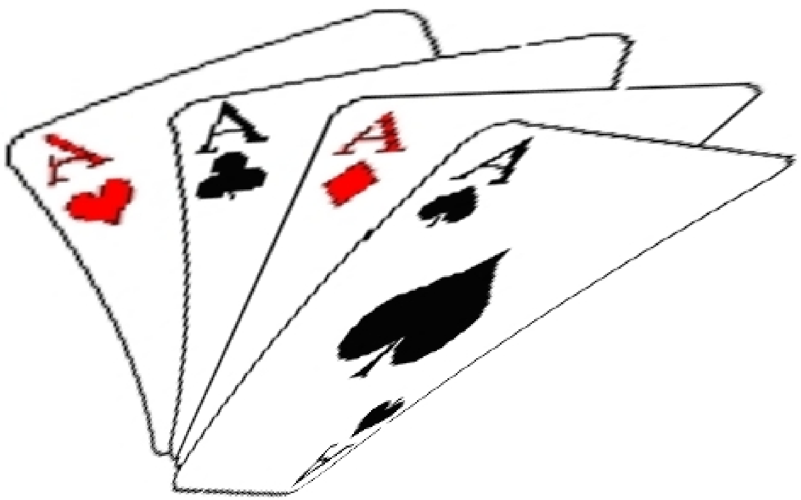
Altitude Climbing Endurance

ACE Training for Cyclists



Arnie Baker, MD

Arnie Baker
C·Y·C·L·I·N·G

arniebakercycling.com

7TH Edition

Altitude · Climbing · Endurance

ACE™ Training for Cyclists

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Reader Comments

"After 16 years of "serious" riding, 4 Near Death Experience Training camps, and 12 years of Death Ride volunteering/organizing I finally earned my first 5 pass pin. Thanks Arnie, your coaching and a little training worked; amazingly enough!"

Jackie Johnson
Alta Alpina Cycling Club
Death Ride Sponsorship Coordinator

"Dear Dr. Baker,

I finished the Death Ride a couple of weeks ago and I have to thank you. I read your "ACE" book at least 10 times; the last time being on the plane on the way out to the ride. You are a good writer and an excellent teacher/coach.
I loved doing this ride and am disgustingly proud for having finished it.
The money I paid for your book was a very cheap price for the wisdom contained in its pages."

Terry Vance

Training for the Everest Challenge (EC) race (www.everestchallenge.com)...
I … found (your ACE Book) it to be … the single most useful piece of training information that I have ever read. What made the book so useful was that it was written in a manner that both 'novice' and 'expert' alike would benefit from.

Julien Nordstrand [Julien.Nordstrand@tnzi.com]

"Dear Dr. Baker,

I just finished the Death Ride (5 passes) and want to thank you for the help you provided in your ACE training book. I used your book a lot both during training and also in the strategy for the event itself. It was a marvelous help in all respects. I'm 51 and this is the hardest single day event I've done. But I was well prepared enough so that I enjoyed most of the ride, was relaxed, and had a good time. Once again, thanks."

Steve Lombardi

Target Audience

The information in this booklet is most suitable for cyclists who have already completed one or more centuries, and who are training for an altitude climbing endurance (ACE™) event such as *The Tour of the California Alps—Markleeville Death Ride*.

Also by Arnie Baker, MD

- Bicycling Medicine—Cycling Nutrition, Physiology and Injury Prevention and Treatment
- Bike Fit
- High-Intensity Training (HIT) for Cyclists
- Nutrition for Sports
- Psychling Psychology—Mind Training for Cyclists
- Skills Training for Cyclists
- Smart Cycling—Successful Training & Racing
- Smart Coaching
- Strategy & Tactics for Cyclists
- The Essential Cyclist
- USCF: Essentials of Bicycle Training & Racing

Coach and Author

Arnie Baker, MD

Dr. Arnie Baker has been coaching since 1987. A professional, licensed USCF coach, he has coached racers to several Olympic Games, more than 120 U.S. National Championships, and 30 U.S. records. He is the National Cycling Coach for Team in Training. This endurance-training program of more than 800 coaches and 30,000 participants raises more than $80,000,000 each year for the Leukemia & Lymphoma Society.

Arnie has a Category 1 USCF racing license. He has held eight U.S. 40-K time trial records, has won six national championships, and has won more than 200 races. An all-round racer, he was the first to medal in every championship event in his district in a single year.

Dr. Baker is a licensed physician in San Diego, California. He obtained his M.D. as well as a master’s degree in surgery from McGill University, Montreal. He is a board-certified family practitioner. Before retiring to ride, coach, and write, he devoted approximately half of his medical practice to bicyclists. He has served on the fitness board of *Bicycling* magazine as a bicycling-physician consultant. He has been a medical consultant to *USA Cycling* and the *International Olympic Committee*.

Arnie has authored or co-authored 16 books and more than 1,000 articles on bicycling and bicycling-related subjects.

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Disclosure

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I thank the Leukemia and Lymphoma Society’s Northern California Team in Training Chapter; all of whom combined to first formally interest me in specific altitude-climbing-endurance training.

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I thank Gero McGuffin, who not only has helped with proofing and criticism, but with whom I have climbed more than 10,000,000 feet during the past 20 years.

Forward

This is a book about altitude-climbing-endurance training for cyclists. It concerns training for “hilly centuries[+]”—one-day events over 100 miles with more than 10,000 feet of climbing.

ACE events require a specialized approach. In addition to general bicycle training and knowledge, ACE riders need to be specialists in climbing, descending, and endurance.

Motivation, focus, breathing techniques, and pacing are especially important.

Knowledge about the altitude’s effects on the body is crucial.

Part 1 is an introduction to the essential elements of successful riding. Although the primary focus of this book is training, this introduction places training within an overall framework. The essentials of bicycle training are reviewed, and heart-rate and power-based training are discussed in some detail.

Part 2 is all about climbing. Here you will find information from the basics—what percent grade means—to the finer details about bicycle climbing positions. It is about technique as well as specific training to get you up hills faster. Descending is also covered. There is also a section on dealing with high altitude.

Part 3 is about the mental aspects of riding. It includes sections on pacing, focus and breathing, and motivation. Many of us who are motivated to participate in this type of bicycle riding have moments of doubt. By understanding a little bit about how our minds work, we can stay focused and motivated.

Part 4 covers endurance sport nutrition. All-day riding requires attention to diet. The principles, as well as specific dietary suggestions for training and the event are found here.

Part 5 is about equipment selection and care.

Part 6 is all about the common bicycling-related medical problems that crop up in endurance riding. Suggestions for prevention and treatment are outlined.

Part 7 gives suggested training schedules. Although training must be individualized, you will probably find the suggested programs helpful.

Finally specific target training goals and schedules are provided.

Beginners are cautioned to approach “all-out” or sustained efforts gradually, and riders over the age of 40 or those with known medical conditions are advised to consult a physician before embarking on an exercise program.

Riding 100 or more miles in one day, climbing more than 10,000 feet in that day is not for everyone. If it is for you, this book will make the going easier and faster.

10 ACE-Ride Commandments

1. Train properly. In the six weeks before the event, ride three or more individual days of at least 60% of target-event climbing. During this six-week period, three of the weeks should include climbing that totals at least 125% of target-event-day climbing. At times during your training, work on climbing rate with interval work.
2. Clarify your motivation and goals before you arrive—so that when you finish four passes you can answer the question: “Do I really need to climb that fifth pass?”
3. Have your bike working perfectly two weeks before the event. Do not make last minute changes.
4. Emphasize carbohydrates three days before the event. On long training and event days, eat > 1,000 calories for breakfast and average > 300 calories per hour while riding.
5. Add salt and eat salty foods the day before and during the event.
6. While riding, drink one to three waterbottles per hour depending upon the heat.
7. Pace yourself. Keep heart rate < 75% of maximum. If you do not use a heart rate monitor, this means you should be able to talk easily in sentences.
8. Keep average climbing cadence > 70 rpm. Have gearing to keep cadence above 50 rpm on 10% grades.
9. On event day, climb > 1,600 to $2{,}000^{+}$ feet per hour depending upon the distance, climbing, and cut-offs.
10. Think safety in your equipment and riding style.

Part 1: Training Basics

Fitness derives from genetic, serendipitous, and planned events.

In other words, you are given it, you are lucky, or you work for it.

Some of us seem almost born to be fit, and respond quickly to training. Others are slower to adapt. The most important strategy in becoming an Olympic athlete might be to choose one's parents wisely; it is just not practical.

Most athletes start out as "fun" enthusiasts. Fitness is achieved, often by chance. Many athletes who do well do so because their training is sound, even if there is no overall purpose, program, or plan. Although demands may be made on the separate elements of fitness, they are not teasing out these fitness elements; they are not optimizing their genetic potential.

Finally, fitness results from planned activities. Coaches, sport scientists, nutritionists, body workers, and others combine to design, develop, and implement training programs to improve or maximize genetic potential.

This part is about some of those planned activities.

In other words, how and what *you* can do to get fitter, and how best to use the fitness you have!

Riding Recipe

Many riders simplistically think that all you need is to be strong. There is a lot more to it. The following information places training in perspective. This book addresses the first three fitness elements of the riding recipe in detail.

Riding Requirements

The major elements of successful riding and racing can be dissected. Consider each ingredient. Train each one—the right amount at the right time. Put the ingredients together. You will go a long way toward optimizing your potential.

Some of these elements are:

- Fitness, including
  - Aerobic fitness
  - Muscle-strength fitness
  - Endurance fitness
  - Metabolic fitness
  - Anaerobic fitness
  - Power
  - Neuromuscular (leg-speed) fitness
  - Neurohormonal fitness
- Body composition
- Diet and ergogenics
- Physical health
- Bicycle specs and maintenance
- Position on the bicycle
- Bike handling
- Strategy and tactics, including energy conservation
- Mental attitude, sport psychology
- Rest-recovery-sleep

Fitness Elements

Fitness means different things to different people. Some aspects of fitness are very specific to specific sports. Weight lifters think of fitness differently than curlers or chess players.

It is valuable to know about the elements of cycling fitness, because knowing what elements are important helps us decide how to train.

Although some aspects of fitness do have genetic limits, most athletes are limited by their training rather than by their heredity.

The elements of bicycling fitness follow.

The performance of most non-racer cycling enthusiasts—century riders, all-day riders, randonneurs, tourists—depends chiefly on the first three.

Racer success may be limited by any of the major eight fitness elements outlined below.

Types of Cycling Fitness

Many elements of cycling fitness belong to more than one type of fitness and so it is sometimes hard to tease out the fitness elements, or understand them clearly. (Consider, as an analogy, various systems on your bicycle: The cogs on your back wheel belong to the drive-train system as well as to the wheel system.)

Aerobic Fitness

The ability to use oxygen for energy production. This is important for performance in any event longer than 30 seconds. The heart, lungs, blood vessels, and muscles are all involved in the aerobic chain.

The amount of blood the heart can pump is a product of how much blood the heart pumps with each beat and how many times the heart beats per minute. Most of the change in aerobic fitness is due to the amount of blood the heart pumps with each beat.

The lungs are usually not the limiting factor in aerobic fitness. They are very efficient in transferring oxygen from small airways to the blood. Although not the limiting factor, the athlete's perception of aerobic limitation is usually perceived to be in the lungs.

Lung power *can* be a limiting factor in the presence of disease (for example, asthma), at altitude, or at high levels of exertion in trained athletes.

The muscles are important in the aerobic chain. Fit riders extract more oxygen from the blood as it courses through the muscles than less fit riders.

Aerobic fitness can be measured by a VO_2 max test. This test measures the volume (V) of oxygen (O_2) the body can use, in liters of oxygen per minute. Power demand is ramped up in 10 to 50 watt increments, depending upon the protocol used. Oxygen use is measured from a formula whose terms include the total volume of air breathed and the amount of oxygen in inspired and expired air. This test is fair at predicting flatland time-trialing ability.

VO_2 max is often scaled to the rider's mass, or weight, in which case it measures the volume of oxygen used per minute per kilogram. Scaled to weight, the test is a good predictor of long, steady hill-climbing ability.

VO_2 can be estimated from the power achieved in ramped tests. Arnie's formula is $VO_2 = 12 \times \text{watts/kilogram} + 3.3$.

Simple field measures cost nothing and are as good or better at predicting performance. For example, after testing hundreds of athletes, I have found that timing ascent up our local 1.3 mile Torrey Pines climb, with 440 feet of climbing, predicts VO_2 as follows: 360 / time in minutes = VO_2. A 6-minute climb equates to a VO_2 max of 60 milliliters per kilogram per minute.

Although considered a measure of aerobic function, not muscular function, a VO_2 max test really does involve muscle mass too. Without adequate muscle mass, there is insufficient oxygen demand, and values will be low.

More important as a predictor of performance is how much oxygen the body can use at submaximum levels, say at time-trial pace, or at other thresholds.

General aerobic fitness is trained at moderate exertion levels that correspond to roughly 65% to 85% of an individual's maximum heart rate.

High-level aerobic fitness is trained at exertion levels that correspond to roughly 80% to 85% of an individual's maximum heart rate. Athletes can train at such levels for up to about 120 minutes per week. Training time beyond this amount is limited by high-energy fuel—the ability to incorporate carbohydrate into muscle.

Read more about aerobic training on page 25.

Muscle-Strength Fitness

All the aerobic capacity in the world will not get you anywhere if you do not have the right muscles to use that energy.

What muscles do is contract, or shorten, when stimulated to do so by the nerves that supply them. They contract because of filaments of actin and myosin that form chemical/mechanical cross-bridges and move relative to one another.

The importance of sport-specific muscle strength is well known. For example, elite runners who try bicycle riding are often not very fast; same with bicyclists who try running. Sport-specific slow-twitch muscle strength is trained during specific sport training. Although weight-room work may help, more sport-specific exercises such as hill running for runners and isolated leg training or big-gear riding for cyclists is often better.

Broadly speaking, there are two types of muscle fibers: Fast-twitch and slow-twitch.

Short, high-power efforts are associated with fast-twitch fibers. For a given power output, the slower the cadence the higher the percentage of fast-twitch fibers recruited.

In a strict sport science sense, muscle strength refers to 1-rep maximum strength—the amount of weight that a muscle can lift, push, or pull one time. One-rep muscle strength is a function of fast-twitch muscle fibers. It is easy to measure 1-rep muscle strength in the gym, although the machines that isolate different muscle groups are not always cycling specific.

In cycling, muscle strength over a period of time, or power, is crucial. To contract repeatedly, muscles need energy. The energy may come from metabolic reactions with or without oxygen.

Reactions without oxygen (or anaerobic energy production) are characteristic of many fast-twitch muscle fibers, called glycolytic fibers. Reactions with oxygen are characteristic of slow-twitch muscle fibers. A subtype of fast-twitch muscle fibers may also use oxygen. Those fibers, which characteristically use oxygen to produce energy, are called oxidative fibers.

Although in pure track sprinting fast-twitch strength is crucial, in most cycling events slow-twitch strength is more important—but slow-twitch strength is very difficult to measure, in part because when slow-twitch fibers reach their limit, fast-twitch ones take over.

One lab test that comes closer to measuring what is important for most road cyclists (for most of us) is muscle fatigability. One way it is measured is by seeing how many repetitions can be performed at 70% of 1-rep maximum, or at a percentage of body weight.

Tests show that elite aerobic endurance athletes are generally not world-class when it comes to strength testing in the lab. Again, these measurements of primarily fast-twitch muscle strength are not relevant to the type of strength that aerobic-endurance athletes need—slow-twitch muscle strength.

Cycling muscles are trained by cycling—by just riding along. You are specifically strength training your cycling muscles when you feel them working.

Big-gear riding and climbing provide aerobic-muscle-specific work. Sprint work provides anaerobic muscle-specific work.

For the most cycling muscle-specific work, I separate out the muscle element of cycling fitness with isolated leg testing and training. In my experience, the power that one can generate with one leg riding at 60 rpm for three minutes is an excellent measure of cycling muscle fitness.

Read more about muscle-strength fitness training under *Isolated Leg Training* on page 28.

Endurance

This is the ability to last. Endurance is required to get to the finish of an event.

Endurance can mean different things. Most sport science discussions about endurance concern events lasting one to three hours. Ultra riders may think of endurance as what Tour de France or Race Across America (RAAM) riders possess. However, track coaches think of pursuiters, as opposed to sprinters, as endurance riders. On the track, the ability to last 4 minutes is endurance.

Although many equate endurance with aerobic fitness, and although there is some overlap, they are not the same. It is possible to be able to perform a 40K time trial in 50 minutes, showing elite level aerobic ability and a VO_2 max over 80 mL / kg / min., yet fall apart in races over 100 miles.

Endurance for events up to a few hours in duration can be predicted by the tests for aerobic fitness described above.

Endurance in the sense of stage racing or ultra-distance events is not measured in the lab. It requires field evaluation.

For example, the best measure of your endurance for the Tour of the California Alps (a 129-mile ride with 16,000 feet of climbing) is simply how well you adapt to long hilly training rides.

Metabolic Fitness

This aspect of fitness comprises many factors. Here are some well-known elements in metabolic fitness:

Mitochondrial energy production. Mitochondria are the energy factories of the cells. They produce energy through biochemical reactions involving oxygen (for example, the Kreb's citric acid cycle). The number and function of mitochondria can be improved with training.

Energy can also be produced without oxygen (anaerobically). Chemical reactions that involve stored adenosine triphosphate (ATP) and creatine phosphate (CP) are important in producing energy anaerobically.

When work is accomplished without oxygen, lactic acid is produced. Lactic acid clearance involves the ability of the body to buffer (or temporarily neutralize) lactic acid as well as the ability of the body to metabolize (or burn) lactic acid. This involves many chemical substances and reactions in the muscles and in the blood (myoglobin, bicarbonate, and hemoglobin, to name only a few). As with the fitness elements listed above, training helps.

Some indication of metabolic function can be gained through lab studies including chemical analyses and muscle biopsies. For example, lactic acid levels in muscle or blood lactate levels can be measured with standard workloads or at threshold. Mitochondrial density can be determined in muscle biopsies. These tests are not as good as those discussed above in predicting human performance.

Anaerobic Fitness

The ability to produce work without oxygen is vital in many forms of bicycle racing. This is a combined metabolic (anaerobic) and muscle-strength (glycolytic) fitness.

Anaerobic fitness is necessary whenever attacks occur, when the pace gets super high, when the period for maximum effort is short.

In fact, this is what mass start group racing is usually all about—riders do not usually get left behind until fitter riders push the pace and force them to exceed their aerobic and anaerobic limits.

The amount of work that can be performed over short periods (less than 30 seconds) can be measured in the lab or in the field. Peak power in the lab can be measured by computerized cycling ergometers in standardized Wingate tests. In the field, one can measure, for example, 200-meter sprint times.

This type of fitness is not particularly important for century rides or all-day touring. Although some anaerobic training may improve your aerobic fitness, you should rarely, if ever, be anaerobic during any part of such events.

Power

For most cyclists, power is the most important lab predictor of cycling performance. After all, it is power that gets you down the road. It is a more important predictor than VO_2 max.

Anaerobic Power

For track sprinters, maximum power in 3- to 30-second tests provides an excellent predictor of track sprinting fitness. The shorter the test, the more pure muscle strength is measured. When the test approaches 30 seconds, combined muscle fitness (glycolytic) and anaerobic metabolic fitness is measured. Again, anaerobic fitness has little importance for century riding or most-of-a-day events.

Aerobic Power

For most other riders, power at time-trial threshold is key to performance. Alternatively, maximum power on a ramped test lasting about 15 minutes. This is really a test of combined muscle-fitness (oxidative) and aerobic fitness. (There is a close correlation between power and oxygen uptake. Where they diverge, power is more important.)

Neuromuscular Fitness

Leg speed is a neuromuscular fitness. It is a skill. It is not strength; it is not related to aerobic or anaerobic function. The ability to respond to changes in tempo, especially in criteriums, requires the ability to move those legs quickly. Successful sprinters have excellent leg speed.

Can you hold 140 or more rpm for several minutes on a stationary trainer with low resistance? Can you spin over 200 rpm for short bursts? If so, you have good to excellent leg speed.

Although important in some specific bicycling disciplines, leg speed is of little importance to bicycle touring or most all-day riding—except that at moderate to high power levels cadences closer to 90 rpm are less fatiguing than those closer to 60 rpm.

Neuromuscular fitness is important not only for leg speed, but for cycling *economy*.

Imagine your right leg rotating though a clock circle. Most of your right leg power comes from pushing down or forward, between about one and five o’clock. You want to stop your nerve cells from activating your right leg push down/forward muscles before you get to the six o’clock position and return your leg back up to twelve o’clock.

Although much has been written about a smooth pedal stroke and pulling up after pushing down, studies show that even professional cyclists do not do this. What is important, and what economical cyclists do, is to not push down on the returning (right) leg while the other (left) leg is in its power phase pushing down or forward. Or, at least, not pushing down too hard.

Isolated leg exercises at low power (in easy gears) at about 80 rpm are an excellent for improving neuromuscular fitness.

Neurohormonal Fitness

This type of fitness is poorly understood, but important. It includes some of the following areas: Pain perception and the neurohormonal response and tolerance of training volume and intensity. How brain cells talk with one another, and how the body's hormones respond and adapt to stress.

Bicycle training not only changes neurochemistry, it may change the physical structure of the brain itself. "Extensive practice in… athletes… changes their brains as well as their bodies."[1]

Neurohormonal fitness is required to respond and adapt to training without overtraining.

Testing for neurohormonal fitness is in its infancy. We are just beginning to understand the physiological underpinnings of neurohormonal factors.

Other Types of Fitness

Above are some of the major aspects of fitness. The list is not complete.

Gastrointestinal fitness can be crucial in endurance events. The ability to drink and eat and to digest nutrients is frequently a limiter to performance in long events. Like other fitness elements, gastrointestinal fitness can be trained.

Much of what we know has to do with what we can measure. What is hard to measure we may ignore. For example, we rarely consider the lubrication of joints and muscle viscosity, which may be important factors in economy (the ability to produce more with less).

Immunologic fitness—the resistance to disease—may also be important for cyclists.

Recovery is an important aspect of fitness, which involves not only some of the systems described above, but also nutrition and rest.

[1] Bill Hendrick, Cox News Service, July 5, 2005.

Fitness Summary

Cycling fitness is more than just big muscles or big lungs.

Often, as stated above, it has nothing to do with either of those two factors.

By understanding cycling fitness, we will understand how to train to improve our performance.

Fitness Element	Components	Code Words	Process	Testing
Aerobic	Heart: the pump Lungs: get oxygen into blood Muscles: get oxygen out of blood	Oxygen transport	Moving oxygen from the air to muscle cells to produce energy.	VO2 Max Submaximum oxygen consumption 4 to 6 minute interval power
Muscle Strength	Muscles	Actin and myosin cross-bridges	Chemical/mechanical linkages in muscle cells result in muscle shortening and movement.	1-rep maximum Reps at 70% of one-rep max
Metabolic	Cells and blood	Chemical reactions	Producing energy aerobically and/or anaerobically. Neutralizing or reacting with waste products.	Blood lactate with standard loads Lactate threshold Muscle biopsy: mitochondrial density
Anaerobic	Muscles ATP and CP energy systems Lactic acid tolerance	Without oxygen	Producing short-term work without oxygen.	Peak power Wingates 5 to 30 seconds Sprint times
Power	Anaerobic and glycolytic muscle strength Aerobic and oxidative muscle strength	Work over time	Anaerobic and/or aerobic systems producing energy to fuel muscles.	Wingates, sprints Ramped tests Power at thresholds Time vs. distance at thresholds
Endurance	Aerobic endurance Muscular endurance	Ability to last	Definition problems. See text.	Power at LT Empiric, in the field
Neuromuscular	Nerve cells stimulating muscles	Skill	Firings of nerves stimulate muscles.	RPM with set protocols
Neurohormonal	Central nervous system Endocrine system	Neurotransmitters and hormones	Psychological states: perception, overtraining, and confidence.	Uncertain

Table 1. Selected cycling fitness elements and characteristics.

Non-Fitness Elements

Body Composition

Excess fat is useless for an athlete. Being lean is important for climbing.

Males have the best combination of bicycling performance and general health at body fat levels around 10%, women at about 15%. Body fat levels up to 5% higher are still healthy levels, but performance may suffer.

Men and women whose body fat levels drop below 5% and 10% respectively may perform even better—but general health may suffer. Excessive leanness may reduce the body's natural immunity. Athletes at such low levels are subject to a number of other health concerns including osteoporosis and eating disorders.

Every excess pound slows you about 20 seconds for every hour of climbing. If you are 20 pounds overweight, a century may take an extra half hour to complete.

Diet and Ergogenics

Know how to use your diet to help you, not hurt you. What to eat, when to eat. Occasionally specific supplements or medicines can help.

For events longer than one hour, fluids and calories improve performance and reduce sense of effort.

Physical Health

You need to keep injury-free and in good physical health.

For example, for many riders backache is a problem on repeated long climbs. Some will adapt easily with a progressive climbing program. For most, back strengthening exercises are also part of our program.

Right Bike

Some bikes are specifically designed for certain types of riding and races. There are bikes better suited for road riding and others better suited for triathlon, mountain biking, or touring.

The bicycle becomes an extension of your body. Use it efficiently by optimizing your bicycle position and riding style.

You need easy gears. Late in the ride, they may not seem easy. At a minimum, most riders are advised to have a 39-tooth chainring and a 27-tooth rear cog for most centuries. A triple front chainring, compact cranks, or mountain bike cogs and derailleur are preferred for epic all-day rides such as *The Tour of the California Alps—Markleeville Death Ride*. Read more about *Small Gears* on page 85.

Lightweight equipment can help on climbs. Lightweight road racing bikes can be five pounds lighter than standard racing bicycles. As with body weight, each pound of non-rotating weight lost will save about 20 seconds for every hour of climbing. Rotating weight (wheel and pedals) saves twice as much time per pound as fat on your body or bike frame.

Aero wheels and tires with less rolling resistance can really help on flat rides. Note, however, that (1) sometimes weight is increased in an aerodynamic design, and that (2) aero wheels are often unstable when descending, especially with crosswinds.

Bicycle maintenance improves reliability and reduces mechanical friction. A clean bike is a happy bike.

Bike Handling

You need to know how to make your bicycle go exactly where you want it to go. This is important in descending, where crosswinds affect bike handling. Safe, controlled descending is a must. Be especially alert near the end of the ride when fatigue reduces your judgment and skill.

Bike handling skills are developed not only during regular riding and racing, but also by practice during specific skill and technique training sessions.

Ride Smart

Use your physical talent correctly. Use your energy at the right time with a ride plan and the parts that make up the overall plan—strategy and tactics.

Most importantly, pace your effort. Do not work too hard too early.

Most riders waste a lot of their precious energy. Efficient drafting and slip-sliding on climbs save energy when riding with groups. Avoid wasting energy with side-to-side and up-and-down motions that do not propel you and your bike forward. Make every effort count.

Sport Psychology

The mental aspects can provide the crucial difference. Motivation, confidence, the setting of realistic and attainable goals, mental rehearsal, and visualization, control of arousal and anxiety can all help you perform to potential. Attending to, understanding, and working through the psychological conflicts we all experience help resolve these frequent barriers to success.

Rest Right

It is not just training that makes us fitter; it is the recovery from training that is crucial. It is not enough to know how to ride hard. You must know how to rest and recover. How to ride easy as well as hard. How to recover to allow a peak for major competitions. How to assure proper sleep despite the logistics of organizing the rest of life, travel and other obstacles.

The Training Curve

The way from point A to point B is not a straight line. If you do not anticipate training curves, you may become frustrated and lose motivation.

Training Is Not Linear

Consider an athlete who is at a relatively low level of fitness, point A. The athlete would like to progress to a higher level, point B.

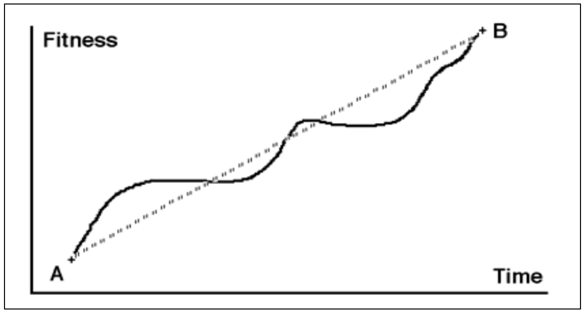

Figure 1. Training curve. Typical training curves are step-like, as in the solid line—not straight, as in the dotted line.

Training will not bring that athlete in a straight line from A to B. With the onset of training, the initial gains are great. However, as training progresses, plateaus are usually observed. Sometimes fitness even decreases.

Gains are made in spurts, in steps, rather than in a straight line.

Expect and anticipate these steps. You will be less discouraged by apparent lack of progress.

This general rule applies during relatively short cycles of weeks and months, as well as with training over long cycles of years.

It applies to many other things as well—for example, it would also be typical for a weight-loss graph.

Training Principles

Follow Your Own Program

Some of us are relatively new to riding and some of us have been racing for years. Get hints and advice from others, but remember your training program is not the same as everyone else's.

Build Up

You are at a certain place now. You may know where you want to be. Get there gradually, building up your miles and speed to reach your goals. Do not expect to get there in one big step.

Challenge Yourself

We get stronger by challenging the body. As our body adapts to training, we can continue to improve by taking on new challenges.

Be Organized

Have a program. Organize your schedule to allow you to stick to your program. Think ahead. Keep lists. It is tough to ride home from the office if you have forgotten your bicycling shoes. It is tough to ride Wednesday evening if you have forgotten to clear the decks and you have to take your child to softball practice.

Do the Same Stuff, Do Different Stuff

By repeating the same or similar workouts you will learn how hard you can go and how and when to work harder. However, changing your workouts every month or so keeps you mentally fresh and trains different aspects of fitness.

Be Flexible

It rains. You get sick. Adversity strikes. Do not brood or get uptight about it. Modify your program, if needed, and get on with your training.

Track Your Progress

Keep a record or log of how you are doing. Review it every week or two. It will let you know if you are on track and whether your program is working or needs adjustment.

Keep it Fun

Do not be a slave to your training. Keep a perspective of your overall goals. If your schedule calls for intervals but you are sick of them, do something else.

Take it Easy

It is tempting to be caught up in any program. Your program is important. However, keep it in perspective and make sure you allow proper time to recover. Avoid overtraining.

Undertraining makes it difficult to get to the finish line. Overtraining can make it impossible to get to the start line.

If you think you need recovery, you do. If you are sure you need a day of recovery, you need two!

Reward Yourself

Consider other rewards along the way. Completed the first six weeks of your training on track? Maybe reward yourself with a new pair of cycling shoes. Or a dinner on the town to thank someone for putting up with you!

Training Triangles

When you work on a particular aspect of fitness, others will suffer.

The Problem

Here are some triangles that represent what is happening: The corners of the triangle might represent speed, endurance, and power. The triangle area represents the total amount of fitness.

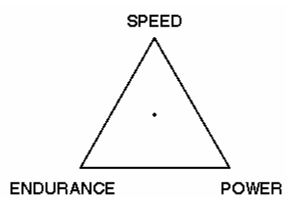

Figure 2. Base fitness triangle.

The distance from a corner to the center represents the relative amount of that fitness aspect.

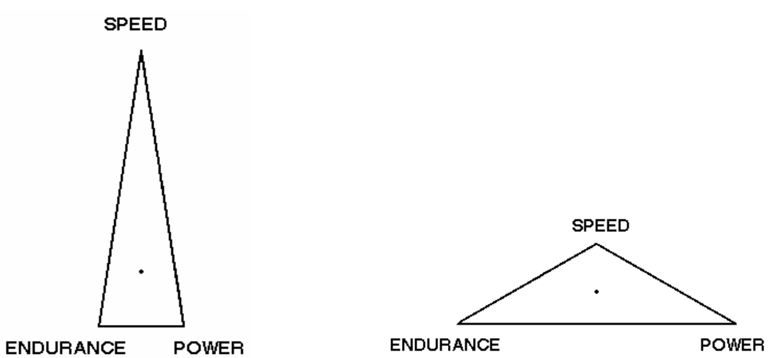

Figure 3. Specialized fitness triangles.

Work on speed—endurance and power suffer. Work on both power and endurance—speed worsens.

Alternatively, the triangles might represent hill climbing, sprinting, and time trialing ability. Work on hills—your sprinting and time trial performance worsens. Work on both time trialing and hill climbing—sprinting ability diminishes.

Training specific aspects of fitness decreases other specific aspects of fitness. How then does one improve? How are the best so good at everything?

The Solution

Consider that there are two general training concepts—general fitness and specific fitness. The answer is that fitter riders have bigger triangles.

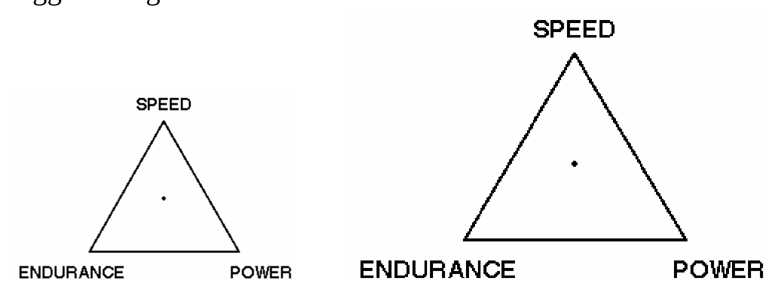

Figure 4. Increase in overall base-fitness triangle.

The best riders still experience the same triangle effect—tug on one side to make it bigger and the other sides get smaller. They are so much better overall that it seems as if they have all the types of fitness. They do not.

The best sprinters in the Tour de France do not time trial well. The best time trialists in the Tour do not sprint well. Sure they do everything better than ordinary mortals, but within the size, or area of their triangles, they still have the same situation.

Overall fitness improves with increases in quality and quantity of work the athlete performs. Many racers, as they go up through the category ranks, increase the amount of time they spend riding as well as the quality of riding through intervals, anaerobic threshold training and racing.

By the end of your program, after concentrating on climbing and riding long distances, you may not be so snappy on the flats. Alternatively, you may find that your overall fitness may have improved so much that you are better at everything.

Training Hints

The only way to get finished is to get started.

As an introduction to training, the following is a list of general hints to keep in mind during the course of your training regimen, whether you are a beginning or seasoned cyclist, or are training indoors or out. Come back to this list for a quick reference occasionally as a way of initiating a review of your overall program. The tips will help keep you on the right track.

- Get a plan, set goals, and figure out what you need to get there.
- Keep a training log.
- Use an altimeter to track feet climbed.
- Periodize your week, training differently during different sessions.
- Learn to work harder on hard days, easier on recovery days. Plan for recovery.
- Work on different aspects of fitness in different workouts.
- Climb, climb, and climb. Learn to love climbing.
- Work on aerobics, endurance, and strength.
- Work on strength with heavy gears and one-legged riding.
- Pull and push with the same-side hand and leg when climbing.
- Establish a breathing rhythm when working hard, especially when climbing.
- Ride with riders both stronger and weaker than you are.
- Play intensity games with friends.
- Improve your riding technique and skills though practice and from coaches.
- Ride with relaxed, bent arms and with your knees in.
- Train in different riding positions.
- Use a heart rate monitor.
- Wear a helmet and gloves. Keep your equipment safe and in good working order.
- Check your position on the bicycle, especially your seat height.
- Rely on food, not pills or supplements, for your nutrition.
- Maintain hydration; drink before you are thirsty.
- Keep carbohydrate solution in your water bottle.
- Optimize your weight.
- Redirect the stresses of your life.
- Have patience in your program.
- Do not try new equipment or foods for the first time on event day.
- When your group is warming up, or cooling down, ride in a smaller gear than just about everyone else to learn to spin better.
- Learn to work hard on a stationary bicycle trainer. Get together and form a class if that is what it takes.
- Practice skills such as pacelines, regularly.
- Watch good riders and how they flow without doing any more work than necessary. Try to learn from them.

Bicycle Workout Variables

By understanding the variables of bicycling workouts, you will understand how workout programs function to achieve different ends and be better able to design your own.

Workout Variables

The components of a bicycle workout can be broken down into six basic variables:

- Volume
- Intensity
- Cadence
- Position
- Pedal-Stroke Emphasis
- Environment

These variables can be adjusted depending on the different goals you wish to achieve. Volume and intensity are standard workout variables that apply to almost any sport. Many riders and coaches neglect to consider that cadence, position, pedal-stroke emphasis, and environment distinguish bicycling workouts and help train different aspects of fitness.

Volume

Volume is the total amount of work performed. In other words, it is the distance or the amount of time you spend training in a given week, month, etc.

When work is performed in intervals, the length of each interval is called the duration of the interval.

Increasing volume up to about 200 miles or 15 hours per week helps improve aerobic and endurance fitness. Additional volume primarily improves endurance.

Training for long road rides requires time in the saddle to toughen the buttock tissues and adapt to riding position. Long rides, even those of minimal intensity, help train these needs.

Intensity—Introduction

Intensity is the load or speed of work performed.

Perceived exertion, heart-rate monitoring, and the less commonly available power monitoring all have roles to play in assessing work intensity.

Perceived exertion is related to many factors including breathing rate and depth, and muscle tension, burning, and heaviness.

Heart-rate monitors help measure intensity, but they, too, are imperfect. If you work on leg speed, for example, and spin flat-out as fast as you can in an easy gear for 5 minutes, your heart rate may be very high, but your power output may be only moderate.

On the other hand, if you sprint in a moderately hard gear for 20 seconds flat-out as hard as you can, your power output may be maximum, but your heart rate may not have time to "catch up" to a maximum effort.

Power measurement—traditionally available on laboratory ergometers—is also available on new-generation portable "consumer" electronic stationary trainers. Force measuring devices can also be installed at the bottom bracket, pedals, or rear wheel axle.

As glycogen energy stores are exhausted, perceived exertion is relatively high compared with heart rate, blood lactate, or power levels.

Cadence

Leg speed is another component of workouts.

Consider a rider told to work at a heart-rate intensity of 150 beats per minute for 15 minutes.

Those with a limited view of cycling fitness might think that defining intensity and duration determines the workout. It does not.

Riding at 50 rpm in a big gear at a heart rate of 150 beats per minute (bpm) trains muscular strength. Riding at 150 rpm at 150 bpm trains leg speed, a neuromuscular fitness. The workouts are quite different and give different physical results.

Some fit riders can pedal very fast—but in an easy gear, they are not necessarily working hard or going very fast.

Position

We know that the leg muscles used in cycling are different from the leg muscles used in running. That is one reason why a good runner might be a poor cyclist.

Within cycling, the muscles used in climbing are different from those muscles used in flat riding. A position component is therefore part of the workout prescription.

Climbing volume and climbing intensity are important factors in climbing fitness.

You can climb standing or seated; on the handlebar tops, on the brake hoods, or in the handlebar drops. There are important reasons to be versatile and to train in all these positions.

For steady climbing, riding with the hands on the handlebar tops is often the best way to climb. That is because the legs have more power when the hip angle is open, and aerodynamics is of minimal importance when climbing.

Pedal-Stroke Emphasis

Athletes may appear to the casual observer to be performing similar work—this is not always the case.

Consider two athletes climbing for 5 minutes at 75% of maximum heart rate, at 50 rpm, on the tops of the handlebars. The athlete who concentrates on pulling up will be performing different work than the athlete who concentrates on pushing forward or who pedals smoothly.

Training by emphasizing different parts of the pedal stroke—working specific muscle groups—defines yet another workout variable.

Environment

Workouts performed at altitude are different from workouts at sea level.

Workouts in the heat, humidity, cold, rain, or snow are different from workouts in temperate weather.

Workouts that require mental vigilance—because they are performed on roadways with potholes or cars, or workouts performed on mountain bike trails—are different from workouts performed on stationary trainers where all one’s mental energy can be focused on the bike.

Workouts performed on flat terrain are different from those where the grade is uphill or changing.

The same workout may present a different stress to the body depending upon recovery state. Sprints at the beginning of a workout are different from sprints after 5 hours of riding, though the duration and intensity may objectively be the same.

The same workout done individually may be perceived differently when performed in a group setting. Though the workload may be the same, as yet ill-defined neurohormonal factors make the environment of the workout different.

Aerobic Training

Aerobic capacity and aerobic endurance are important cycling fitnesses.

Aerobic Capacity

Aerobic capacity is the ability to work using oxygen in combination with fats and carbohydrates as fuel sources to produce energy.

At low-aerobic levels, fat is the primary fuel source. At high-aerobic levels, glycogen—stored carbohydrate in muscle—predominates as a fuel source.

Aerobic Endurance

Aerobic endurance is the ability of the body to perform aerobic work over long periods. This is important in sustained efforts—in time trialing or in long hill climbing.

To improve aerobic endurance one must improve the quantity or quality of components of this system.

Aerobic endurance involves oxygen transport from the air we breathe to the chemical factories of the body that burn fats and carbohydrates in combination with oxygen for fuel.

This fitness system includes the heart, lungs, circulation, cell transport systems, and the cells' chemical factories—the energy-producing mitochondria.

Aerobic Training Principles

Aerobic training requires the rhythmic action of large muscle groups, as in cycling or running. Vigorous video game play using only smaller hand muscles can never place enough demands on the body to be aerobic.

Aerobic training begins at about 66% of an individual's maximum heart rate.

An increasing workload is required to stimulate aerobic training as an individual becomes fitter. Consequently, aerobic training should be progressive:

Since the body is constantly adapting, the intensity of workouts must be increased until an individual's genetic aerobic potential is reached.

For the very fit, training at rates higher than 93% of maximum heart rate will cause anaerobic systems to kick in, allowing fewer aerobic repeats. For the less fit, anaerobic systems may take over at heart rates as low as 80% of maximum.

Besides reaching your aerobic capacity, you can train to increase the length of time over which you can work at or near this level.

Aerobic fitness may begin to be lost in as little as one to two weeks; training regularity is important. Accumulate thirty minutes of aerobic training twice a week for maintenance.

Intensity, Duration, Frequency

As stated above, aerobic training begins at about 66% of an individual's maximum heart rate.

To maximally train the aerobic system, riders need high-level aerobic work—loads that result in 80% to 90% of maximum heart rate.

Once you have built a base of a thousand miles or more over a few months, you can aim to train at this intensity two or more times per week. Aim for a cumulative total of about two hours per week.

Endurance may be improved by training at lower intensity levels, but maximal oxygen uptake may not increase.

Spending more time training at high-aerobic levels may be productive during some training phases. During these phases, riders may train at high-aerobic levels up to six hours per week.

There is a limit as to how much time riders can spend at high-aerobic levels because there is a limit to high-aerobic energy sources. Intramuscular glycogen is a limiter.

There is also a neurohormonal limiter. High volumes of high-aerobic work should not be performed routinely because of overtraining risk.

Racers need training at 86% to 92% of maximum heart rate to reach the limits of their aerobic potential. Training near this level overlaps with anaerobic training at times; this is threshold training. When training at such very-high aerobic levels, reduce the overall volume of aerobic work.

Aerobic fitness may begin to be lost in as little as one to two weeks; training regularity is important. Accumulate thirty minutes of aerobic training twice a week for maintenance.

High-level aerobic training is not required for everyone. Riders are commonly able to complete a hilly century successfully without maximizing their aerobic training.

Value of Interval Training

As elsewhere noted, unless intervals are performed at a cadence, heart rate, power, or torque level above that of continuous work, interval work is unlikely to be of more benefit than continuous work.

One may exercise longer at the limits of high-aerobic metabolism by performing intervals rather than by continuous training. There *is* evidence that interval training is helpful in high-level aerobic training

Length of the Aerobic Interval

High-level aerobic intervals should be long enough to reach maximum oxygen uptake in most of the intervals, and short enough to minimize fatigue.

Because experimental results are inconclusive regarding the benefits of short (15–30 seconds) and long (up to 5 minutes) intervals for aerobic training, a variety of training intervals is recommended.

My favorite interval length is 3 to 5 minutes. This is because it is relatively easy to perform such intervals effectively.

In order to be effective, the majority of 3- to 5-minute intervals must be performed at workloads above 30-minute time trial pace.

Although not effective in increasing maximum aerobic capacity, intervals performed below 30-minute time trial pace may:

- Help adaptation to high-intensity work
- Build a bigger base/increase overall training volume
- Increase general aerobic or muscular endurance
- Assist in rehabilitation
- Provide variety, reduce boredom
- Provide workout structure, or
- Improve neuromuscular technique or skill.

To train aerobically, intervals shorter than three minutes require similarly short recoveries—otherwise aerobic demands may be low or work may be performed anaerobically.

Mild exercise during rest intervals (heart rate 100–120 bpm) hastens recovery. Keep your legs moving!

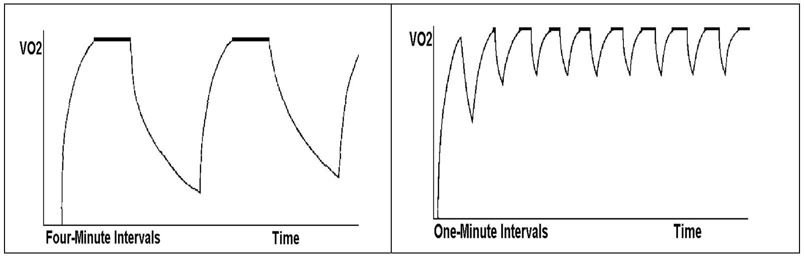

Figure 5. Eliciting maximum oxygen uptake. The left figure is of 4-minute intervals with equal-length (4-minute) recovery. The right figure is of 1-minute intervals with 30-second recoveries. Maximum oxygen uptake occurs at the top, flat sections of the curves.

Maximum oxygen uptake occurs during roughly the last half of the 4-minute intervals, regardless of the length of the recovery. Unless recoveries are short, maximum VO2 will not occur with 1-minute intervals. Note that in the figure it is only after the third 1-minute interval that VO2 max is achieved.

Interval Training

The following is a rudimentary introduction to cycling intervals. For more information, see my companion book *High-Intensity Training for Cyclists*, referenced on page 126.

What Are Intervals?

Cyclists often use the word *interval* to specifically denote training at intensities below those found in sprints and above those in a 10-mile time trial. Exercise physiologists include sprints in their definition of intervals. Colloquially, cyclists do not.

Exercise physiologists use the word *interval* to denote *any* work period. Therefore, intervals can be aerobic if done below threshold intensity or anaerobic if performed above this level.

It is not that one definition is right or wrong; it is just cycling jargon vs. science jargon. As a coach and scientist, I will use the second meaning.

Interval Training Works

The benefits of hard-effort interval training include improved acceleration, high-speed endurance, and the ability to respond to a changing pace. Interval training is a relative shortcut to improving speed and strength. Intervals have been proven to help anaerobic power and capacity.

Intervals may also be of lower intensity. For example, you may spend time working on riding in the drops of the handlebars or standing while climbing. These types of intervals will also be important in our program.

Intervals can be performed on stationary trainer, velodrome, flat terrain, and hills.

Examples of Intervals

Assume you can ride a time trial at 20 miles an hour for 10 miles. Interval work might consist of 5 to 10 hard 1-mile efforts at 22^{+} mph.

Another technique is decreasing intervals. For example, you might ride as hard as you can maintain for 2 minutes, and then ride each successive interval for 10 fewer seconds, down to 30 to 60 seconds.

Another type of interval is the hill interval. Distances of 0.5 to 1.5 miles up a steady grade might be used. You might ride as fast as possible up a 1-mile climb, coast down to recover, and then repeat another 5 times.

Heart-Rate Monitor?

A heart-rate monitor can be very helpful in assuring that you are making a hard effort during intervals. Many inexperienced riders benefit from the feedback that heart-rate monitors provide. Many experienced racers like to confirm their intensity. Most coaches swear by their value.

Remember, for short intervals, or intervals not preceded by a good warm-up or high aerobic level of work, heart rate might not "catch up" to effort.

U.S. multiple time-trial record holder Jane Gagne has another point of view. She does not see the need for heart-rate monitoring: "Basically you ride as hard as you can to complete the interval—it doesn't matter what your heart rate is."

Isolated Leg Training

What if I told you there was a simple method of bicycle training that would improve almost all aspects of fitness. A method that would help strength, spin, leg speed, anaerobic power, focus, and breathing. A method so powerful that in training hundreds of athletes, I have never met one who did not benefit and see improvement within a few training sessions?

You would want to try this method, I hope. It is called isolated leg training, ILT, or one-leg riding.

What You Do

Unclip from one of your pedals. Ride with one leg. If riding on the road, dangle your inactive leg to one side, or find a safe place to rest your heel on your chainstay or seatstay, away from your spokes.

On a stationary trainer, you can rest your inactive foot on the back of your trainer, on a side support (a box or a stool), in the drop of your handlebar, or in your waterbottle cage. Work up to three-minute intervals. Work up to four repetitions.

Work On Strength

In my experience, high-load 50 to 60 rpm ILT is the best method of improving cycling-specific strength.

However, do not use high loads to start. Take several sessions to adapt to this exercise.

It is easiest to perform this work on a stationary trainer or on a hill (up to about 6% grade).

Choose a moderately-hard gear, one that you can only pedal between 50 and 60 rpm.

Since you are working only one leg, your heart rate response will probably not be high. You will be working on your muscles, not on your cardiovascular system—isolating the muscle component of fitness.

With moderate loads, you can focus on difference parts of your stroke. Sometimes focus on pushing down. Sometimes focus on pushing forward. Sometimes focus on pulling up. Sometimes focus on pulling through, or pulling around.

After adapting to moderate loads, choose a harder gear.

Pedaling smoothly does not necessarily result in the highest average torque or power. Pedaling smoothly also means that you are not working your most powerful muscles to their potential. A harder gear will specifically strengthen your quads and glutes—the most important cycling propulsive muscles you have.

You may be able to perform high-power ILTs with so much force that you can push yourself up off the saddle. It helps to stabilize and anchor yourself with your arms. Pulling with your arms may allow you to work harder. If you are performing a left leg ILT, pull more with your left arm. Elite athletes may perform ILTs with such high torque that they may require two hands on same side of the handlebar to keep in the saddle.

Road racers and mountain bikers work with their hands on the tops. Time trialists, criterium riders, and track specialists work more with their hands in the drops.

When performed in an easy or moderate gear at 70 to 90 rpm, this exercise tends to work the hip flexors (pulling up muscles) more.

Work On Spin and Leg Speed

Why do riders bounce at high rpm? It is because they do not send a neurologic signal to their muscles to stop pushing down at the bottom of the pedal stroke fast enough. A leg that is still pushing down at the bottom of the stroke while the pedal is already coming up forces the rider off the seat.

Bouncing here is not a question of too high a saddle, leg strength, aerobic or anaerobic fitness. It is a question of neuromuscular coordination. It is a skill.

This skill comes from neuromuscular practice.

Choose an easy gear. If you have a heart-rate monitor, choose a gear that allows you to ride at less than 65% of maximum heart rate. If you have a power meter, choose a gear that allows you to ride at less than 50 watts.

Ride with one leg at a cadence between 80 to 90 rpm.

Pedal stroke will improve.

Leg speed will improve—even for two-legged cadences at more than twice this rate.

Pacing, Focus, and Breathing

ILTs are excellent exercises to help improve pacing. It is easy to mistakenly work too hard initially and not be able to maintain cadence for the prescribed duration.

Athletes operating near their time trial threshold in steady, hard efforts often perform better by focusing on their own efforts, listening to their bodies' rhythms.

Intense, narrow, internal, and associated focus improves performance for almost all athletes.

Isolated leg training is an ideal exercise in which to start counting strokes or practice rhythmic breathing.

Then extend the coordination of counting, breathing, or other rhythmic action to time trialing or climbing with both legs.

Give ILT a Try

One-leg riding helps every type of cyclist—from mountain biker to sprint specialist to RAAM rider.

Start with two or three repetitions of one minute, and build up to three or four repetitions of three minutes over six to ten training sessions.

Perform ILT training once or twice a week.

You can mix 50 to 60 rpm high-load and 80 to 90 rpm low-load work in the same session.

After just six training sessions, I am confident that you will notice a benefit.

If you want to continue training with one leg, give ILT a rest for a week or two, and then build up to another peak over 3 to 4 weeks.

Now give ILT a rest. Remember, it is not during training, but during the recovery from training that we improve fitness.

Allow a month or two before entering another 6-week ILT phase.

Four ILT phases a year are probably best for maximizing gains and minimizing boredom or staleness.

Heart-Rate-Based Training

Heart-rate monitors allow you to observe your heart rate while working out. This helps training, providing immediate feedback about aerobic exercise intensity.

Why Use a Heart-Rate Monitor?

As with all measures of intensity outlined above:

- Use a heart-rate monitor to help design your training and racing programs.
- Use a heart-rate monitor to help ensure that you work according to plan. A monitor helps make sure that you work hard enough when you want to work hard. It also helps make sure that you do not work too hard on easy days.
- Use a monitor to help analyze how you feel and what happens to your body in training and in racing. Monitors do not necessarily change your training, but may help allow you to understand what is going on.
- Use a monitor to help motivation. The feedback provided is engaging for many riders.

Maximum Heart Rate

Determining maximum heart rate is the first step in developing a heart-rate training program.

Why Care About Maximum Heart Rate?

For most riders, heart-rate zones for aerobic, threshold and anaerobic work are determined from maximum heart rate.

Some coaches and athletes attempt to determine maximum heart rate a few times a year to set training intensities.

Maximum Heart Rate Defined

Maximum heart rate is the highest heart rate you can achieve.

For most riders, maximum heart rate is the highest accurate number seen on their monitor during the last year. Electromagnetic transmitters are a common source of false readings.

Individualize Your Numbers

220 minus your age, and other similar formulae are useless. The statistical average for the population is wholly unsuitable for the individual. It is like saying the average person is 5’9” tall, so all bikes should be made 55 cm.

Maximum Heart Rate Changes

Maximum heart rate is not a static or fixed number.

The unfit may not be able to achieve their genetic potential because of a lack of muscular strength or energy to work hard. Their maximum heart rate will increase as they become fitter.

Once fitness exists, maximum heart rate does not change much, but it does change. Elite athletes often have a lower maximum heart rate during their competitive seasons.

Maximum heart rate is sport- and climate-specific. Maximum heart rate is higher when vertical than when horizontal, and higher when more muscle mass is engaged. Therefore, maximum heart rate running is higher than maximum heart rate cycling, which in turn is higher than maximum heart rate swimming.

Finding Your Maximum Heart Rate

To obtain a maximum heart rate value, you need to be:

1. Rested.
2. Well warmed-up.
3. Motivated to make a maximum effort.

Why rested? Rest provides for recovery from previous exertion. With muscle fatigue/soreness or a lack of glycogen, it is not possible to produce a maximum effort.

Why a warm-up? Maximum heart rate depends upon maximum cardiovascular demand. If you are not well warmed-up, there is less blood flowing to your working muscles (the pre-capillary sphincters are not all open)—maximum effort cannot elicit maximum response.

Why motivated? Many people only see their max in a race or a test in which they are motivated. It is often difficult for riders to test their max when by themselves.

There are a number of different ways to find your maximum heart rate. Here is one way:

Warm up for at least 5 to 10 minutes. After working at a moderate pace for three minutes, increase your effort by about 10% every minute.

Cyclists on an ergometer can increase power output by about 10% each minute.

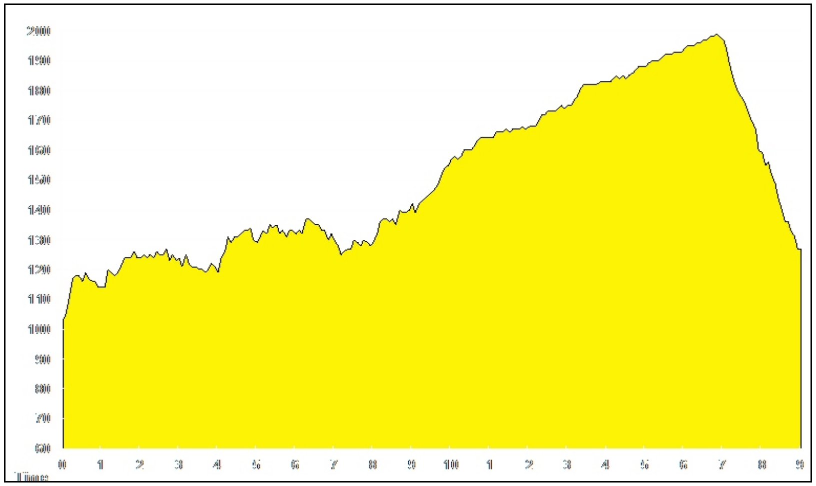

Figure 6. Ramped maximum heart-rate recording.

Cyclists riding on a velodrome or open road: Since power requirements rise between the square and the cube of speed, a 10% increase in power each minute does not mean a 10% increase in speed. Increase cadence by 3 – 5 revolutions per minute, or increase your gearing by one gear of difficulty every couple of minutes.

When you get to the point that it is extremely difficult to continue at pace, sprint as hard as you can for 30 seconds. Watch your heart monitor. This value should be close to your maximum.

Resting Heart Rate

Resting heart rate provides a tool for monitoring fitness and recovery.

Morning Resting Heart Rate

Determine resting heart rate by counting or monitoring your heart rate while not engaging in physical activity. This is usually measured first thing in the morning while lying still in bed.

Conventional wisdom states that resting heart rate is a measure of fitness and recovery. As you get fitter, your resting heart rate falls. When you are not recovered, your resting heart rate rises.

Use resting heart rate as tool in evaluation, but do not be spooked by high values: Some riders have their best performances on days that their resting heart rates are high.

Factors Affecting Resting Heart Rate

Dehydration, fever or other illness, drugs, stress, or the environment might raise resting heart rate.

For many riders the discomfort of a full bladder, the physical activity of getting up to urinate, or the jarring of an alarm clock will raise heart rate. Resting quietly in bed for several minutes after returning from urinating or turning the alarm clock off will give a more accurate reading.

The value measured while lying flat on the back is often slightly lower than that measured while lying on the side.

Threshold Heart Rate

The heart rate that you can sustain for prolonged efforts is important in prescribing exercise training and as a measure of fitness.

Thresholds are Variable

Elite athletes can sustain 92% of their maximum heart rate in events lasting about one hour. For events longer than this, the threshold will be lower. For shorter events, the threshold will be higher.

Your Threshold

Elite athletes may sustain efforts corresponding to more than 92% of their maximum heart rate for one hour. In contrast, once beginners have the strength and endurance, they ride at about 80% of their maximum heart rate.

Since a century represents many hours of work, the level one can sustain will be considerably less. Elite racers finish a century in about 4 hours, averaging more than 80% of maximum heart rate. Beginners finish a century in more than 8 hours, averaging 65% to 75% of maximum heart rate.

Factors Affecting Heart Rate

A variety of individual and environmental factors affects heart rate. Interpreting heart rate in the context of these factors provides better insight into the meaning of heart rates.

Recovery/Fatigue State

Fatigued riders may ride at lower heart rates with the same power output.

Temperature and Humidity

Heart rates may be one beat higher for every two or three degrees above 70° F. Cold weather results in lower heart rates.

Heart-rate recordings at different temperatures are shown in Figure 7.

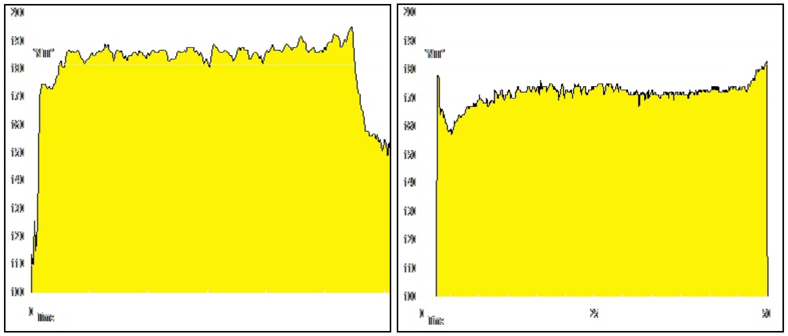

Figure 7. The same athlete performing at 90° F and 60° F. Heart rate is about 10 beats per minute higher when the temperature is 30-degrees warmer.

Altitude

Threshold and maximum heart rates are reduced about one beat for every 1,000 feet of elevation for sea-level athletes when at altitude.

Dehydration

Dehydration places increased demands upon the cardiovascular system. For a given power output, heart rates are increased.

Fitness

As most athletes become fitter, they improve their cardiovascular function and increase their sport-specific muscle mass—they are able to achieve higher maximum heart rates.

As athletes become fitter, they are able to produce more power for a given heart rate, or produce the same power with a lower heart rate.

Medications/Drugs

Drugs may decrease or increase heart rate. For example, beta-blockers like propranolol (commonly used to treat high blood pressure) can decrease heart rate and thyroid medication can increase heart rate.

Illness or Disease

Medical conditions can decrease or increase heart rate. For example, thyroid disease can decrease or increase heart rate, and illnesses with fever generally increase heart rate.

Heart-Rate Training Zones

You can establish heart-rate training zones based on percentages of your maximum heart rate.

Table 2 shows a simple zone system.

Noodling

Riding under 65% of your maximum heart rate. Easy riding. If your maximum is about 180 beats per minute, your noodling rate is under 120 beats per minute. This is recovery riding.

	% Max Heart Rate	Effort
Noodling	< 65%	Recovery, easy, "below pace"
Aerobic	66% – 85%	Group rides, "pace"
Threshold	80% – 92%	Time trials, "above pace"
Anaerobic	> 93%	Surges, jumps, intervals, sprints

Table 2. Heart-rate zones.

Aerobic Training

Your century pace is within this range.

Working between 66 and 85% of your maximum heart rate. You are training aerobically—"with oxygen."

Heart-rate economy will improve: As you become fitter, you will be able to accomplish the same work at lower heart rates. Put another way, you will be able to accomplish more work at the same heart rate.

Recovery heart rate will improve: The fitter you are, the faster your heart rate will recover from hard efforts.

Threshold Training

Working between 80 and 92% of your maximum heart rate. You are at a transition between aerobic and anaerobic work. This level of work is sustainable for efforts up to an hour. Training at this level some of the time will improve your fitness for shorter and for longer events.

Threshold level will rise: New riders can commonly sustain 80% of maximum heart rate for one hour. As fitness improves, athletes can maintain levels closer to 92% of maximum heart rate.

Anaerobic Training and Racing

Heart rates 93% or more of your maximum heart rate. Efforts that you cannot keep up very long. This is very hard work. You get these redline efforts in jumps, intervals and sprints. Not the exertions needed by most commuters, weekend riders, or century riders.

Training Time Needed to Progress

As stated above, aerobic training begins at about 66% of an individual's maximum heart rate.

To maximally train the aerobic system, riders need high-aerobic work—80% to 85% of maximum heart rate.

Once you have built a base of a thousand miles or more over a few months, you can aim to train at this intensity two or more times per week. Aim for a cumulative total of two or more hours per week.

Endurance may be improved by training at lower intensity levels, but maximal oxygen uptake may not increase.

Spending more time training at high-aerobic levels may be productive during some training phases. During these phases, riders may train at high-aerobic levels up to six hours per week.

There is a limit as to how much time riders can spend at high-aerobic levels because there is a limit to high-aerobic energy sources. Intramuscular glycogen is a limiter.

There is also a neurohormonal limiter. High volumes of high-aerobic work should not be performed routinely because of overtraining risk.

Racers need training at 86% to 92% of maximum heart rate to reach the limits of their aerobic potential. Training near this level overlaps with anaerobic training at times; this is threshold training. When training at such very-high aerobic levels, reduce the overall volume of aerobic work.

High-level aerobic training is not required for everyone. Riders are commonly able to successfully complete a hilly century without maximizing their aerobic training.

Heart-Rate Training Isn't Everything

Although heart-rate monitoring has revolutionized training for many, it is not a be-all and end-all.

While heart rate is one measure of training intensity, it is not always the appropriate way to measure intensity. It is an excellent way to measure aerobic intensity. It not the best way to measure or evaluate strength training, neuromuscular fitness (leg speed), or anaerobic work.

Not everyone finds that heart-rate monitoring improves performance.

Heart Training is Specific

When you are training, you must consider the purpose of your training. Do you need to monitor heart rate? Are you training aerobically? Or are you training strength? Or anaerobic power? Or skills? Or leg speed? Or recovering?

Strength Training

You will end up stronger by having "separate" workouts or aspects of workouts for leg strength or power. The legs develop more strength in bigger gears. However, when you ride big gears, the intensity of your workout is not matched by your heart rate.

For example, it is not unusual for riders to train in big gears going up hills at 75% of maximum heart rate. Exertion may be similar to that perceived while riding at 85% of maximum heart rate in a smaller gear.

Unreliable for Anaerobic Work

Although heart-rate readings of 93^{+}% of your maximum are anaerobic, not all anaerobic efforts will result in heart rates in this range.

High-level aerobic work preceding anaerobic effort is generally needed to see such high heart rates.

Your heart responds to changing exercise intensity, but this response lags behind true effort. In addition, monitor readings lag true heart rate by several seconds. These lags mean that you may already be recovering before your monitor has the time to reflect true effort.

Don't Be a Slave to Your Monitor

Riding under 65% of your maximum heart rate? You are not training your heart. That may not be necessary.

Training with new aero-bars? Perhaps you want to adapt to the position, not train aerobically. You might ride an easy workout at a heart rate of 110 beats per minute

You *are* training. You are training your back muscles, your forearms, etc. You may be resting your legs, and recovering from a recent hard ride.

Recovering—that is an important part of training too!

Power-Based Training

The basics of power-based training follow. Find more information in *High-Intensity Training for Cyclists*, referenced on page 126.

Power is the rate of work. Power monitors provide the best measure of muscular work.

Power on a bicycle is measured in watts.

Power over time, or work, is measured in kilojoules.

Power is a measure of workout intensity. Its key features are:

- **A**bsolute, objective measure
- **R**ace predictor
- **N**ot affected by confounding variables.
  Unlike speed, for example, it is unaffected by environmental conditions such as wind or elevation change.
- **I**mmediate
- **E**ffort sensitive

Power-Monitoring Benefits

- Quantify and document current and past fitness
- Compare fitness to others
- Quantify and document fitness changes that have occurred with training, overtraining, overuse injury, or traumatic injury
- Quantify total work, total work during intervals or stratify work performed at various intensities
- Quantify the demands of events
- Quantify and compare work performed with confounding variables—such as varying grades, wind conditions, temperatures, and group vs. solo riding
- Provide training intensity targets
- Encourage athletes to ride harder, or easier
- Provide training guidelines in rehabilitation
- Predict performance in training and events
- Show the decrease in ability with exposure to altitude—and the improvement that comes with acclimation
- Show the decrease in ability with exposure to heat, humidity, or cold—and the improvement that comes with acclimation
- Demonstrate changes in power with hydration status or fatigue
- Suggest a check for medical causes of decreased power
- Demonstrate the aerodynamic savings of equipment
- Demonstrate the aerodynamic savings of position
- Demonstrate improved power with changes in position
- Demonstrate the value of drafting, especially to “slow learners”
- Give a measure of calories burned
- Provide immediate and reviewable feedback about pacing
- Provide athletes with biofeedback and quicker appreciation of perceived exertion
- Show that performance (power) may be fine even though feeling tired or otherwise “slow”
- Help motivation
- Help confidence

Training Load and Event Predictor

Power measurement is the gold-standard measure of absolute workload.

Power is what gets you down the road. (Wind resistance, rolling resistance, and gravity hold you back. Formulae exist for predicting performance based on power.)

Hill climbing ability correlates well to aerobic power output divided by weight. Time trialing ability correlates well to aerobic power divided by frontal area or drag. Sprinting ability correlates well to anaerobic power.

While other measures of intensity, such as perceived exertion or heart rate, can provide relative measures of individual workload intensity, they do not predict performance.

Power-based testing is easy. Testing can help evaluate the effectiveness of training. Like VO2 max testing, power testing is valuable in predicting race performance. Unlike VO2 max testing, power testing can be portable and need not require a physiology lab.

Immediate and Effort Sensitive

The first thing most riders notice is that power readings change dramatically and immediately even in the course of what might have been thought of as hard steady efforts.

Heart rate is a physiologically smoothed function. Riders used to looking at heart rate values know that if they surge or relax somewhat during the course of a time trial, heart rate may change only a few beats. As Figure 8shows, power changes may be striking.

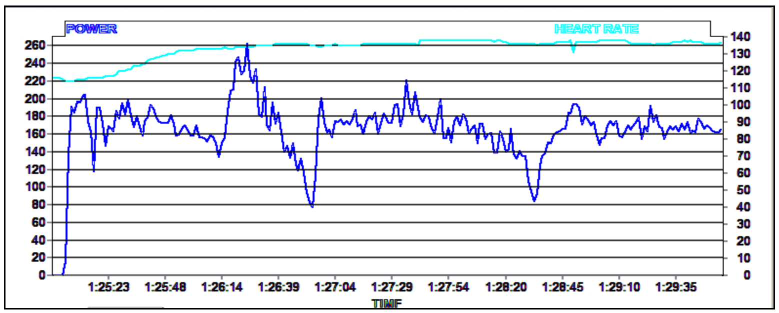

Figure 8. Dramatic change in power, little change in heart rate. Power, blue, bottom; heart rate, turquoise, top. Five-minute climb. Heart rate rises and stays high. Power output varies from 80 to 260 watts.

Devices

Power measurement—traditionally available on laboratory ergometers—has been available on new- generation portable consumer devices for more than a decade.

Durability was initially a problem for some units. This has improved.

Electronic stationary trainers generally measure power as the rear wheel turns a resistance device.

Figure 9. Stationary trainer power-measuring device. Manufactured by CompuTrainer.

Figure 10. Hub power-measuring device. PowerTap manufactured by CycleOps.

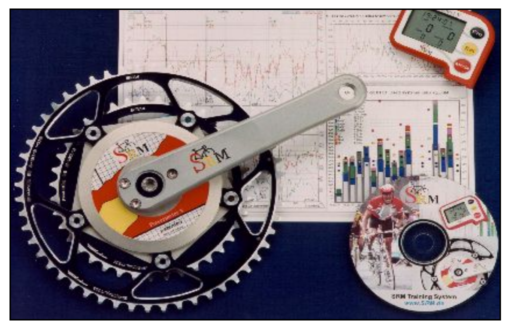

Figure 11. Crank power-measuring device. Manufactured by SRM (Schoberer Rad Messtechnik).

Force-measuring devices that can be installed at the pedals, crank, bottom bracket, chain, or rear wheel axle are available.

These allow riders to measure power on the road, trail, or track.

Some devices may add up to half a pound in weight and so fractionally worsen uphill performance.

Some devices that purport to measure power output do not—they impute it from speed, gradient, and rider weight. Such units are useful in that they provide a measure of relative workload intensity under identical conditions—for example, climbing a steady grade with no wind.

Total Work

Training hours and mileage are commonly used as measures of training volume. Total work may be a better measure of training stress.

Power is the rate of performing work. Many devices can compute the work accomplished over a period of time. This is commonly reported in kilojoules.

A joule is one watt of power for one second. There are 3,600 seconds in an hour. One kilojoule equals 1,000 joules. Therefore, averaging 100 watts of power for one hour yields 360 kilojoules of work.

Calories Used

Rule of Thumb—Close Enough

Since a kilojoule equals 0.24 calories,[2] and since the body is about 24% efficient in converting energy to muscular work, kilojoules of work provide a good estimate of calories burned.

That is to say if your total ride work is 1,200 kilojoules, you have also burned about 1,200 calories in producing that work.

[2] Technically one kilojoule equals 0.24 *kilo*calories. A scientific kilocalorie is popularly referred to as a calorie.

More Precise

For most riders, the body is closer to 22% efficient, about 10% less than the 24% quoted above. If your total ride work is 1,200 kilojoules, you have burned about 10% more calories, or about 1,320 calories.

Three Ways to Use Power

Riders and coaches use power meters in three general ways:

1. During a workout
2. Download and analysis of a single workout
3. Analysis of multiple downloads

Power During Efforts

This is what most riders and coaches initially examine.

What power can be sustained during a climb, time trial, or other interval?

What happens during racing? What kinds of efforts are required? Are those efforts simulated in training?

Determination is made crudely while riding, or more precisely with computer software of downloads.

Watts Per Kilogram

Just as absolute heart rate is of limited importance for most riders (percentage of maximum heart rate is a more useful statistic), absolute power output is less relevant than power per unit of mass, that is, watts per kilogram. (Metric units are used more frequently for this statistic, although some use watts per pound. A kilogram equals 2.2 pounds.)

A 90-kilogram (200-pound) rider will generate roughly twice the power of a 45-kilogram (100-pound) rider to ascend at the same speed. Watts/kilogram (pounds) will be roughly the same.

Pacing

Power monitoring provides a much better measure of pacing performance than heart rate. A declining heart rate usually indicates declining power. However, heart rate may remain high even though power declines, as Figure 12 shows.

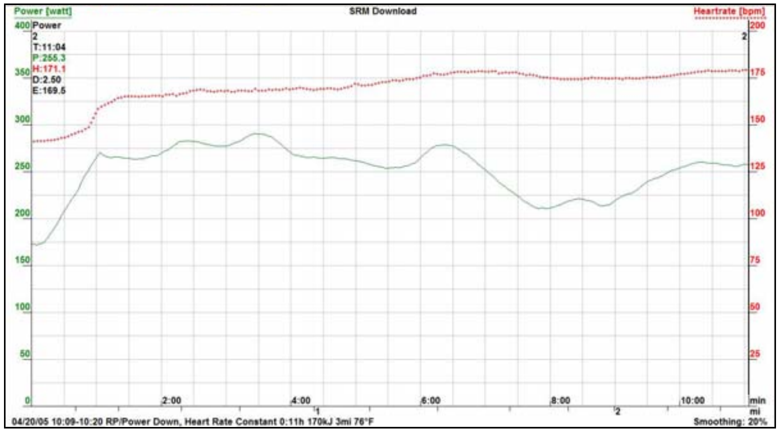

Figure 12. Pacing: Power is a better pacing indicator. Heart rate, red, above. Power, green, below. During this 10-minute effort, heart rate rises and stays up. Power of 260 watts is not held, and falls after a few minutes.

Power Ranges for Athletes

Riders of different abilities have substantially different power outputs.

This is in contrast to the percentage of maximum heart rate at which riders can time trial—this value is similar for men and women, young and old, beginning racers and professionals.

For example, most riders are able to complete 3- to 5-minute intervals at 90% of maximum heart rate. Beginners may perform these intervals at 100 watts. Professionals at 500 watts.

Power range standards for elite riders, stratified by age and sex, are available.

Values based on athletes I have coached are listed in *High-Intensity Training for Cyclists*, referenced on page 126.

Training: Power-Based Intervals

The shorter the interval, the more average power can be generated for the interval.

Power ranges for workouts are large—given the great variations in individual fitness.

One goal of training is to increase the power that can be generated for any specific length interval.

Summary

- Power-measuring devices provide an immediate indication of absolute workload.
- Watts per kilogram is generally more useful than absolute power.
- Power-based testing is useful. Like other measures of fitness, it is contextual, most accurate under controlled conditions.
- Power-based training can be effective in training many fitness systems.
- Unless one knows at what percentage of possible power one is riding, power does not provide a measure of relative individual exercise effort.
- In practice, I use power-measuring devices to evaluate current fitness, estimate what is possible, and to help motivation and pacing.
- I generally fall back to the oldest methods of measuring intensity—perceived exertion and instinct—in determining how much work to perform.

Part 2: Climbing

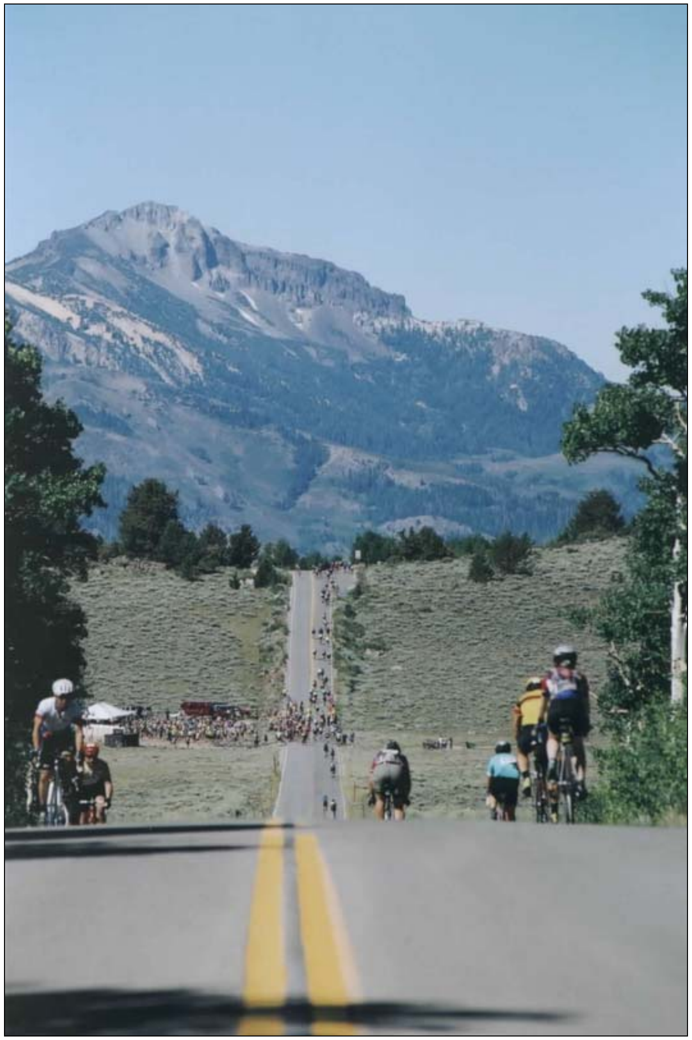

Figure 13. Monitor Pass. Tour of the California Alps—Markleeville Death Ride.

Climbing—Introduction

Climb, climb, and climb.

Learn to Love Hills

ACE rides are epics. Rides with names like *Death Ride*, *Triple Bypass*, *Heartbreak*, or *Challenge* are usually so named because of the amount of climbing in the ride.

For elite athletes, the work of every 1,000 feet of climbing is like an extra 5 miles on flat terrain. For recreational riders, 1,000 feet of climbing is more like an extra 10 miles.

In effort and time, the 129-mile, 16,000-foot *The Death Ride* is close to a relatively flat double century—200 miles.

One of the most important determinants to your success will be your hill climbing fitness. Plain old endurance climbing is more important than intervals, weight training, stretching, everything else. The way to improve this fitness is to climb, climb, and climb.

Percent Grade

Percent grade is a measure of hill steepness. By definition, percent grade is rise over run multiplied by 100.

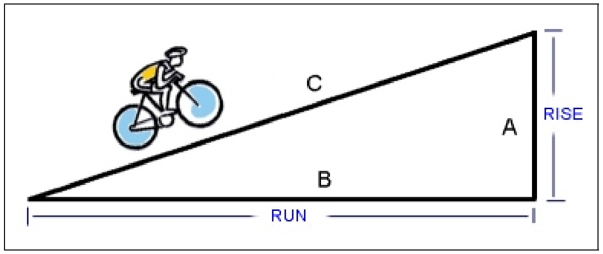

Figure 14. Percent grade is A/B x 100.

Think of a hill as a big triangle, a triangle with a 90-degree angle:

- The rise is the length of side A, or the height of the hill.
- The run is the length of side B, the horizontal measure of the hill at ground level.
- If you rise 100 feet over a horizontal distance of 1,000 feet, rise over run equals 100 divided by 1,000, or 0.1. To get the percent grade, multiply by 100.
- Percent grade is therefore 10.

It does not matter what units of distance you use (feet, meters, miles, or kilometers) as long as rise and run are measured in the same units.

In common practice, people often refer to percent grade as the rise divided by the distance traveled going up the hill (side C), rather than the horizontal distance (side B). This is because this is easier to measure side C. This is not technically the grade, but for roads that are not very steep, it is close because the horizontal distance and the length of the actual road are nearly the same.

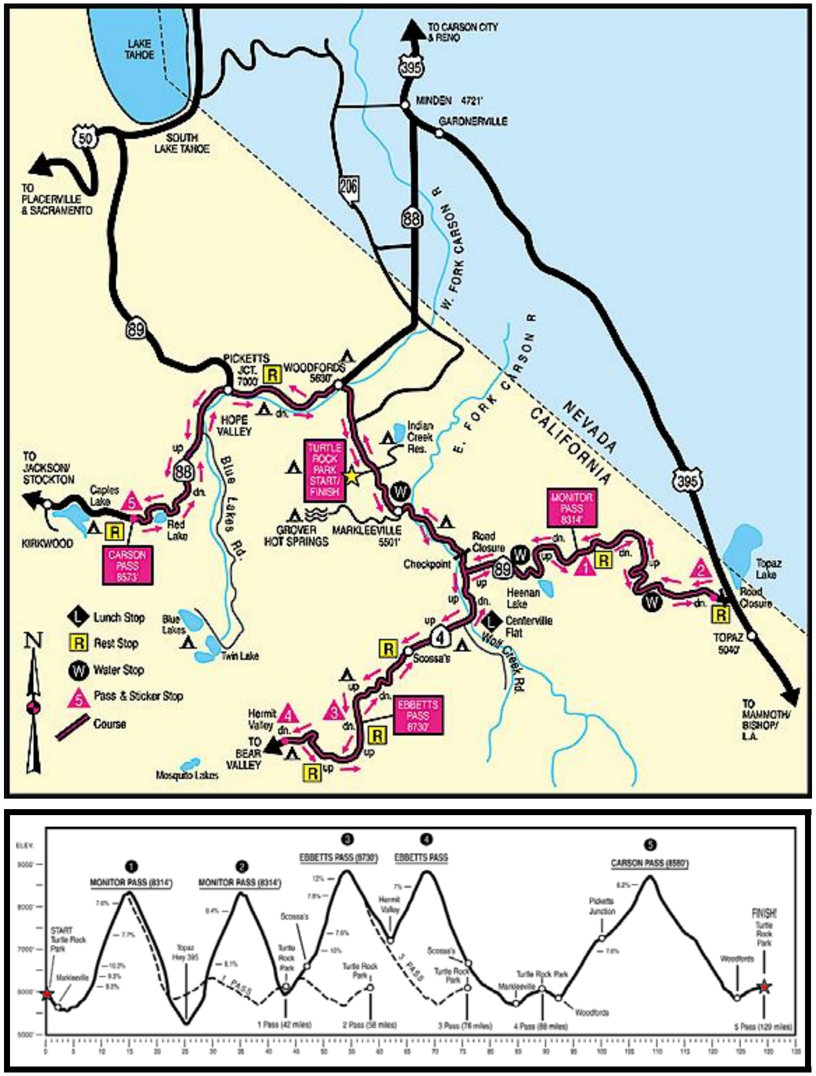

Figure 15. Markleeville Death Ride. Typical route and profile map.

For example, if you ride exactly 10,000 feet (about 2 miles) up a steady grade, and your altimeter shows that you have climbed exactly 1,000 feet, you might figure the hill has a grade of 10%. Technically, it is 9.95%.

How Much Climbing is 16,000 Feet in 129 Miles?

Let us use *The Tour of the California Alps—Markleeville Death Ride* as an example. It is 129 miles. It has 16,000 vertical feet of climbing.

Let us do some math. To climb 16,000 feet in 129 miles, you will average about 125 feet per mile. Since what goes up must come down, the overall climbing average per mile for a ride doubles: When you are not descending, you will average 250 feet of climbing per mile. That is a 5% grade.

Some of the time the climbs will be a lot steeper—perhaps 12% to 15%. Some of the time, you may actually ride on level ground—but not much—less than 25 miles.

On balance, you will spend most of your day climbing. If the ride takes you 12 to 13 hours, about 8 of those hours will be spent climbing.

Keep a Climbing Log

Want to be a better climber? Almost any coach will suggest keeping a training log to keep track of volume—how much riding you do, and intensity—how hard you ride. However, very few people keep track of their climbing. You have to do this.

Just as no method is perfect in tracking overall volume—there is endless debate about logging miles or hours, there is no perfect method of keeping track of climbing. The important thing is to have some method.

Feet Climbed

This is the easiest, simplest, and most effective way to track climbing volume.

Questions arise: Do you keep track only of major climbs, or every little highway overpass? How do you measure climbing: Do you need a computer or can you just guess?

Get an Altitude Computer—an Altimeter

There is no other way. You know you have traveled 60 miles because your bike odometer computer says so. Sure, you can guess, or look at a map. However, if you are hoping to see elevation markers on the roadside at the bottom and top of each climb, hope again. You need an altitude computer.

Barometric-derived accumulated totals are more accurate than GPS totals.[3] Depending upon the terrain, GPS-derived values may be as more than 100% higher than barometric measurements.

GPS units that also use barometric pressure, such as the Garmin 305, are much more accurate than those using GPS alone.

GPS units may be downloadable and interface with topological-

[3] Barometric units may read high or low due to improper calibration or change in weather. However, accumulated totals reasonably assess accrued barometric changes.

GPS altitude may be as accurate as 15 feet at any given time. However, over the course of a ride, altitude up-and-down errors build up to overestimate total climbing.

or satellite-based programs. Again, topologically determined elevation gains are overestimates.

Climbing Hours

For those without an altitude computer, tracking how long you climb is another approach.

Perhaps the easiest way is to use a bike computer or handlebar mounted watch that can measure elapsed time. Simply turn the time on when you start climbing, off when you stop.

This presents logistical difficulties except for sustained climbs.

Climbing Volume

Though it will take a while to build up, I recommend that you build up weekly climbing volume to a minimum of 125% of event climbing volume during three of your training weeks. If you love to climb and have the time and fitness, once or twice aim for over 25,000 feet per week.

Aim to climb at least 60% of event climbing volume several times. If your event has 16,000 feet of climbing, you must climb 10,000 feet in training in one day on at least several occasions.

For reference (not to make you feel bad), the best climbers in the world may occasionally climb 60,000 feet in a week. Many pros regularly climb 30,000 to 40,000 feet per week. National-level women and masters may climb 20,000 feet per week. For those living in Florida, only a thousand feet of climbing per week might be possible, even seeking out all available highway overpasses. Moreover, a few local criterium racers I know get woozy just looking at a hill.

Stationary training with the front of the bicycle/trainer elevated can help train climbing muscles. Give yourself credit for half your maximum hourly road-climbing rate for every hour that you are on the trainer. For example: Climb at 3,000 feet per hour on the road? Give yourself credit for 1,500 feet per hour on a front-elevated bicycle/trainer. (Read more about climbing on stationary trainers starting on pages 44 and 53.)

Mountain biking? To equate to road, double feet climbed on single track. Add 50% for fire roads. For example: Climb 1,000 feet of single track. Give yourself credit for 2,000 road feet. Climb 1,000 feet on fire roads? Give yourself credit for 1,500 road feet.

Climbing Intensity

Of course, you can use perceived effort, heart rate, power output, or any other standard method of determining intensity. In climbing, there is another possibility—climbing feet per minute or hour. This is dependent upon grade. You can climb more feet per hour up an 8% grade than you can up a 2% one.

To complete *The Death Ride* within the cut-off time, you will generally need to be able to sustain a climbing rate of more than 2,200 feet per hour up 8% to 10% grades in most sea-level training. Or more than 2,000 feet per hour up 6% grades.

This gives you the margin to manage the inevitable 10% to 20% reduction in your climbing rate during the event due to altitude and all-day riding.

The absolute minimum climbing rate during *The Death Ride* to make the cut-offs and complete 5 passes is about 1,650 feet per hour. This assumes you can descend well, keep rest breaks short, fix any mechanical problems swiftly, and have good weather. This minimum climbing rate results in a 14^{+}-hour day.

Again, for reference (not to make you feel bad), a few of the best climbers in the world can climb at the rate of 6,000 feet an hour.[4] Most pros average 5,000 feet per hour. The best women and masters riders climb up to 4,000 feet per hour.

Of course climbing rate is dependent upon the length of the interval—you can climb faster for 5 minutes than you can maintain for a whole hour. A pro climber I coach who climbs a 7% grade at 5,000 feet per hour climbs closer to a rate of 7,500 feet per hour for 5-minute intervals.

4 Both Marco Pantani (1997) and Lance Armstrong (2001) have climbed the 21 switchbacks and 3,656 foot 8% grade of Alpe d'Huez in about 37 minutes. Furthermore, this has been in the middle of the Tour de France, at the end of a 100^{+}-mile stage with up to 17,000 feet of total climbing.

Although you may want to determine your climbing rate, this will not generally govern the intensity of your training. Base the intensity at which you train and ride a high-altitude event on perceived exertion, heart rate, or power.

Figure 16. Climbing can be intense. At times, train intensely. Ride ACE events at your own pace.

Stationary Trainer Climbing

I am a big advocate of stationary trainer workouts. They are precise and one of the best friends of the performance athlete. They are also a bad weather necessity for anyone interested in cycling fitness. Moreover, for most of you who have other day jobs, you need them so that you can work out and climb in the dark.

Use a stable stationary trainer to which your own bike mounts. (If you have an old bike, you can keep it permanently mounted.) Rollers, Lifecycles and Spinners are poor substitutes because it is difficult to train as well on them.

Increasing trainer load per se does not simulate climbing. You need to train the right muscles: The front of the bicycle/trainer must be elevated. You can use a block of wood, proprietary trainer block, or other device. CycleOps-brand trainer climbing blocks are stackable.

Make the Trainer Stable

Without fail, someone has fallen off their trainer every year at our annual stationary trainer classes.

Make sure the bicycle is securely attached to the trainer.

If your rear wheel has a skewer that does not fit perfectly securely in the trainer supports, replace it with one that does.

Trainer workouts are improved when the front of the trainer is stabilized. A front-fork mounted trainer, as in Figure 17 is best. Other good alternatives include proprietary climbing blocks, a fork-mounted support on a step ladder, or mounting the front wheel on a second trainer.

Front wheels on telephone books do not work. Small coolers or tool cases are unstable. Plain wood is marginal.

Reader Warren Carswell writes: “During the past Vuelta A España I propped my front wheel on the TV to simulate a couple of the climbs. It worked fine until I stood and cracked the TV.”

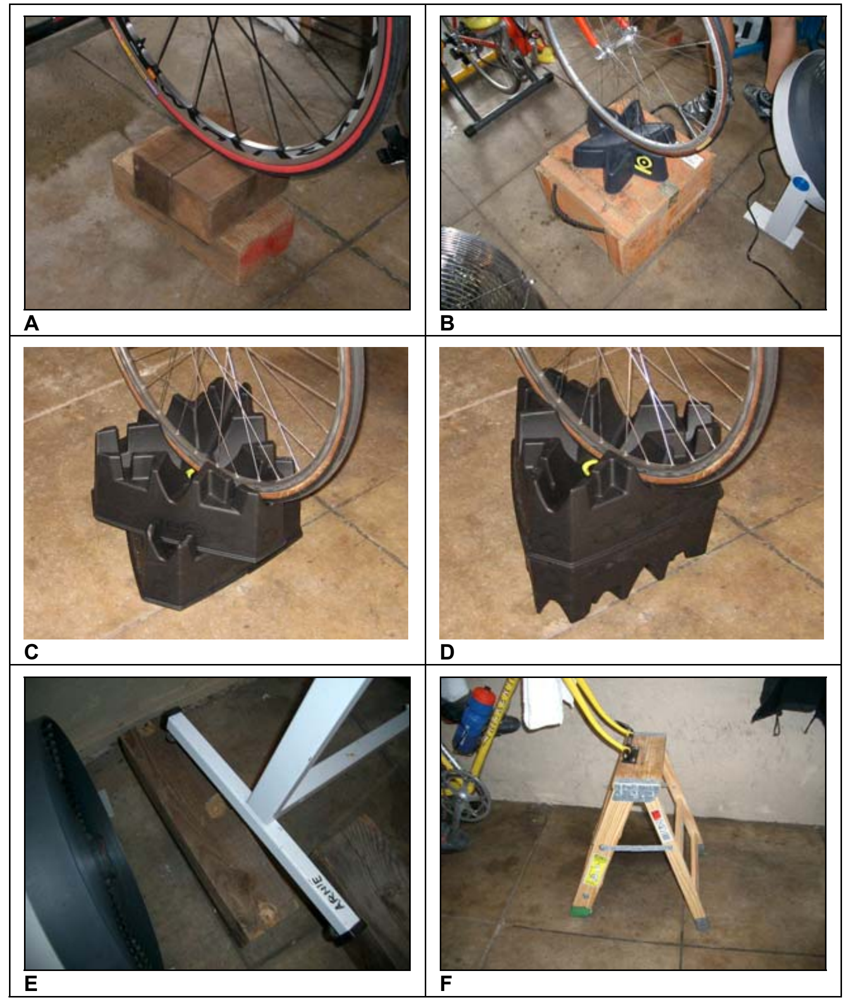

Figure 17. Raised bicycles/trainers. A, 4″x4″ blocks of wood—marginal stability; B, plastic trainer block on wood case—better stability; C, CycleOps climbing blocks stacked—good stability; D, CycleOps climbing blocks back-to back—good stability; E, 8″x4″ block of wood with cutouts for trainer leveling bolts—excellent stability; and F, 24″ stepladder with front-mount support—very good stability.

As you gain experience, you can raise the front of the bicycle/trainer up to 8 inches. Since the trainer raises the back of the bicycle up to 2 inches, this amounts to a net front elevation of about 6 inches. Raising the bicycle/trainer more than this amount risks an accident, wheelieing backward.

How Much Climbing?

Since percent grade equals rise over run, if the front of your bicycle/trainer is 6 inches higher than the rear, and the bike's wheel base is 40 inches, you have a roughly 15% grade.

My rule of thumb for climbing workouts: Each hour on the stationary trainer in climbing position is equivalent to one-half the maximum road climbing feet one can climb in an hour. Another way to say the same thing: On a sustained climb, can you climb 3,000 feet per hour? If so, give yourself credit for 1,500 feet of climbing for each hour you spend on the trainer.

More Info

Use fans for cooling and plan ahead with waterbottles.

For more information about stationary training, see the workouts on page 53 and *High-Intensity Training for Cyclists*, referenced on page 126.

Climbing & Descending Tips

Hills present a special challenge. When you ride on the level, you can ease up and rest, and still go forward. However, hills are different. You have to keep putting out a good level of energy just to avoid falling over!

There is something else to consider. Descending. For some, descending, especially with corners or crosswinds, is very scary. Fortunately descending skills and techniques can be learned. These can make going down hills safe and a blast.

Climbing

Train on the Hills

It is obvious, of course. Riding the hills makes you better on the hills. It astonishes how many riders are disappointed at their slow progress on hills—and when I ask them whether they train on hills, they say: "No."

Steady hill riding, interval hill riding, big-gear hill riding, and hill sprints. Incorporate them into your program and you will certainly climb better.

Climbing logs—made possible with an altimeter—help many riders record and plan their hill climbing work.

If you do not have easy access to hills for training, a stationary trainer with the front elevated about 6 inches will train climbing muscles.

Train Your Mind

If you look at each hill as an opportunity to improve your climbing, you will. If you see each hill as an obstacle to where you are going, it will be.

Sometimes keeping focused on the top of the hill helps draw you up to the top. At other times mentally dividing the hill into more manageable segments works better. Be flexible in your approach, and use both techniques to help you.

Get the Right Gears, Shift Early

Balance the work of your muscles and aerobic system.

New riders frequently use their muscles until they cannot push any more. When their legs bog down, they shift to an easier gear—if they have one. However, by then it may be too late. The muscles may be exhausted and unable to continue, even in a "bail-out" or super-easy gear.

It is a much better strategy to shift early to easier gears. Save your legs. If you find that you are going well, you can always shift to a harder gear later.

This is the strategy used by many top professional racers. On a hard, steady climb, the top pros shift to harder gears, not easier ones half way up the climb.

Many riders do not have "easy" enough gears to allow them to climb comfortably. There is no shame in having easy gears. The first few races I entered I had a 26-cog on my rear wheel. My competition had 21s. They did make comments about my "easy gears." However, when I won every one of my first few races, they did not laugh at me anymore—they asked where they could buy a similar set-up.

Think of it another way. If a top pro rider can climb twice as fast as you can, and uses a 21-cog, maybe you should have a 42-cog!

There is no shame and there is a lot of sense in having a triple chainring set-up. With a triple, you have more gear options. Some professional riders use triples in the hills. Many bikes are sold with triples. Alternatively, you can convert your double-ringed bike.

Read the information about *Small Gears* on page 85.

Be Conservative, Go Easy

If hills intimidate you, or are your weak link, take it easy. Go 5-10% easier than you think you need to. Conserve. You can always pick it up later.

If you are a great hill climber, the opposite strategy may hold. You obtain an overall better time by working a little harder on hills.

Get the Proper Body Position

Sure, bent over in the drops is the efficient way to fly along on level ground. However, hills are different. There is much less aerodynamic resistance.

You get the most power sitting up as high as you can. Open up the hips.

Place your hands on the tops of the handlebars—that is where they generally belong.

Most riders do better by pushing back on the saddle and pushing forward with the legs, rather than down.

The sitting-up high, hands on the tops position is generally the most comfortable and economical climbing position.

Some other positions can be used effectively as training exercises. The six most common climbing positions are discussed more fully on page 49.

Sit or Stand?

Everyone has his or her individual preference.

Most of us do better sitting on long climbs.

Everyone needs a change in position from time to time, and standing helps work different muscle groups and gives a partial rest to some leg and back muscles.

Standing can also allow you to maintain or give a little more power, without shifting, on short, steeper pitches.

A minority of riders, especially light riders, climbs better standing.

Establish a Breathing Rhythm

Get a rhythm. Concentrate on each stroke. Coordinate your breathing with your legs. At moderate intensity, perhaps take a breath every two revolutions of your legs. At harder intensities, perhaps take a breath every one and one-half revolutions of your legs. You will go faster!

Read more about *Focus and Breathing* on page 69.

Relax

Do not get tied up in knots on the climb. Relax you arms. Relax your shoulders. Relax your back. Use your legs.

Working Really Hard?

At hard intensity, fit riders can push down on their pedals with forces greater than body weight, and lift themselves off their saddles.

At high intensity levels, stabilize your body by pulling up on the handlebar. Pull with the same-side arm as the pushing leg.

Weight

An extra pound on your body or bike frame is worth about 20 seconds for every hour of climbing. Rotating wheel weight is about double.

20 pounds overweight? That hour-long mountain climb will take you about 7 minutes longer.

Do not sacrifice equipment weight for reliability.

Descending

Be Safe and Be In Control

Do not scare yourself. Start with gentle descents and gentle corners. Learn proper techniques. Always feel comfortable and in control—let faster descenders go by you. With practice, you will improve.

If you have a friend who is a skilled descender, ask him to slow down a little and let you follow his line at a safe distance.

As you ride faster, rider further from the pavement's edge. Scan for pavement hazards in front of you at the same time as you look farther down the road.

Keep both hands on the handlebars. Keep your hands in the drops, with a firm, yet relaxed grip. Do not concentrate on the road beneath you or stare at the corner you are approaching. Rather, look where you are going, look around the corner to where you will be.

If you need to brake suddenly, shift your weight rearward. Apply more front brake than rear.

Initially your hands and wrists may tire on long, winding descents. You may need to stop and rest after a mile or two. If you do not adapt with time, hand and wrist strengthening exercises may help.

When on a straight descent, gripping the top tube between your legs can help stabilize the bicycle, allow more relaxation of your upper body, and help prevent front-end shimmy. When cornering, allowing your inside thigh to stabilize your bike's top tube against your body can be helpful.

Anticipate

While scanning for road hazards, trust the big picture. Look ahead. Look beyond the corner. Look where you will be going.

Anticipate at what speed you want to ride the corner. If you are concerned about maximizing your speed through corners, remember that exit speed is more important than entrance speed. If you will need to reduce speed, break before corners, not in corners. However, if you have misjudged the corner, breaking late is better than going off the road.

Balance Rules

In addition to looking ahead, as described above, apply standard balance principles:

1. Keep your eyes level with the horizon by pointing your chin where you are going.
2. Shift a little rearward on the bicycle.
3. When not cornering, keep cranks and feet level.
4. Lead with your dominant leg.
5. Relax.

Cornering Technique

If traffic safety and rules of the road allow, ride from the outside of the lane or road to the inside apex of the corner, then to the outside of the lane or road on exiting the corner. This effectively straightens out the corner.

By raising or lowering your chest, you can modulate your speed. A dropped chest results in greater speed, and a lower center of gravity.

Put your outside leg down. Straighten out your outside leg. Put weight on your outside leg.

Although some riders point their inside knee into the corner, most find that stabilizing the inside knee against the top tube improves balance.

Important advanced techniques for corners: Put weight on your inside hand. As the bike balances between your outside leg and inside hand, lean the bike more than your body, slightly unweight your rear end, and move slightly back on the saddle. More weight on the inside hand and greater bicycle lean allows you to turn more sharply; less weight on the inside hand and less bicycle lean allows you to increase the radius of your turn—even while in the corner itself.

As your skill allows, you will often find that the fastest descents are achieved by sprinting out of corners and tucking into an aerodynamic crouch, not by steadily pedaling in a big gear.

Crosswinds

Slow down and get down. The less your body is acting like a sail, the less you will be blown around. Lower your center of gravity. Put more weight on your pedals. Ride with the hands in the drops and a low chest. Since this position improves aerodynamics, use your brakes to slow down, if necessary.

As traffic safety and rules of the road allow, allow some margin for the wind to blow you to the edge of the road.

Relaxed riding, with relaxed yet firm arms and grip, and mildly allowing the bike to “go with the flow” is usually safer than tensing up and trying to (over)correct for every gust of wind.

Extend your leg on the lee side. Weighting the lee leg, leaning the bicycle into the wind, with weight on the windward hand, allows relatively safe compensation for wind gusts.

Look ahead. Anticipate gusts when direction or protection from hills or other geographical features changes.

With crosswinds from the left, anticipate that passing or oncoming vehicles, especially trucks, will result in gusts.

Equipment

Wheels can make big differences in descending comfort and safety.

Deep-dish rims catch crosswinds and can make safe descending more difficult, occasionally impossible.

Lightly-spoked wheels may be less laterally stable during cornering.

Dual-tread and other tire compounds can improve cornering force and slip-out angle. Although narrow tires are often chosen because they are lighter and have better aerodynamic profiles, keep in mind that wider tires reduce rolling resistance and improve cornering.

Summary

With training and practice, you will climb and descend more comfortably, with greater skill and safety.

Six Climbing Positions

Riders and coaches have debated for years the pros and cons of sitting vs. standing when climbing on a road bike.

In fact, there are six basic possible positions: The hands may be on the tops, hoods, or drops of the handlebars while sitting or standing.

Riders may feel awkward and weak in any position different from that in which they commonly train. When positionally trained, riders are and feel more comfortable and powerful.

In this article, I will discuss the pros and cons of these six basic positions.

Sitting, Hands on Tops

Figure 18.

This is the most common climbing position.

It is the most economical (energy-saving) climbing position for most riders. Read more about *economy* in the *notes* section at the end of this article.

With steady effort, this position results in the most endurance climbing power. The rider sits relatively upright. The hip angles are the most open, allowing climbing muscles to be used to the best mechanical advantage.

Seated forward tends to emphasize the quadriceps muscles; seated rearward tends to emphasize the gluteal muscles.

This position is the most comfortable one for most riders.

However, riders are not able to accelerate—to attack or to respond to surges—in this position as well as they can climbing seated with their hands on the hoods.

Sitting, Hands on Hoods

Figure 19.

This is also a common climbing position.

Relatively high on the economy scale, it is often employed by racers when climbing in groups. It allows a quick transition to standing with hands on the hoods, a position change often required to respond to surges or to temporary increases in climbing grade.

This position is overall quite comfortable, although some riders feel too stretched out.

Sitting, Hands in Drops

Figure 20.

Of all the climbing positions, this one is the least powerful for most riders.

This is because the closed hip angles result in riding muscles at their worst mechanical advantage.

For a minority of riders who preferentially train climbing in this position, it may be a relatively powerful way to climb. For some riders it is the most powerful position for sprinting.

Riders commonly pedal sitting with hands in the drops when racing on flat terrain or downhill because aerodynamics more than compensate for the loss of muscle power. However, aerodynamics is not that important in climbing—and so this position is relatively rare on climbs.

Many riders find this position uncomfortable and experience lower back pain especially when climbing, but also on flat terrain.

Even though this position is often less powerful and uncomfortable for climbing, there is good reason for racers, especially time trialists and sprinters, to use this position. By training muscles in this position, those muscles will be stronger and more powerful when needed to time trial, sprint, or otherwise assume an aerodynamic position.

Standing, Hands on Hoods

Figure 21.

When standing, this is generally the position most riders use.

Many riders like to stand occasionally with their hands on the hoods to take pressure off their rear ends and to stretch their backs.

This is a relatively economical position, especially for lighter riders who tend to stand more often than heavier riders do. When standing, the bicycle seat no longer supports most of the body weight. Heavier riders use more energy to support their body weight.

It is the most comfortable standing position, and permits the rider to gently rock the bicycle from side-to-side with each pedal stroke, allowing the body to remain relatively perpendicular to the ground and gravity to help propel the bicycle.

Best technique for most riders is to slightly pull up with the right arm as the right leg pushes down on the cranks, and slightly pull up with the left arm as the left leg pushes down.

Standing, Hands in Drops

Figure 22.

This position is occasionally used by many of the world's best climbers.

It initially feels unstable for most riders.

Standing with the hands in the drops allows the rider to use slightly different muscle fibers than those used when seated. Standing with hands on the hoods uses muscle fibers between these two positions.

Once you feel stable, this is the best position to allow partial rest while climbing. Let me explain more: When riding on the flat, it is possible to stop pedaling without much loss of momentum. When climbing, this is much more problematic. In general, if your pedaling slows down, muscle tension increases, and rest is not possible. Brief rests while climbing are often counterproductive, because overcoming momentum loss requires increased power.

However, standing with the hands in the drops allows a more up-and-down (rather than circular) style. This, combined with a more pronounced rocking than occurs when standing with hands on the hoods, allows potential energy and gravity to best overcome the loss of momentum that occurs if the rider slightly pauses at the bottom of the stroke.

Like the rest-step high-altitude climbers learn, climbing while standing with the hands in the drops allows a partial rest with each stroke, a welcome climbing relief to riders who have learned this technique.

Standing, Hands on Tops

Figure 23.

This is the least common of all six positions.

It is also the least stable—the position with the highest center of gravity and narrowest base.

A firm grip places the hands and wrists in an uncomfortable and awkward position.

The position does provide an occasional welcome alternative when climbing while standing for long periods on a stationary trainer. Since bicycle stability is not a problem on a stationary trainer, the hands, wrists, and arms can be more relaxed than when on the road.

Notes

Economy

Economy refers to energy-saving style or technique. Energy used to move the body up and down, for example, rather than to rotate the pedal cranks, is wasted energy and decreases the effectiveness of the rider's effort.

Bicycle Adjustment & Fit

Positioning the handlebar drops to point to the rear brake and the brake-lever tips in line with the bottom of the drops works best.

This position allows riders to comfortably and safely brake, and makes riding comfortable with the hands on the hoods or on the drops.

Figure 24. Handlebar and brake levers. Notice: Drops pointing to rear brake, brake lever tips inline with bottom of drops, and short stem.

Check that your handlebars are in this position because they often slip from their original position. Make sure that the stem bolt, which fixes the handlebar position, is securely fastened.

Relatively short stems, as shown above, allow the rider to sit more upright. This allows the hip angles to be more open, improves mechanical advantage of muscles, and allows you to generate more power.

Generally, the higher the saddle the more power you can generate, and the less the aerobic cost. (You must not be so far extended that your hips rock or that your spin is restricted when you pedal.)

Climbers often move rearward on the saddle to effectively increase their leg extension. With hands on tops, there is only a modest penalty in terms of closing the hip angle—unlike moving rearward when in the aero time trial position.

Too forward a saddle position makes safe descending more difficult.

High-Power Output States: Use the Upper Body

There is a limit to how much force a rider can use to simply push down on the crank. When sitting, at some threshold point the rider pushes down hard enough to lift himself or herself off the saddle. When standing, stroke effectiveness can be similarly lost.

If the body is stabilized, or relatively fixed, these force thresholds can be crossed. Riders therefore use their upper bodies to fix their position on the bicycle.

The most effective method is to use the arm on the same side of the body as the leg pushing down. That is to say, pull with the right arm when the right leg goes down; pull with the left arm when the left leg goes down.

This technique is most effective when standing with hands on the hoods or in the drops.

Loss of Traction

Steep grades, roads with sand, wet roads, or roads with algae or other slippery material may result in loss of traction. Loss of rear wheel traction is most common. Loss of front wheel traction also occurs.

Loss of rear wheel traction is more common when standing than when sitting. Sitting increases the weight on the rear wheel and improves traction.

Surges in torque, as opposed to a smooth pedal stroke, worsen traction. Pulling on the handlebars, as described above in high-power output states, worsens traction.

If rear-wheel traction is poor, pushing forward slightly on the handlebars when pushing down on the pedals can help.

Final Words

See the climbing position summary table below.

There are six basic climbing positions.

Climbing while standing with hands on the tops is best reserved for occasional use on a stationary trainer. The other five positions each have distinctive benefits on the road. By training in these different positions, riders can become better climbers, better all-round riders, and enjoy climbing more.

CLIMBING POSITION SUMMARY

Position Notes	Economy (Energy-saving)	Comfort	Ease in Acceleration	Stability
Sit, Tops Most economical	🚴🚴🚴	🚴🚴🚴	🚴	🚴🚴🚴
Sit, Hoods Allows transition to stand	🚴🚴	🚴🚴	🚴🚴	🚴🚴🚴
Sit, Drops Trains flat-land power	🚴	🚴	🚴	🚴🚴
Stand, Tops Unstable except on trainer	🚴	🚴	🚴	🚴
Stand, Hoods Best overall stand position	🚴🚴	🚴🚴🚴	🚴🚴🚴	🚴🚴🚴
Stand, Drops Allows dynamic rest	🚴🚴	🚴🚴	🚴🚴🚴	🚴🚴
Scale:	🚴🚴🚴 🚴	Most Least		

Table 3. Climbing position summary.

With a Stationary Trainer Emphasis

Climbing Workouts

If you do not have a workout plan when training on a stationary trainer you are wasting you time. It is too boring otherwise.

Stationary trainer workouts are precise and time-efficient. If you have a half hour in the morning to ride before getting dressed for work, you are probably just not going to get a meaningful climbing workout in on the road. If you are like most folks I know, it takes longer to get out of city traffic and find a good hill. With a trainer, you can easily perform a worthwhile half hour of climbing.

Here are some climbing workouts for the stationary trainer that combine many of the principles discussed above. You can easily adapt these workouts to the road by finding a climb of suitable length and grade.

Here is a typical two-hour program that will introduce you to climbing.

Two-Hour Stationary Trainer Workout

Overview

~ Duration	Exercise	Gear	RPM	Intervals
12 minutes	Warm-up	39/23	to 120	
14 minutes	Climbing ILT	53/17	50-60	3 & 4-minute reps
15 minutes	Climbing	53/13	50-60	
24 minutes	Climbing	53/13	50–60	3 x 3-min up/down reps 3 x 1-min up/down reps
8 minutes	Climbing ILT	53/16	50-60	4 minute rep
10 minutes	Cool-down	39/21	100^+	

Table 4. Sample 2-hour stationary trainer workout.

Front-Elevate

As stated above on page 44, resistance or load does not stimulate climbing. Position does. Whenever you are on a trainer, elevate the front of your bicycle trainer.

This not only simulates climbing, it makes it easier for your crotch to tolerate long trainer workouts.

Stability is important. See *Make the Trainer Stable* on page 44 and Figure 17.

Warm-up Spin-up

The first 10–15 minutes of every workout are spent warming up. Choose the easiest, or almost easiest gear, available, with very little resistance on the trainer. Start at about 60 rpm—pedaling a cadence of one stroke every second. Build up 5 rpm every minute until you are spinning about 120 rpm. If you are new to spinning, it may take some time to be able to spin this quickly.

Isolated Leg Training

One of the best ways to work on leg strength is one leg at a time. By pedaling with just one leg—isolating that leg—you can focus on pulling up, on evenly applying force to the pedals around the stroke, and on building tremendous push-down forces. The key is to focus on the leg, not the cardiovascular system—which is precisely what ILT does.

An easy gear will force you to concentrate on smoothness and the pull up motion of your leg. A hard gear specifically strengthens your quads and gluts—the most important cycling propulsive muscles you have.

It is hard to be precise about the gear, because everybody's trainer is different. Choose a gear that allows you to pedal with a cadence of about 50 rpm with a heart rate of about 140 or 70% to 75% of you maximum heart rate.

Steady Hill Climbing

Keep the front of your trainer elevated.

Choose a hard gear with significant trainer resistance. Stand up and pedal 50 to 60 rpm steadily for 15 minutes.

It may take a while to build up to this. It is helpful to concentrate, focus, or visualize rather than just wait for the 15 minutes to finish.

For example, concentrate on breathing out every stroke-and-one half. Or concentrate on pushing down for 10 strokes with your left leg, then on pushing down for 10 strokes with your right. Or concentrate on breathing every stroke-and-one half, and count to ten, 10 times.

Or concentrate on pulling up with your left hand when you push down with your left leg. After about a minute, focus on your right side and concentrate on pulling up with your right hand when you push down with your right leg.

There are lots of different counting and visualization games you can play. It is not critical which games you choose, but games like this will make the time pass more easily and help the workout.

Up/Down Hill Climbing

Keep the front of your trainer elevated.

Pedal easily with both legs for about five minutes.

Stand for 3 minutes; then sit for 3 minutes. Do not change to an easier gear. It may take a minute to get your cadence back up. Repeat this up and down standing and sitting two more times.

Then stand for one minute, sit for one, stand for one, sit for one, stand for one, sit for one.

That will be a total of 24 minutes of climbing simulation.

When you get to the one-minute up one-minute down part, try to pick up the pace progressively, so that when you are finished you are working all-out.

ILT

Pedal easily for 5 minutes.

Repeat a 4-minute ILT set in as hard a gear as you can push to finish the 4 minutes.

Cool-Down

Almost as important as the warm-up is a proper cool-down. With minimal trainer resistance, spin up to 100–120 rpm, hold it for 5 minutes, and gradually spin down.

Remember the racehorse adage: By the time it gets back to the barn after a hard workout, a racehorse should be breathing normally and not sweating.

Climbing Workout Variations

The workout above is a possible two-hour stationary trainer workout.

Many different climbing workouts are possible. All climbing exercises are performed with the front of the trainer elevated 4 to 8 inches. Some elements of workouts are common to all workouts; for example, a warm-up and cool-down. Since many riders neglect standing when climbing on the road, most trainer workouts incorporate more standing than seated climbing. Steady-state climbing adds climbing endurance to almost any hill climb workout.

Here are some suggestions for items to add to make up a climbing trainer workout depending upon what aspect of climbing fitness you wish to work on, and time available.

Endurance Climb—Stand

Works standing climbing muscular endurance.

- Stand 20 to 30 minutes.
- Hard gear.
- Rpm 50 to 55.
- Heart rate 75% to 80% of maximum at the end of the endurance climb.

Endurance Climb—Stand and Sit

Works standing and sitting climbing muscular endurance.

- Stand 20 to 30 minutes.
- Hard gear.
- Rpm 50 to 55.
- Alternate standing and sitting every 5 minutes.
- Heart rate 75% to 80% of maximum at the end of the climb.

Progressive RPM Climb

Works climbing muscular endurance, cardiovascular system.

- This is a good way to perform some hard work even when you are a little tired. It is usually pretty easy to "get into it."
- Hard gear.
- Start with a cadence of 50 to 55 rpm.
- Alternate standing and sitting. Start with 3 to 7 minutes. Decrease duration of effort by one minute every time you stand again. Increase cadence 1 rpm every time you change position. Sprint the last 30 seconds.

  If you start with 4 minutes, the duration of the exercises is 20 minutes. If you start with 7 minutes, the duration of the exercise is 56 minutes.

  An example starting from 5 minutes is shown in Table 5.

It will take a while to develop the climbing endurance. Start with just 3 minute standing. Build up to a 7 minute-standing start after a year or two.

For example, if you begin with 5 minutes of standing and sitting, and start at 54 rpm, the details will be:

When you get to the 2-minute efforts, you heart rate should be 85% or more of maximum HR. You should end at over 92% of maximum HR.

Duration	Position	Typical Gear	RPM
5 minutes	Stand	53/14	54
5 minutes	Sit	53/14	55
4 minutes	Stand	53/14	56
4 minutes	Sit	53/14	57
3 minutes	Stand	53/14	58
3 minutes	Sit	53/14	59
2 minutes	Stand	53/14	60
2 minutes	Sit	53/14	61
1 minute	Stand	53/14	62
1 minute	Sit	53/14	63

Table 5. Progressive RPM Climb, starting with 5 minutes.

Climbing with Surges

Works climbing muscles, cardiovascular system, lactate tolerance.

As the progressive climb described above, this exercise helps you perform hard work even when you are a little tired. It is usually pretty easy to "get into it."

- Stand or alternate standing and sitting (every minute or every other minute) for 10 to 30 minutes.
- Hard gear.
- Baseline rpm 50 to 55.
- Begin surges anywhere from the top of the 3rd to the top of the 20th minute. If performing 8 or fewer surges, surge 20 rpm higher than baseline until 3 surges remain, at which time go almost all out each surge. If performing a total of more than 8 surges, surge 10 rpm higher than baseline until 8 surges remain. Then surge to 15 rpm higher than baseline until 3 surges remain, at which time go almost all out each surge.
- Heart rate 90% of maximum, or more, at the end.

Climbing with "Sprint" Surges

Works climbing muscles, cardiovascular system, lactate tolerance and clearance.

- Stand or alternate standing and sitting (every minute or every other minute) for 10 to 15 minutes.
- Moderately hard gear.
- Baseline rpm 50 to 60.
- Begin surges anywhere from the top of the 3rd minute. Surge for 15 seconds to at least 120 rpm. You may stop pedaling for up to 15 seconds after each sprint. Then back to baseline rpm, and surge again at the top of the next minute.
- Heart rate 90% of maximum, or more, at the end.

Transition/Build into Intervals

Works climbing muscles, lactate tolerance, maximum oxygen uptake.

- Stand, sit, or alternate.
- Hard gear
- *3-minute transitions.* Start at 55 rpm. Increase rpm by 5 every 3 minutes. Total duration of repetition 9 minutes. Perform 2 to 4 reps. May stand, sit, or alternate.
- *2-minute transitions.* Start at 55 rpm. Increase rpm by 5 every 2 minutes. Total duration of repetition 6 minutes Perform 3 to 4 reps.
- Heart rate 90% of maximum, or more, at the end of the 6- or 9-minute interval.

Climbing Intervals

These are the toughest workouts. However, the rewards are great.

Works climbing muscles, lactate tolerance, maximum oxygen uptake.

- Stand, sit, or alternate.
- Moderate gear.
- If standing, start at least at 60 rpm and end at least at 70 rpm. If

seated, start at least at 75 rpm and end at least at 85 rpm.

- *3- to 4-minute intervals.* Standing or seated. Heart rate 90% of maximum, or more, at the end of the interval.
- *Pyramid intervals.* 1-2-3-4-4-3-2-1–minute intervals (a total of 8 intervals). Rest intervals of 2-3-4-4-4-4-3 minutes. For the 3rd to the last interval, heart rate 90% of maximum, or more, at the end of the interval.

Climbing Sprints

These are tough workouts. Again, the rewards are great.

- Works climbing muscles, lactate tolerance.
- Stand, sit, or alternate.
- Hard gear.
- Pedal slowly, perhaps at only 30 rpm.
- Sprint as hard as you can, to 140 or more rpm, for 15 to 30 seconds. Rest 2 to 5 minutes. Repeat up to 8 times.
- The effort is too short for heart rate to accurately reflect your work intensity, so do not look to your monitor to gauge training effectiveness.

Climbing ILTs

Works climbing muscles. High rpm ILT preferentially works hip flexors and neuromuscular system.

- Sit. Unclip one leg from your pedal, as described above in the detailed 2-hour climbing workout.
- Hard gear. 50 to 60 rpm. 3 to 4 minutes each leg. Works "pushing muscles."
- Easiest gear. 80 to 85 rpm. 3 to 4 minutes each leg. Works "pulling muscles." These are good when you want to add workout time, but your push climbing muscles are tired.
- Heart rate is not usually relevant—the muscles, not the cardiovascular system, are being trained.

Summary

A big part of enjoying climbing is mastering the fitnesses required. A wide variety of climbing workouts, and lots of them, will ensure your climbing success.

Dealing With High Altitude

Traveling to over 4,000 feet and planning athletic activity? Moderate or high altitudes will affect your performance.

Traveling to over 8,000 feet? Mountain sickness may be a problem.

Altitude—What We're Talking About

From the athletes' point of view, it means less oxygen. As one ascends, there is less barometric pressure and as a result, less oxygen is absorbed into the blood.

At sea level, the average barometric pressure is 760 millimeters of mercury. At 10,000 feet, the barometer reads 510. The percentage of oxygen in the air, about 21%, does not change—but the density of air, and hence oxygen, does. At 10,000 feet, only two-thirds of sea-level oxygen is present.

Altitude Side Effects

Mountain Sickness

Many who travel rapidly to high altitude experience side effects. Most people adapt to high altitude more quickly when they have traveled to high altitude frequently in the past.

The side effects, however, are not predictable. Some individuals may have problems on some occasions and not on others. Problems do occur in proportion to the change in altitude. Those living at sea level have more problems when traveling to 8,000 feet than those living at 3,000 feet. Changes in altitude less than 4,000 feet do not present much difficulty.

Those who travel to 8,000 feet and above may experience headache, drowsiness, mental fatigue, dizziness, nausea, vomiting, insomnia, dimness of vision (especially color vision), and euphoria. Judgment and memory are ordinarily normal to 9,000 feet. At 11,000 feet, reaction times, handwriting, and psychological test scores may be 20% below normal. Pulmonary edema, convulsions, and coma can occur above 23,000 feet.

Dryness, Dehydration

The air at altitude is usually very dry. Extra fluids may be lost because of increased breathing. Since fluid losses are greater, it is easy to get dehydrated. Skin chaps easily. *Be sure to drink plenty of fluids. Use moisturizer.*

Sunburn

Sun intensity at high altitude is higher. Protect your skin and lips with sunscreen, and reapply as needed.

Headache

Headache may be related to mountain sickness, described above, or to the increase in brightness that occurs at high altitude. Most sunglasses filter most, if not all, ultraviolet rays. *Wear sunglasses.*

Decreased Performance

Reduced aerobic capacity results in reduced power output for athletes. Anticipate reduced aerobic performance and pace to help optimize results.

Reduced Appetite

High altitude often suppresses appetite. If planning to participate in an endurance aerobic event, it is important to maintain good carbohydrate (glycogen) energy stores. *Ensure adequate caloric intake.*

Acclimation

The body adapts to altitude—a process called acclimation.

Short-term acclimation is usually complete by two weeks. Many athletes have a bad day between the second and fifth days at high altitude.

If one ascends beyond 6,000 feet at the rate of less than 1,000 feet per day, side effects can often be avoided.

The medication acetazolamide (Diamox) may help prevent or treat mountain sickness. This medicine is a diuretic and affects acid-base balance. It may worsen athletic performance.

Other illnesses, such as colds or flu, may make mountain sickness symptoms worse.

Some heart and lung problems are worse at altitude. Check with your doctor if you are concerned.

Diet

The following dietary suggestions reduce mountain sickness and help acclimation:

- Increase fluid intake
- Add a little more salt to your diet than usual. This helps hydration
- Avoid alcohol—it worsens mountain sickness
- Frequent small meals, rather than few large ones, may be helpful
- Emphasize carbohydrates

Other Methods of Managing Mountain Sickness

- Descend
- Supplemental oxygen
- Medications

Warning!

Consider expert care if you experience the following:

- Symptoms worsen rather than improve
- Hacking cough
- Trouble waking
- Confusion
- Hallucinations
- Visual problems

Timing Your Arrival at Altitude

Altitude acclimation is helpful for athletes who wish to train or race at altitude.

If you are traveling to an important event and have the time, arrive three weeks early. You can train at an easy pace for the first few days, be over the worst altitude effects by one week, train hard the second, and taper slightly the third.

As stated above, riders often have a bad day between the second and fifth days at altitude. As this bad day is unpredictable, there can be no blanket arrival-at-altitude advice statement for everyone.

Most riders find that every day spent at altitude before an event is helpful; others have set altitude records by arriving only hours before competing.

Some events take place over a range of altitudes. If you have not had the time to acclimate, it may be better to rest and sleep at lower elevations.

A Primer on Altitude Physiology

Resting Heart Rate Changes at Altitude

During travel to altitude, there is a rise in resting heart rate for a week or two, although there may be a short small dip in the middle of the first week. A fall in resting heart rate back to baseline is a measure of acclimation.

Threshold and Maximum Heart Rates

Threshold and maximum heart rate are reduced about 1 beat for every 1,000 feet of elevation for athletes who have trained at sea level. For a given submaximal power output, heart rate is higher.

You cannot maintain the same power output at altitude as you can at sea level. So plan to pace yourself and go slower at altitude.

VO_2 Maximum at Altitude

At 5,000 feet, VO_2 max, or the body's maximum ability to use oxygen, is reduced by about 5%. At 6,500 feet, it is reduced by about 8%.

At Monitor Pass, California, the reduction is about 12%. At nearby Ebbetts, about 15%. Thinking about training in Colorado at Pike's Peak or competing at Mt. Evans? There will be a reduction of about 25% in your VO_2 max.

The reduced amount of oxygen means that less work can be performed. Cycling time trial records are often accomplished at altitude because the reduced ability to work is more than compensated for by reduced air resistance. Athletes in sports with less aerodynamic benefit, such as running, do worse in aerobic events at altitude.

Even when adapted, you cannot sustain the same levels of aerobic work as you can at sea level. For a given workload, your heart rate may be higher. Since you cannot work as hard at altitude, your threshold working heart rate may be lower. For a given speed on the level, your heart rate may be lower.

Acid-Base Balance at Altitude

At altitude, the acid-base balance in the body changes. This occurs because carbon dioxide levels in the blood fall as a result of faster breathing. This changes the blood pH toward alkaline and then results in loss of bicarbonate from the kidneys.

Due to the loss of bicarbonate, the body is less able to buffer lactic acid. However, other mechanisms more than compensate and result, in fact, in decreased lactate levels as described below.

Acclimation—How the Body Adjusts

Adaptations to altitude are long-term and short-term. Long-term adaptations and physiologic changes of altitude living can take months or years. The body adapts to altitude in several ways. Here is how:

Increased Breathing

After first ascending, breathing may increase as much as 65%. This initial effect is limited. Increased breathing blows off carbon dioxide and increases blood pH, which, in turn, inhibits breathing.

This inhibition fades with time, but later, rates may increase again, up to 500% of normal.

Increased Diffusing Capacity of the Lungs

The lungs exchange gases, taking in oxygen and giving up carbon dioxide. The normal volume of gases exchanged, per minute, increases at altitude.

This may be due to either (1) increased pulmonary capillary volume caused by expanded capillaries and increased surface area, or (2) increased lung volume.

Increased Hemoglobin in the Blood

Hemoglobin, the blood protein that carries oxygen, may increase from 15 to 22 grams per 100 milliliter of blood. The hematocrit, the percentage of red blood cells in the blood, may increase from 40–45 to 60–65. This degree of change occurs only in some people at extremely high altitudes. How much extra hemoglobin is made depends on how high one ascends and how long one is exposed to reduced oxygen levels. Generally, increases are more modest. Hemoglobin/hematocrit usually increases about 4% for every 1,000 meters (3,000 feet) of elevation above sea level. The volume of blood is reported to increase in some studies, to decrease in others.

The net effect is this: Studies show that the total circulating hemoglobin may increase, in extreme circumstances, from 50% to 90%. Increases in the 10% to 20% range are more common in athletes who live or train at altitude.

The increase results from the naturally produced hormone erythropoietin (EPO). Studies show that EPO levels begin to rise significantly in two hours, and evidence suggests that exposure to an elevation of 8,000 feet for six hours daily will raise hemoglobin levels approximately 10% after two to three weeks. Further increases may occur with more prolonged exposure to higher altitudes.

Increased Vascularity of Tissues

The body responds to reduced oxygen by making more blood vessels. Studies have shown that the smallest blood vessels, capillaries, become more concentrated in muscle. This adaptation may take months to years.

Increased Ability of Cells to Use Oxygen

Myoglobin, the muscle protein that transports oxygen, increases about 15%. There are increased mitochondria—the energy factories of cells. Some studies have shown an increase in 2, 3 DPG, a chemical that helps release oxygen to the tissues. Oxidative enzymes are increased.

Decreased Lactate Levels with Exertion

Studies show that exposure to high altitude results in decreased lactate levels for a given workload. This could be due to increased levels of myoglobin and hemoglobin, both of which buffer acids, or an increase in certain enzymatic pathways. Altitude exposure decreases bicarbonate—this works against improved buffering.

Ethics and Synthetic EPO

Erythropoietin (EPO) is a hormone released by the kidney that stimulates the bone marrow to make red blood cells. This hormone has been produced synthetically since the early 1990s. There is good reason to believe that this substance can help human performance. However, artificially increasing the numbers of red blood cells may result in thick blood that clots. This has been reported to be responsible for athletes' deaths.

Altitude has a similar effect but may produce some protection that guards against this, and the body has regulatory mechanisms governing the quantities of EPO produced. Athletes may take synthetically produced EPO in quantities higher than those produced in response to altitude.

One hears about EPO causing death in athletes; one does not hear about this problem in residents of Mammoth, California; Park City, Utah; or other high-altitude cities.

There is another problem: EPO is a banned substance.

Altitude Exposure Can Help Sea-Level Performance

Increased hemoglobin results in increased aerobic capacity. This improves the aerobic fitness of the athlete. The increased vascularity of tissues and the increased ability of the cells to use oxygen could also help athletes, but these effects take months to develop.

The improved performance of runners following high altitude exposure, especially when coupled with brief visits to lower altitudes for high-intensity work, is documented in many scientific studies.

The mechanical aspect of cycling—gears—results in considerations unique to that sport. Cycling balances aerobic and muscular fitness. Faster cadences at a given power output require more aerobic metabolism than slower cadences. Slower cadences at a given power output require more muscle fiber recruitment.

The increased aerobic capacity present after altitude exposure of several weeks means that the balance of gear selection allows a shift to higher rpm. This improves the response to the changing accelerations that characterize cycling events.

Altitude Exposure Can Hurt Sea-Level Performance

The ability to perform high-level work is reduced at high altitude and may lead to detraining: a loss of muscle mass, a loss of anaerobic power, and a loss of threshold ability. As stated above, altitude may decrease the body's ability to buffer lactic acid because of the loss of bicarbonate. Mountain sickness may lessen the athlete's ability to train.

Many elite athlete teams travel to high-altitude camps. Although such camps can be good for training, living in close quarters increases contagious illnesses such as the common cold and stomach flu. Many athletes are plagued by boredom or homesickness. Coupled with the stress of traveling and performing, high-altitude camps are not good for all athletes.

Summary

- Acclimation to high altitude is helpful for high-altitude performance
- Repeated short exposures, or arriving several weeks before events, can help
- Timing optimal arrival at high altitude up to two weeks before an event is often guesswork
- Use sunscreen, and reapply as needed
- Use moisturizer
- Wear sunglasses
- Anticipate reduced aerobic performance and pace to help optimize results
- Increase fluid intake
- Add a little more salt to your diet than usual
- Avoid alcohol
- Ensure adequate caloric intake
- Emphasize carbohydrates
- Frequent small meals, rather than few large ones, may be helpful
- When warning signs of more than mild mountain sickness develop, get expert medical care and
    - Descend
    - Use supplemental oxygen
    - Use medications

Part 3: Mind Matters

Pacing

Pacing requires self-knowledge and self-control.

Pacing may be required when what will limit your performance later does not limit you now.

Pacing means going more slowly at the beginning so that you can go faster at the end. Pacing also means going more slowly at the beginning so that you can reach the end.

Years ago, runners used to run the mile by starting out almost as fast as they could go. They invariably pooped out at the end. Roger Bannister broke the four-minute barrier for the mile back in the 1950’s by planning to run each quarter mile in just under one minute. That planning allowed him to become one of the most famous athletes of all time.

Why Pace?

Because You’ll Finish Faster

Figuring out at what pace you should ride is crucial to great performance in events where the aim is to cover a set distance in the shortest time. This is an essential strategy in track and road time trial events. It is also very important in cross-country mountain biking. In mass-start cycling events where drafting and tactics play important roles, pacing is a less important component of racing success—but even here, it often makes or breaks a race.

Pacing commonly improves finishing times in such events by 1% to 3%. Very fast starts may worsen finishing times even more.

At many levels of competition, there are often very small differences between winning and losing. At the highest levels—the Olympic Games or World Championships—the margin between the glory of a top-three medal and anonymity is often less than 1%.

The difference between going out too hard and pacing yourself well can cost 10 seconds in a 3–K track event, a minute in 10-mile road time trial, and several minutes in a pro cross-country mountain bike race. In mass start events, a lack of pacing can drop a rider who otherwise might win!

Because You’ll Finish!

In all-day century and ultra-distance events, pacing can play an even greater role. Finishing such events may not even be possible for some participants without pacing!

Sooner or Later We All Slow Down

Whether you plan on pacing or not, sooner or later, we all slow down. The question is, is it planned? What strategy provides the best chance of finishing? What strategy provides the best finishing time? In a group, or mass start event, what strategy gives the best place finish?

Why Pacing Works

Pacing works because you ration resources that will be needed later, now. Common resources are fuel (usually glycogen), fluids, and heat regulation.

A simplistic explanation of the pacing principle may be the following:

- Go out too slowly and you never have the time to catch up.
- Go out too fast and you run out of energy.
- Go out too fast and your lactic acid levels zoom up too quickly.

  It is easier to tolerate high lactic acid levels for short periods rather than longer ones.

  If high lactic acid levels must be endured, it is easier to tolerate them at the end rather than at the beginning of a race.

Psychologically, the natural tendency of many athletes is to get excited at big competitions and go out too hard. By consciously backing off just a little this risk is reduced. Build to a crescendo rather than start with a bang and fizzle.

There are other benefits to pacing. For example, in a longer event, starting out more slowly will allow you to drink and eat more easily, and so have more energy for the end of the ride.

Why We Slow Down

There are a number of physiological reasons why we slow down: The main reason is that we run out of fuel energy. Dehydration, overheating, and muscle and neurohormonal fatigue can also contribute.

Dehydration

Consider dehydration in ultra-endurance cyclists as an example why pacing is required:

Suppose an athlete can work reasonably well until 3% dehydrated. Suppose at 6% dehydration health is threatened. Suppose an athlete weighs 140 pounds. Suppose it is a hot and humid day. Suppose working hard, an athlete loses 2.5 quarts (5 pounds) of fluids per hour. Suppose working moderately an athlete loses 1 quart per hour. Suppose the maximum rate of fluid intake is 1.5 quarts per hour. After two hours of hard work, the athlete will be performance impaired. After four hours, general health will be threatened.

The only options are to slow down early (pace) or stop when fatigued or exhausted. Pacing results in a higher overall speed.

Fuel Energy

Efforts up to about 10 seconds can be performed “all-out.” Pacing allows efforts of all other lengths to apportion higher-energy producing fuels over longer periods. Pacing results in overall total work and better overall times.

Fuel energy exists in several forms:

Anaerobic energy fuel sources include ATP, which supplies energy for just a few seconds, and CP—creatine phosphate, which helps supply energy for up to 30 seconds.

Aerobic energy fuel sources include carbohydrates and fats.

Glycogen, a form of carbohydrate stored in muscle, allows prolonged work at relatively high energy levels, associated with high heart rates. We are able to store a maximum of only about 2,000 calories of glycogen. After that stored glycogen runs out, we are basically burning stored fat.

That may sound great to those trying to lose weight, but it means that you cannot ride hard and that you generally feel terrible. Regardless of how hard you ride, you will burn about the same amount of fat. At higher intensities, you burn carbohydrates as well.

Running out of glycogen means we operate at less than 60% of maximum heart rate. That is what happens to ultra-distance cyclists after their first 24 hours of competition.

A 25-mile time trial, performed at 92^{+}% of maximum heart rate, may exhaust almost all of our glycogen. A two-hour mountain bike race certainly will. It is simply not possible to continue at a pace of 90% of maximum heart rate for more than about two hours—one runs out of glycogen.

Glycogen is also stored in the liver. Liver glycogen helps keep the blood sugar level up, which can help spare the glycogen in the muscles. When the muscle glycogen is gone, blood sugar can be converted to useful energy, but not as efficiently.

By maintaining blood sugar with the ingestion of fuels—sugary drinks or carbohydrate solids—we can spare our stored glycogen and ride strongly longer. Consuming calories while riding will allow you to ride comfortably for many more hours than is otherwise possible.

Temperature Regulation

On hot and humid days, athletes may need to reduce workload in order to keep from overheating.

Overheating not only reduces power output, it can risk heat cramps, heat exhaustion, and heat stroke.

Overweight athletes are more subject to overheating.

Athletes occasionally pace up long climbs in order to keep their clothes dry and so prevent wind-chill from contributing to hypothermia on subsequent descents.

Neuromuscular (Skill) Control

Racing all-out to the top of a climb is frequently a poor tactic for mountain bike racers. Exhaustion at the top of climbs contributes to loss of neuromuscular control and overbraking on descents—resulting in slower overall times.

Heart Rate on Long Rides

Consider a racer with a maximum heart rate of 200 beats per minute, who performs the following events by himself, without the benefit of slipstreaming or drafting a group of riders.

25-mile time trial: It takes 60 minutes. The athlete can maintain 25 miles an hour, with a heart rate of 185 beats-per-minute or about 92% of his maximum.

100 miles: It takes 4.5 hours. The athlete can maintain 22 miles an hour. The heart rate is 160 bpm, or about 80% of maximum.

200 miles: It takes 10 hours. The athlete can maintain 20 miles an hour. The heart rate is 140 or about 70% of maximum.

2500 miles: It takes eight days. The athlete can maintain 13 miles an hour. The heart rate is 120 or about 60% of max.

As a beginning racer, your times will be slower, but your percentage of maximum heart rate will be similar.

Pacing Exceptions

Drafting

Cycling is different from running in the sense that drafting, or riding in another's slipstream, is much more important. Since you can use more than 20% less energy riding behind another rider, or group of riders, a fast-paced group provides enormous benefit in overall time.

It is possible to draft within a group at a heart rate 30 or more beats per minute below what would be required to ride alone at the same speed. Therefore, it might be worth it to exert yourself a little bit more than your pacing strategy allows to reap the enormous benefits of group travel.

It might be worth working harder than planned over the top of that hill, to be able to stay with the group down the hill and along the flats

Other Strategies and Tactics

Sprints or finishing kicks, hill-climbing ability, and other tactical considerations often affect race strategy in mass start events as much as pacing.

Prove the Value of Pacing

It is easy to prove the importance of pacing, on your own, with a simple test:

Perform the test on a stationary trainer, in a hard gear, riding with one leg, using a cadence computer.

Let us assume that you find the perfect gear for which 55 rpm is the most rpm you can maintain at a steady cadence for 4 minutes. After several weeks, try this experiment: Ride a cadence of 53 for the first 2 minutes, and then try to ride 57 rpm for the last 2 minutes. At your next workout session, try riding at a cadence of 57 for the first 2 minutes, and 53 for the last 2 minutes.

Which way was harder? The vast majority of riders find the slow-start strategy much easier.

Events to 15 Minutes: 51/49 Principle

In its most basic, simplistic form, pacing usually means even effort throughout the event.

Reports from many coaches and studies confirm that in events of up to 15 minutes, going at about 98% race pace the first half and 102% race pace the second half is the best strategy. That is, the first half takes about 51% of elapsed time, the second half 49%.

Longer Rides: Even Pacing

The longer the ride, the closer the overall half splits are to 50/50.

A 40K championship TT might have nearly even splits. If the 40K were to be divided into 4-kilometer tenths, however, the first tenth might be at 49% race pace, and the last tenth at 51%. This means that most of the race might be paced at 6 minutes per 4-kilometers. The first 4K might be paced 5 to 10 seconds slower, the last 4K that much faster.

Century⁺ Pacing

You can quickly exhaust your glycogen stores by starting out quickly on a century. Why care?

Because you might not finish. Or you will finish with a slower time than you could otherwise achieve.

Riding speed does not increase proportionally to energy output. Since air resistance increases at more than the square of energy output, you will get a faster overall speed by pacing.

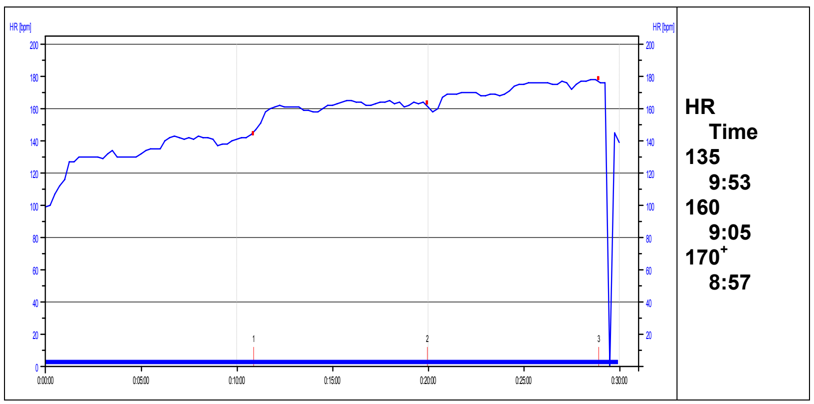

Figure 25. Heart rate vs. time. Pacing trial showing that for considerable change in heart rate (and perceived exertion) time gains are marginal. The athlete rides three 4-mile repeats at heart rates of 135, 160, and 170⁺ bpm. The time difference between repeats performed at 160 bpm and 170⁺ bpm is 8 seconds in 9 minutes.

Consider this simple example: Riding a fast downhill. You might marginally increase your speed by pedaling furiously in a big gear—but the speed improvement is slight. You would probably do much better coasting and resting.

Working at 75% of your maximum heart rate? You will spread out your glycogen stores for many hours. Work at 90% and you might go a few miles an hour faster. However, when you are out of glycogen, the difference between speed at 60% and 75% of maximum is a lot more than a few miles per hour!

Death Ride Pacing Example

The faster the time, the higher the maximum percentage of heart rate that can be held for the event. For most riders, with Death Ride finishing times more than 10 hours, average heart rates will not exceed 70% of maximum, and heart rates on climbs will not exceed 75% of maximum.

Figure 26 shows the heart rate and cadence recording of Dave Roth, a top 5 finisher in 2004—finishing time: 8 hours, 3 minutes.

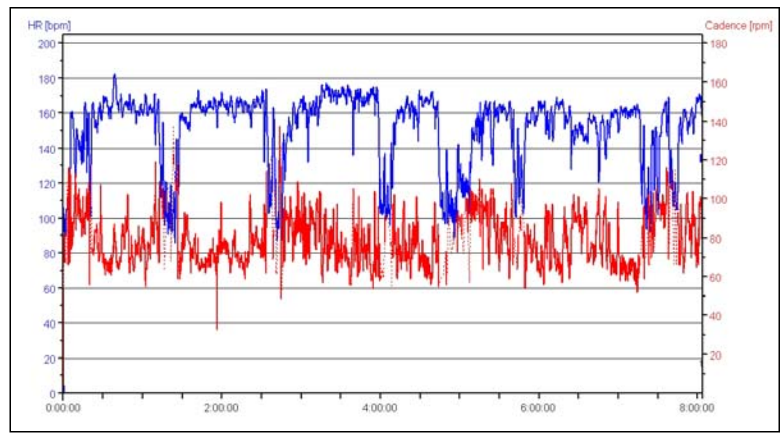

Figure 26. Heart rate (blue) and cadence (red) recording from Dave Roth, Death Ride 2004. Top 5. Finishing time 8:03.

Dave's maximum heart rate is about 205. He averages about 160 beats per minute on the climbs, or 78% of maximum heart rate. For the entire ride, he averages 151 beats per minute, or 73% of maximum.

Remember, Dave is a top-5 finisher. If you are not as fit or fast as he is, limit yourself to 75% of maximum heart rate on Death Ride climbs.

Notice how Dave puts a lot into the third climb, the front side of Ebbetts, riding at about 170 beats per minute. Although perhaps tactically required for a front-of-the-pack racer, it hurts. His average heart rate on the fourth and fifth passes—the back side of Ebbetts and on Carson—is lower. This means Dave has worked above pace in the middle of the event, and his power climbing Carson is dropping. Again, tactically this may be correct for a front-of-the-pack racer. For anyone else, it is a mistake: Your time will be slower and you will suffer more.

12 Hour Event Pacing Example

As stated above, the vast majority of riders will maintain an average heart rate of no more 70% of maximum.

Reproduced below is the heart-rate, cadence, and speed recording of Jim Dover, the winning solo rider from 12-Hours @ The Summit, an endurance mountain bike race at Big Bear.

Lap times, heart rate averages, maximums, and minimums are given in Table 6.

This athlete has a maximum heart rate of about 200 beats per minute. He was advised not to exceed a heart rate of 150 beats per minute during the event, or 75% of maximum. Although athletes will average no more than 70% of maximum heart rate, some of the time they will be coasting downhill or will be taking short breaks off the bike. Jim did exceed these values on occasion, especially in the first half of the race.

Jim's average heart rate for the event was 137 beats per minute, or 68% of his maximum heart rate.

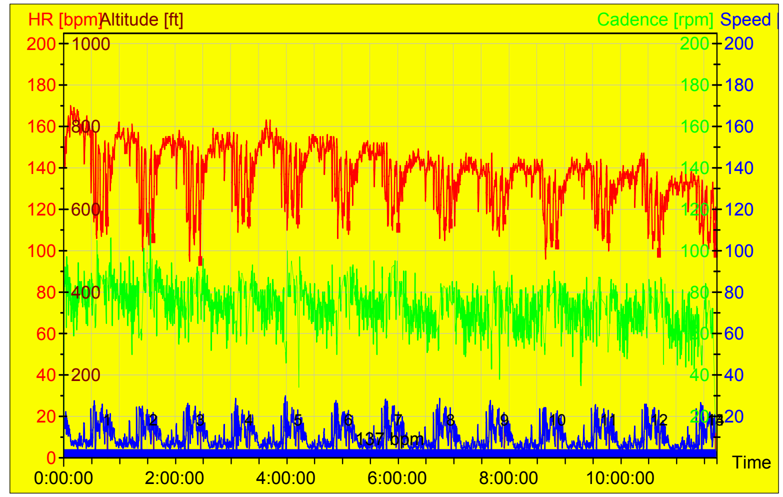

Figure 27. Heart-rate (red), cadence (green), and speed (blue) recording from a 12-hour mountain bike race. Jim Dover, Big Bear, August 2, 2003.

Lap	Lap Time	Ave HR	Max HR	Min HR
1	46.75	149	170	106
2	49.89	142	162	100
3	50.56	141	158	95
4	52.67	142	159	96
5	52.90	144	163	110
6	54.32	142	156	106
7	53.84	139	153	110
8	56.31	135	149	105
9	57.66	133	147	107
10	57.22	131	145	96
11	55.39	131	147	100
12	54.28	130	147	101
13	60.32	125	138	100
Overall		137		

Table 6. Lap times, heart rates, and minutes per mile in a 12-hour mountain bike race. Jim Dover, Big Bear, August 2, 2003.

Although Jim won the event, he might have done a little better by going just a little easier for the first few laps. His early lap times would have been a little slower; his late lap times perhaps much better.

If Jim is one of the world's best at this, doesn't it make sense that you too should keep your heart rate below 75% of maximum heart rate?

Pacing Not Everything

Pacing is a very important strategy. In time trials and mountain bike racing, it is crucial. Several of the pro mountain bikers I coach have had their best races after learning patience and pacing. Even in mass start events, it can be very valuable.

On the other hand, it is not everything. At a recent road race in Arizona, I and three other teammates in four separate races broke away solo from our respective fields with 10 to 90 miles left. Our fields could have caught us had they been organized. Mass start racing is much more than pacing: It is feints, it is who has the best sprint, it is who wants not to work thinking someone else will, it is who wants to help someone, and it is who can't stand a rival being off the front.

Sometimes, "No guts, no glory." Three out of the four of us stayed away and won our races.

What You Need to Pace

- Self-knowledge. You need to know your limits. Based on past performance, you need to know how hard you can go.
- Self-control. You must not let others dictate your pace.
- Correct equipment. For example, you need the right gears. If you have a straight block 12-21 cogset and want to climb a 10% grade at 70 rpm and at less than 75% of maximum heart rate, you may need easier gears. You may need a heart-rate monitor.
- Warm-up. The shorter and more intense the event, the more important it is to warm up. For more information, read the ABC handout Warm-Ups. In many events, to achieve target pace your overall effort level will be too low if you do not warm-up properly.
- Nutrition. Food and fluids will help you maintain target pace.

The Bottom Line

Learning to pace is a hard lesson for many riders to learn. It is so very tempting to take off from the start at too fast a pace—there is all the excitement and enthusiasm, and you certainly do not want to look like the slowest person there!

However, if you start at a reasonable pace, at the halfway point or later you will be passing many people who thought they left you in the dust at the beginning.

Focus & Breathing

Focus has intensity, width, direction, and relevance.

Athletes can learn to intensify, narrow, internalize, and associate their focus and thereby improve their performance.

Learning focused, coordinated breathing is one of the best tools to achieve this gain.

Focus

Focus, or attention, may be *strong* or *weak*, *external* or *internal*; *narrow* or *wide*; *associated* or *dissociated*.

External focus is attention directed outside the body. Internal focus is attention directed inward.

Narrow focus is restricted; wide focus, like peripheral vision, takes in a large field of view.

Beginners frequently *dissociate*—separate what they are thinking about from what they are doing. For example, beginners may think about favorite restaurants while racing.

Elite athletes *associate*. They invariably try to keep from dissociating.

The harder the effort, the more important it is to be able to keep a strong, narrow, internal, associated focus.

Studies show that elite time trialists do precisely this: they keep a strong, narrow, internal, and associated focus—they concentrate within—not on the flowers on the hillside, upcoming television shows, or the conflict in the Middle East.

Although studies show that elite athletes are more focused than beginners are, it is something elite athletes learn. If beginners learn focus techniques, they benefit as well.

Shifting Focus

In many events, it is important to be able to shift focus. For example in a road race, it is important to have a wide, external focus in order to see competitors up the road or falling behind, and then have a narrow, internal focus in order to work harder to make the break or leave others further behind.

Riding recreationally along the roadway, it is important to shift focus: To narrowly pay attention to potholes just a few feet ahead as well as to widely notice, for example, the flow of traffic, stop signs, pedestrians, opening car doors, animals, and other riders.

Riders who disassociate while riding, thinking about their jobs or family arguments may be more likely to have accidents.

The ability to shift and hold focus is a critical element that separates champion athletes from beginners.

Although as efforts increase in intensity elite athletes increase the intensity of their focus, shift their focus inward, and associate—they also maintain flexibility in width and direction.

For example, in track pursuit (an effort of several minutes' duration), in addition to focusing on their effort, athletes must have an external focus on their line—they must make sure that they don't drift upward on the track, traveling farther.

Rhythmic Effort

Got rhythm? Watch video footage and listen to commentary of time trialists or climbers narrated by the well-known voice of cycling, Phil Liggett, and you will hear about riders "getting into a good rhythm" or "not in their rhythm."

Steady-state hard effort demands a good rhythm. Such a rhythm is part of all aerobic endurance sports such as swimming, running, rowing, marching.

Humming or singing a song is one way to keep rhythm—hence soldiers' marching songs. Counting pedal strokes is another.

Music

Music is used in many aerobics and spin classes—and this may be its best use.

Many riders use music during their stationary trainer workouts.

Music is most suitable for moderately-high level, rhythmic, aerobic work. It helps athletes increase arousal and focus on their work.

Sophisticated set-ups allow music to be played at variable rates—allowing instructors to coordinate the music's beat with the exercise rhythm.

However, music may not always coordinate with the best cadence for any given rider, and is generally not suitable for the highest intensity work that requires an internal focus.

Listening to music while riding on the road or trail is not safe. Racers also need to train without music so that they can learn self-monitoring and pacing for racing.

Focus & Breathing

Focus on effort and the self-monitoring of effort are characteristics of elite athletes.

Breathing is one of the cardinal self-monitoring focus tools.

Of course, you breathe whether you think about it or not: from as little as 10 times per minute at rest to more than 60 times per minute at maximal effort.

Breathing technique is important in hard, steady efforts. It is not important when you are noodling—riding slowly. It may not be applicable when you are constantly changing efforts, as in criteriums or when you are making a maximum effort, as in sprinting.

Breathing technique is also important when you want to keep to a pace, even if it is not at a high threshold. By breathing regularly, your pace will stay steady as well.

Focused breathing is also well known to help when you face a crisis—whether related to pace, a cramp, or a crash. It helps get you back on track. After all, think how many women in labor have been helped with the focused breathing techniques of Lamaze.

Focus & Breathing Helps Beginners

Although champion athletes have been the most closely studied, focus is just as important for beginners. It is very helpful for all riders when climbing long steady hills.

Almost all of riders will benefit from learning to breath and count even if it only helps them get to the top of the next hill before they know it.

Why Focused Breathing Works

Focusing on breathing helps us draw on our reserves and get closer to reaching our potential.

Consider an analogy: If you can normally perform about 20 push-ups, performing 10 is a piece of cake, and you do not need to focus on technique. However, if you are trying to do 21, it is a different story. You need focus. You need to count. You do not want outside distraction, people talking to you. If you focus, if you count each push-up, you can get closer to the limit of your potential.

Studies of elite athletes show that they focus on how their bodies are working, that they develop a sense of pace, and that they constantly seek to test their pace and efforts.

Beginners tend to focus more on the outside environment and factors not within their control. Focusing on breathing is a key to self-monitoring of effort and developing the ability to work to your maximum potential.

How Often Should You Breathe?

To some extent, you do not have much choice. It is not that one can say you should breathe this many times a minute and just do it. For any given effort, there will be a limited range of what is comfortable.

You can vary the frequency of your breathing by modifying the depth of your breathing.

Notice your breathing and co-ordinate it with the pedal stroke of your legs. This is the key to unlocking a good rhythm.

For many riders, working at about 75% of maximum heart rate, breathing frequency will be about 30 times per minute. For many riders, working at 85^+% of maximum heart rate (near VO_2 max), breathing frequency will be about 60 times per minute.

Cadence, or number of pedal strokes per minute, will vary with the type of riding.

Timing your breaths with pedal strokes will therefore vary depending upon how hard you are working and the type of riding you are performing.

For many riders, climbing at a cadence of 60 rpm, breath timing will be once every two pedal strokes at 75% of maximum heart rate, once every pedal stroke and a half at 80% of maximum heart rate, and once every stroke at 85^+% of maximum heart rate.

For many riders, at maximal road time-trial pace, breath timing will be once every stroke and a half. Since cadence will be about 85 rpm, this will translate into a breathing rate of about 55 times per minute at 90% of maximum heart rate.

Concentrate on Breathing Out

When you concentrate on breathing, concentrate on breathing out—exhaling, rather than breathing in—inhaling.

Use Your Mouth

At high-aerobic intensity, the nasal passages restrict airflow. Nasal dilators have not been shown to be effective.

Consider Purse Breathing

Slightly narrowing your lips when breathing may improve air exchange for some riders, yet not overly restrict airflow.

In many riders, the breathing passages may partially collapse or constrict.

The positive pressure exerted through the breathing passages may help keep them from collapsing and improve air exchange.

Learn to Belly Breathe

Breathing with your diaphragm and expanding your abdomen may increase lung capacity, improve relaxation, and use less energy.

It also uses different muscles than the standard chest breathing, and so may be helpful to help prevent you from tiring from prolonged respiratory muscle work.

Learn to belly breathe lying flat on your back with a book on your abdomen. As you breathe in, the book should rise.

Alternate Stroke Emphasis

If you are breathing once every pedal stroke and a half, you will naturally alternate emphasis on the left and right leg.

If you breathe once every stroke, your emphasis may be on one leg. Consider breathing once every stroke on your left leg for 10 strokes, then once every stroke on your right for 10 strokes, then your left, and so on.

By varying your emphasis, you make the exercise more interesting. Shifting your focus reduces boredom. It also prevents fatigue or stress on one side vs. the other.

Change Your Breathing

It is not as if you should always have the same rhythm. Consider the analogy of music. It may have a basic rhythm or beat. However, this need not stay constant for the whole composition. Sometimes it shifts to another rhythm, or a third, only to return to the original later.

It is the same thing with riding. Suppose you are climbing, breathing every stroke and a half. As you get near the summit, you can change your rhythm to every stroke as you pick up the pace to surge over the top.

Hyperventilation

Caution: Overbreathing can be a problem. Anxiety can cause hyperventilation; in some athletes, the reverse is true: overbreathing can increase anxiety.

The Work of Breathing

Focused, coordinated breathing does something else: It reduces the work of breathing.

At maximal work levels, the muscles of breathing can use up to 20% of the energy and oxygen you are producing and need. Energy you save by improving breathing economy can be used by your legs to get you down the road.

Exercises for Focused Breathing

Let us face it, not all of us were born with rhythm. Perfecting breathing technique takes practice.

Efforts on a stationary trainer can be precisely controlled. Stationary trainer workouts can provide an excellent place to start learning breathing techniques.

For example:

1. During a steady 75% to 80% of maximum heart rate effort at 90 rpm, focus on exhaling every two pedal strokes.
2. Pick up the pace about 10% and concentrate on breathing every stroke for about 15 seconds.
3. Back off to steady-state 75% to 80% of maximum heart rate effort again. Focus on exhaling every two pedal strokes again, this time counting strokes of the alternate leg.
4. Work at about 85% of maximum heart rate effort at 90 rpm and focus on an every-stroke-and-a-half rhythm. Breathe once every second.

The Arnie Waltz

Those of you with musical talent may have instantly understood the breathing-every-pedal-stroke-and-a-half concept—that results in alternate stroke emphasis and a breathing rate of about 55 times per minute when time trialing.

Think of it perhaps as a waltz—you know, the ONE-two-three, ONE-two-three, ONE-two-three, ONE-two-three rhythm.

Each time you pedal, with the left or the right leg, count. Each time you have a count of ONE, breathe out.

It is easy—now you are doing the Arnie Waltz!

Picking Up the Pace

Want to go a little faster? Try focusing on your breathing, getting a rhythm. Then slightly increase your breathing rate. Let your cadence increase with your higher breathing rate. Watch your speed computer. You will go faster!

Summary

Athletes can learn to intensify, narrow, internalize, and associate their focus and thereby improve their performance.

Like fitness training, breath training requires practice.

With practice, breathing techniques will become second nature, automatically improving focus, training, and race performance.

Motivation

Although riders may wish it were different, you do not buy motivation at the store and take a pill of it in the morning.

By understanding what makes you tick and why you are doing what you are doing, you may improve your performance.

George Mallory, when asked why he wanted to climb Mt. Everest, replied: “Because it’s there.” If you can do a little better than that, you may be able to persevere when, for example, on the fourth pass of *The Tour of the California Alps—Markleeville Death Ride* you wonder why you should bother trying to do the fifth.

What We’re Talking About

Motivation is something that causes a person to act. It is the ability to focus on a goal and work toward that goal, regardless of physical ability. It is willpower.

Motivation has two important elements: direction and intensity. Direction is the choice of goal. Intensity is how energized the individual is toward that goal. Intensity, which is related to psychic energy, is influenced by emotion.

Motivations’ Origins

Motivations have *distant* or *recent* origins.

Some adult motivations derive from early childhood experiences— for example, trying to please or live up to a parent’s expectation or wanting to be fit to prove a childhood tease or bully wrong.

Other motivations derive from current events—for example, the sickness of a loved one, divorce, inheritance, or a new baby.

Though it is not always necessary, it can be helpful, to understand the origins of one’s motivations. It is usually important for athletes, especially competitive athletes, to have a clear picture of their goals.

Intrinsic and Extrinsic Motivation

Motivation of an individual may come from within (intrinsic) or from without (extrinsic).

People who are intrinsically motivated have an inner striving to be successful, to master their task, to reach their goal. Athletes who are intrinsically motivated participate because they love the sport, or, perhaps, because other goals are facilitated in so doing. Intrinsic rewards—such as feelings of accomplishment, mastery, or self-confidence—tend to be self-perpetuating and powerful.

Extrinsic motivation comes from other people through positive and negative reinforcement. *Positive reinforcers* increase the likelihood or frequency of positive behaviors; *negative reinforcers* decrease the likelihood of negative behaviors.

Positive reinforcers—the carrots—include praise, trophies, recognition, and money.

Negative reinforcers—the sticks—include ridicule, embarrassment, and punishment.

Most athletes are motivated by a combination of intrinsic and extrinsic rewards. The proportions may vary greatly.

Extrinsic rewards that are excessive or manipulating, and those that are not contingent upon accomplishment, tend to lose effectiveness. Extrinsic rewards can also increase or decrease intrinsic motivation. With time, many extrinsic rewards lose their value: Enough prizes, trophies, or money will eventually fail to motivate. When earned for accomplished behavior, extrinsic rewards can be extremely motivating. Extrinsic rewards that transform into intrinsic rewards tend to sustain motivation.

One of my favorite stories about excessive extrinsic rewards concerns a child, Jack Miller, who comes home from school with a “Child of the Week” award. His mother appears very proud and asks Jack why he appears nonplussed. Jack says, “Aw mom, this week it was the turn for the ‘M’s in the alphabet.”

Motivation Theories

Hierarchy of Needs

On the most basic of levels, we need to satisfy our hunger, thirst, sleep and sex drives. After that, we look to our safety and security needs.

Once our basic needs are satisfied, we seek to satisfy our social needs for belonging, love, self-esteem, self-worth, and self-respect. We also have needs for play, excitement, and avoiding boredom.

Older athletes may be motivated by the perceived retention of youth and health that exercise may impart.

Optimal Challenge/Frustration

An optimal challenge or frustration results in the greatest motivation. Too much challenge or frustration (a task too difficult) reduces motivation. Too little challenge or frustration (a task too easy) also reduces motivation.

Control

We have relatively little control over our genetic ability or talent, the demands of a given race, and luck. We have relatively more control over our own effort and preparation.

Many athletes correctly attribute their success to effort and preparation; they often incorrectly attribute their failure to factors over which they have little control.

Why We Ride

Our motivation to ride may come from reinforcers, needs, or challenges.

Most of us ride for one or more of the following reasons:

- "Fun," which involves stimulation, excitement, challenge, and creativity.
- Health and fitness.
- Social affiliation with others, belonging to and being accepted by a group. Altruism.
- Self-worth, confirmed by demonstrating competency.

These reasons all satisfy social needs. For some professional riders, it is more a question of economics: earning a living.

Fun

Stimulation must not be too much or too little. The skill difficulty must match ability. There must be challenge and some success. Realistic goals are needed. Control of the scheduling of activities and events, and not always having "to perform," keeps things fun.

Health and Fitness

Bicycle riding helps many improve and maintain their health and fitness.

Bicycling injuries are common. If you ride only for health and fitness, crashes may soon cause you to leave the sport.

Social Affiliation

An appropriate group is necessary. You need to be able to identify with your team and be accepted by teammates.

Your local club may help you feel part of a team.

Self-Worth

Self-worth, self-esteem, confidence, and achievement are closely tied. Goals appropriate to ability levels help maintain motivation. Competency, mastery, and success will be important.

Suppose you are a 32-year-old racer, beginning bicycle racing after a successful running career ended by injury. You are used to placing in 10K races.

However, bike racing is different. Different muscles are used, different skills are required, and different tactics are employed. You may have difficulty with self-worth if you start out racing against the Category 1, 2 Masters. Start racing senior Cat 4, 5, or Masters 3, 4, 5. Your feelings of self-worth are less likely to be affronted. As you become accomplished at your level, advance.

An epic like *The Tour of the California Alps—Markleeville Death Ride* can provide a great sense of achievement for almost everyone. Whether you do one pass or five, most of us deservedly feel like winners just for showing up.

Motivation Personalities

Coaches notice sport-personality types. Most of us are a composite of types; many of us change with time or coaching.

Success-Driven

Like a toddler that learns to walk to be like adults, or a child who wants to learn to ride a bicycle because her friends can, some competitors are motivated by other successful athletes.

Fear-of-Failure-Driven

These athletes perform as a response to negative feedback. They want to prevent a negative result from happening again. They are concerned about validating their personal worth. Some athletes who find success become motivated by fear of failure and worry about not winning again.

Fear-of-Success-Driven

Top-level athletes sometimes want to avoid the responsibility of celebrity status.

Perfectionist

This personality type may be psychologically related to fear of failure and concern about personal worth. Unrealistic expectations can be a problem with these athletes. They sometimes break down or burnout when things do not go exactly their way. Perfectionists find it hard to deal with setbacks.

Underachiever

These athletes do not reach their potential and can be frustrating for coaches.

Effective-Learner

These athletes are aware of what works. They work with the truth to get better. Their egos are out of the way. They typically ask: "What can I do to achieve the next step?" They understand the need to work and that time and setbacks are common, necessary roadblocks to be negotiated in order to achieve their goals. These are true students of sport, and most coaches love these athletes.

Problem Situations

What reduced motivation? How can you increase motivation?

Anticipate

Many athletes do not consider motivation issues until they have them.

Anticipate that problems with motivation are common. Consider any situations in the past when motivation issues arose and how you dealt with them then and over time.

Most importantly, plan, keep your goals in mind, and remember your past successes.

Getting Going

Century riders often become stuck when they see the final goal of riding 100 miles. Chunk it. Break down final goals into smaller bites. "A trip of a thousand miles begins with a single step." Make it easy to take the first step: take baby-steps.

Racers often feel or think: "What am I doing here?" Remember, this has happened before. Remember, events went okay before.

Discomfort

We often deal with uncomfortable situations, whether physical (for example, a saddle sore), or psychological (for example, asking others for sponsorship).

We do better when we discuss our discomforts with coaches or teammates. Others, who have been there before, can share tips or perhaps they know a simple solution.

For example, in the case of a saddle sore, a change in saddle or position, or an effective healing balm.

Setbacks

Whether, for example, an overuse injury or family emergency, motion toward a goal is sometimes slowed or comes to a standstill.

This loss of momentum can easily derail an individual.

The solution is to start again, perhaps with baby steps—no matter how small, and go through the motions of training again.

Poor Performance

The learning curve is upward, but leveling off or reduced performance often occurs. Anticipating plateaus or reduced performance helps prevent athletes from becoming frustrated.

Not Into a Workout

Sometimes one does not feel like training even though one is not injured, and one is properly recovered to do the job.

Allow yourself to warm-up slowly. Try to do one-third of efforts well, and see how things go.

Alternatively, do a couple of submaximal efforts. Arousal may increase. Then you may be motivated to work hard.

Performance Anxiety

This often occurs when an athlete is finally face-to-face with a race or target event.

Recalling past training success, bargaining to just start, or completing perhaps one-third of an event—to look at a smaller piece of the pie—often makes it easier to finish the whole thing.

Staying Motivating During an Event

Keeping focused and motivated midway through an event is a common difficulty. Fatigue, hunger, and pain all reduce motivation.

Sometimes riders search for and seize upon small excuses in order to drop out: Out of food, out of water, saddle sores, or need to urinate = a reason to stop.

Racers sometimes openly wish for a flat tire so they can DNF gracefully.

Racers who feel their chances are poor during the finish of a race may lose motivation to try for a placing.

Since losing confidence decreases motivation, realistic confidence-building work before events helps. Clarifying goals before the event begins is crucial.

Recalling similar past feelings and one's reactions at the time, breaking down the remaining distance into smaller chunks, and striving for incremental improvement are all strategies that help riders.

Deriving motivation from teammates can help. Sometimes you may realize during an event that it is not your day, but that you may be able to help your teammates do well.

Focus on breathing, pedal stroke, and the controllable sometimes helps.

Visualizing what you want to do, not what is hurting or holding you back may be helpful.

Summary: Get & Stay Motivated

- Understand your reinforcers and needs—why you ride, why you race.
- Set realistic, specific goals.
- Expect to be over-frustrated at first, or limit task difficulty.
- Get coaching or advice as a way to find the most efficient, direct, and intense reinforcers.
- Set up appropriate reinforcers.
- Work on the most controllable factors—preparation and effort.
- Get confident.
- Achieve your goals.