Progressive Power Training: The Secret to Increased Speed on the Bike
Put The Hurt On Your Riding Buddies
After Only Eight Weekly Workouts

By
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Cycling Coach
PROGRESSIVE POWER TRAINING: THE SECRET TO INCREASED SPEED ON THE BIKE

PUT THE HURT ON YOUR RIDING BUDDIES AFTER ONLY EIGHT WEEKLY WORKOUTS

Bill’s Southern Elite Youth Cycling Race Team

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Coach Bill Edwards is perhaps the most successful cycling coach you may have never heard of. Bill’s experience spans more than sixty years as both racer and coach. In retrospect it seems to me that Bill’s athleticism has been enhanced from his methodic engineer’s approach to training, much the same way Roger Bannister conceived, then ran the first 4-minute mile. In short order Bill’s methods proved effective and he won four masters national championships. With a wealth of firsthand knowledge gleaned from his years in the saddle, he honed his client training business after being mentored by cycling Hall of Fame coaches Mike Walden and Chris Carmichael, and later he founded the successful Texas Youth Cycling race team, Southern Elite. Never one to seek the limelight for the sake of self-promotion, Bill began developing a broad array of talent, both Youth and Masters Racers in his adopted home town of Houston, Texas. Working both on Houston’s Alkek velodrome, and directly at home, he developed his series of Progressive Power Training workouts.

Perhaps Bill’s most noteworthy client on the Southern Elite team is Al Whaley, a Masters multi-national champion. Under Coach Bill’s tutelage, Al logged an incredible 14 world masters championships in the sprint and kilo time trials. Al gives Coach Bill full credit for engineering the creative training program that took him to the top tier of masters cycling. Wanting to be the best coach I could possibly be, I sought his council. His own successful example of proving his methodology with personal cycling success spoke volumes. For several years Coach Bill had been refining that information for his training clients.

I traveled to Houston to spend a few days, hopefully picking the master’s brain. Unlike other coaches who carefully guard their perceived proprietary training, Bill was happy to share what he had found to be effective. My experience with Coach Bill’s Progressive Power Training proved profound. Several weeks later, using my own CompuTrainer, I recorded a best time ever for our standard testing protocol, a half-mile test. At age 62 that’s saying a lot. I’m grateful to coach Bill for opening my eyes to some simple, yet profoundly progressive training techniques. I’m certain many athletes will benefit from these workouts from this day forward with the introduction of this landmark book.

John Howard, July 2009

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None of this would have been possible without the awesome mentoring that I received from two of the greatest American coaches who ever lived: United States Cycling Hall of Famers Mike Walden and Chris Carmichael. They provided the solid foundation that has made it possible for me to suggest what might be needed to take cycling to the next level.

The very idea of even being able to suggest taking cycling to the next level came to me from the sport of swimming. Think about this: Swimming has managed to break records nearly every year for more than 50 years!! Indeed, Michael Phelps just broke SEVEN Swimming World Records in the same Olympic meet! How is that possible? It has to be through careful, proper, scientific preparation and great coaching. It simply has to be the proper understanding and application of the Principle of SPECIFICITY: “You need to be able to do in practice precisely what you expect to be able to do in the competition!”

During the past 50 years cycling in America has not been breaking records every year. Maybe every 5-10 years? I believe this is because cycling needs to take an example from other sports such as swimming and track and field. Cycling coaches need to learn how to think “outside the box!”

This book could not have been presented in its existing form without the extensive help of Andrea Ferdinand and her father Kevin in editing and formatting the book. Thanks to both of you. I also must acknowledge the patience of my wonderful wife Sarah. I could not have done this in between all of the trips to M.D. Anderson for Chemo, surgeries and numerous visits to the ER without her daily help. I love you, Sarah. The thoughts and prayers of my wife, my many friends and my family (David, John, Karen and Tom) have sustained me during my fight with cancer and during the writing of this book.
In a letter to the VeloNews editor (VN June 2, 2008, Page 16) a gentleman from Montreal, Canada interested in the science of power generation suggested the following:

“It would be very useful to learn from the pros how they train to increase their watts.” The VeloNews editor gave him the following answer: “As to how to improve your watts, that’s the million dollar question, isn’t it?”

This book is the answer to that million dollar question! Indeed, Progressive Power Training when properly implemented is capable of taking the sport of cycling to the next level of performance.

Cyclists of any ability and any discipline can significantly increase their speed on the bike using the concepts, the principles and the workouts described in this book. Progressive Power Training (PPT) applies equally well to recreational riding, century riding, hammering in groups, sprinting for the city signs, triathlon, time trialing, road racing, road sprinting, mountain biking, pursuit racing on the track, or match sprinting on the track. Moreover, PPT should apply equally well to professional cyclists and to amateur cyclists alike.

It is possible to achieve dramatic increases in one’s maximum sustainable power output and acceleration capability in less than eight weeks of following the PPT program. It also is possible with a little more effort to extend the time it takes before one’s legs “turn to rubber” during an all-out surge or sprint to catch up with and pass the riders in front of you.

As an example, one of my “recreational racing” clients was able to increase his maximum power output by thirty-nine percent with just five weekly PPT workouts. More importantly, he no longer was being dropped when the hammer went down because he was able have stronger surges, recover more quickly, and maintain a higher speed. The principles and workouts in this book also have been proven at the world class level of cycling when they were used by my all-time favorite client, fourteen time Masters World Champion and World Record holder Al Whaley.

An important point that is made in this book is that you don’t need to be a dedicated gym person or a body-builder to develop more power on the bike. Huge legs, in and of themselves, do not make a great rider. It is the generation of more power on the bike as measured in watts, and it is not the ability to lift more weight as measured in pounds that makes you faster. Think of World Champion Taylor Phinney or the Tour de France Schleck brothers (they all have thin legs, and they can generate incredible power). If you want to learn how to become a faster rider, read on.
CHAPTER 1

THE SECRET TO SUCCESS

THE ABC’S OF INCREASING SPEED ON THE BIKE

Increasing speed on the bike requires executing what I like to call the ABC’s: first, acquire the appropriate muscle fiber strength and recruitment; next build a huge aerobic engine into those newly developed muscle fibers; and finally, increase lactic acid tolerance in the recruited cycling / event-specific muscle fibers. Many books and articles have been published regarding B and C; this book covers the ABC’s with a special focus on A.

A. Develop appropriate muscle fiber strength
   - Increase the recruitment of cycling-specific / event-specific muscle fibers
   - Increase the size (diameter) of the recruited muscle fibers (increased muscle mass)
   - Increase the efficiency of the recruited fibers for applying torque to the pedals
   - Program the neuromuscular motor pathways to maximize pedaling smoothness
   - Increase the concentration of in-situ phosphocreatine (PC) in the recruited fibers
   - Increase the concentrations of the corresponding in-situ PC enzymes

B. Build a huge aerobic engine
   - Increase the capillary density in the recruited cycling / event-specific muscle fibers
   - Increase the mitochondrial density in the recruited muscle fibers
   - Increase the concentration of aerobic enzymes in the recruited muscle fibers
   - Increase the power generated at lactate threshold (one result of aerobic training)
   - Decrease heart rate at every power output (another result of aerobic training)
   - Increase VO2Max and cardiac output (stroke volume)

C. Increase lactic acid tolerance in the recruited cycling / event-specific muscle fibers
   - Reduce the blood lactate concentration at every wattage output
   - Increase the rate of clearance of lactic acid
Category “A” focuses strictly on developing one’s capability for applying increased torque to the pedals in a smooth, efficient and powerful manner. Categories “B” and “C” focus on increasing one’s ability to deliver both oxygen and the critical energy producing adenosine tri-phosphate molecules (ATP) within the working muscle fibers. This is accomplished by increasing the capillary density, the mitochondrial density and the concentrations of ATP, PC and the Krebs cycle enzymes (catalysts that speed up the energy delivering chemical reactions) in the working muscle fibers.

INTRODUCTION TO PROGRESSIVE POWER TRAINING

There is a distinct parallel between Progressive Power Training and the “Progressive Resistance Training” which is practiced in the gym (see below). Progressive Power Training focuses on training those muscle fibers that actually produce the angular force (torque) on the pedals, whereas Progressive Resistance Training focuses on those muscle fibers that produce force for lifting a weight up and down with the feet flat on the floor or flat on the platform of an inclined leg press machine (for example).

Coach Matt Dixon, MSc recently observed the following: “For less experienced bikers, some traditional strength training may be beneficial; but I have tried this with my established athletes and it didn’t produce positive results.” [Ref: Inside Triathlon, December 2008, Page 60].

My experience over the past fifteen years in working with clients from every cycling discipline (recreational riders on the road, road racers, track racers, triathletes and mountain bikers) has also mirrored this fact (further examples or this are given in Chapter 2). Whereas traditional strength training does not help raise an established athlete to the next level, Progressive Power Training can bring about dramatic improvements in speed on the bike, even for experienced athletes.

HISTORY: THE PROGRESSIVE RESISTANCE CONCEPT

Progressive resistance (mainly a winter training tool for cyclists) is a concept that has been around for many decades and is widely known among those who work out seriously in the gym. When one begins training in the gym with a personal trainer, the first thing the trainer will do is to determine the amount of weight that can be handled to perform the desired number of repetitions for each exercise. This initial weight that the personal trainer specifies will create a sufficient overload to cause an increase in the strength of the muscles exercised.
After several trips to the gym, that same weight no longer is enough to cause strength increases because it becomes too easy to handle. If the intensity is not increased at this point, there will be no further gains in strength. One therefore adds weight to the barbell in order to make further progress. This is known as **Progressive Resistance Training**. As you get stronger, you are challenged with more weight and that in turn makes you even stronger. It all makes perfect sense!

When one performs squats for example, the number of repetitions per set usually is in the 8-12 range and the number of sets usually involves 3-5 sets. One repetition usually takes about 6 seconds to execute, so we are talking about no more than around five minutes of actual squat exercises in a given session. If one performs two sessions per week, it amounts to no more than 10 minutes of squat exercises per week. And yet, one can get much, much stronger with that little amount of time spent. A person can increase the amount of weight lifted by as much as 75% in just eight weeks of such workouts.

The explanation of this phenomenon is that it is the intensity of the exercise and the recovery from that intense exercise that makes you stronger. It is not the amount of time spent exercising that makes you stronger. Please keep this in mind when we discuss the **Progressive Power Training** concept below.

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**THE NEW SECRET: LIFT WATTS, NOT WEIGHTS**

The secret to increasing one’s speed on the bike is to carry out a program similar to progressive resistance training, only this time on the bike. This new program has been defined using the term **Progressive Power Training**. It is a simple matter of employing **Watt Lifting** on the bike instead of Weight Lifting in the gym. PPT is a totally novel concept as far as I can tell, and I have been using it in my coaching business since 1992. It is indeed a training tool for all seasons, as compared to Progressive Resistance Training which is mostly used only for winter training.

It is a fact that leg strength alone (as developed in the gym) can be very helpful up to a point, but beyond that point it does not necessarily guarantee more speed on the bike. The reason for this is that power is a combination of both the strength of the legs for generating angular force at the pedals and the speed of the pedals (cadence). It is a scientific fact that power involves more than just pure leg strength.
The muscle fibers and the motor pathways that are needed to force the pedals around and around in circles at the required cadences are not at all the same as those that are needed to lift weights with the feet flat on the floor or on the leg press in the gym. Moreover, the development of strength is speed-specific. That is, strength and power developed at lower revolutions per minute (RPMs) does not translate well into the strength needed to turn the pedals over powerfully (and generate higher wattages) at higher RPMs.

The real secret, then, is to begin by testing how many watts can be achieved on the bike in an intense but very short time frame (say, 10 full revolutions of the pedals or 10 reps) and then carry out an exercise program in which you develop the ability to produce more watts by adding watts (not pounds) to the challenge you are forced to deal with. The Principle of Specificity demands that the wattage gains must be developed on the same bike, in the same position, and in the same cadence ranges that one plans to use out on the road or on the track.

Using this technique, one’s power output can be significantly improved in as little as six to eight weeks by spending only a few minutes doing super-intense on-the-bike exercises each week. It is not necessary to spend hours and hours on the bike to improve your power output, just as you do not need to spend hours and hours in the gym doing squats to improve your leg strength.

Being able to accurately measure and record power output in a carefully calibrated and controlled environment is critical to assessing progress (you need to know if you are improving or not). It is difficult to accurately measure progress if the PPT workouts are done out on the road, on the track, or on a wind- or magnetic indoor trainer. The key to achieving the gains I am promising is to create sufficiently intense wattage challenges for carefully specified (short) times at precisely specified cadences while simultaneously acquiring important feedback information on the maintenance of form and the detailed progressive results.

A number of cycling specific devices currently are available to cyclists that can measure and record power in watts on the bike. These devices do a good job of measuring and recording power, but most are not suitable for use in the kind of controlled environment needed for implementing a successful PPT program.

It is absolutely critical for the wattage and the cadence to be completely de-coupled and this can be done only on special equipment which at the same time demands that one must use the very same identical bike, in the very same position, with all of the same specific equipment that is
being used out on the road or on the track. It also is essential to be able to track and document every detail of the workouts (some of which last only 10-15 seconds) for later review and analysis and to have instantaneous quantitative feedback concerning any breakdowns in form (efficiency on the pedals) during each workout effort.

Currently the CompuTrainer / Velotron (CTV) System is one system that is available to cyclists that meets all of the above requirements. Wind / magnetic trainer and on-the-road workouts can be very helpful. However, although these workouts will result in improvements, they do not guarantee the kind of dramatic results that I claim can be achieved with PPT when using proper equipment. The reason: insufficient intensity demands.

The good news is that there already are CompuTrainer facilities (including multi-rider systems where groups of eight cyclists at a time can have fun competing against each other) in nearly every large city in the United States right now. If your city does not have a CompuTrainer you could try to encourage your local favorite bike shop to get one and rent it out. An immediate solution for the average cyclist therefore to is to find a facility that offers the use of CompuTrainers for an hourly fee.

On the other hand you might consider purchasing the necessary equipment yourself. After all, we spend thousands of dollars on our bikes, but who ever thinks about investing a modest amount of money on the future ability to ride one’s bike much, much faster? It is not about the bike: indeed, it is the rider who generates the speed at the end of the day.

| The real secret: Lift watts, not weights!! |

**UNDERSTANDING SPECIFICITY**

Specificity is without a doubt the single most powerful concept in sport. However, I have found that few cycling coaches have been able to understand the profound implications of specificity as applied to riding a bike. Nor do they seem to comprehend the “art” of how to apply the concept successfully in any detail.

Basically, specificity states that if you want to get better on the bike you need to train on the very bike, in the very same position, at the very same pedal velocities (cadences), for the appropriate time periods including rest intervals, and in some instances the very same event-specific mode.
that you plan to use on the bike. Training in the gym is helpful, but as we now know it is not the final answer to getting faster on the bike.

Cycling Hall of Fame Coach Mike Walden, who was my first mentor when I was learning how to coach cyclists used to say, “God did not make us to be having our feet going around in little tiny circles! To become more powerful on the bike you need to do in practice precisely what you plan to do out on the road or on the track.” Standing on the floor with both feet and lifting weights up and down is not the same thing.

A truly significant study in specificity was reported more than twenty years ago by D.G. Sale in Medicine & Science in Sports & Exercise (October, 1988). Subjects performed squats for 8 weeks and made impressive gains averaging a 75% increase in strength. The strength gained when they were tested in the leg press (which one might think uses the same muscles as the squat) was only 35% and the gain when tested in the leg extension was only 5%. The conclusion here is that only those muscle fibers used in the specific exercise movements showed significant gains! The actual muscle fiber movements employed in the leg press are not the same as the movements one makes during the squat. There are many other such published studies that provide incontrovertible scientific proof of the profound impacts of specificity on achieving desired results.

It is a well-known fact that if one wishes to get faster in time trialing, it is essential to train on the time trial bike, because different muscle fibers are used when the arms are in the aero bars than when the hands are on the road bars. Coach Mike Walden used to say that if you want to be a good Criterium racer, you must train with your hands in the drops, not on the hoods or on the tops of the handlebars, because different muscle fibers are being recruited. It is normal in a Criterium race to ride in the drops for the entire race, whereas in road races a significant fraction of the time can be spent with the hands on the hoods or on the tops of the handlebars.

You can test this for yourself. Begin by riding at a firm pace out on the road with your hands on the tops of the handlebars. Then, without slowing down, put your hands down in the drops. You will feel that your legs are recruiting different muscles!
The point is that to get faster on the bike, both your strength and your power need to be developed using the same identical movements on the very bike and in the specific mode (including cadence and position on the bike) that you wish to use on the road or on the track.

THE SECRET OF HOW TO NOT FAIL IN APPLYING PROGRESSIVE POWER TRAINING

What I have found in the past is that individuals and coaches have taken the ball on a new idea like this one and then they have misapplied it because they simply were not able to comprehend what it really is all about. I have encountered this situation on numerous occasions during the past ten years.

The important point to be learned from the following discussion is that one first must choose the appropriate cadence ranges for the workouts and not the gear on the bike for Progressive Power Training to succeed.

In April 2008 I was privileged to able to work with the USA Cycling National Team Track Coach who was designated to take several of our track cycling athletes to Beijing. The deal was to make available two free CompuTrainers and a specially made free custom-made Tiemeyer training bike for the months of May, June and July 2008 provided the athletes would follow my Progressive Power Training recommendations. Although the athletes did receive the CompuTrainers and the Tiemeyer bike, they were unable to follow the program. All of them failed to perform in Beijing.

For sprinters it is important to have a good qualifying 200 meter time trial capability because this dictates the seeding for the subsequent sprint rounds. A better seeding means that one goes against weaker opponents in the early rounds. It is essential in any time trial event from 200 meters on up to 40 kilometers or more to get into a winning rhythm as soon as possible after the start and to maintain that winning rhythm right to the finish without breaking form. On the bike, that rhythm is defined by the cadence. In training for a time trial event it therefore is important to develop that sense of rhythm in such a way that it becomes an integral part of the very mind and
the very soul of the athlete, so that one need not even think about it during the event. It just happens.

The program that I recommended for the sprinters involved focusing strictly on practicing at cadences that were somewhat higher than they had ever been able to achieve in their race gears during competition. The recommended program would have them focusing on Progressive Power Training at about 10 RPM higher than they had produced in March 2008 at the World Championships in Manchester, England.

It is important to recognize here that when riding a fixed-gear track bike there are only two ways to increase speed. One can increase the RPM in the same gear or else one can keep the same RPM and develop the ability to push a harder gear. There are no other options. The downside of using a harder gear is that it can cause the loss of what we call "snap" which is the same thing as "quickness" because it takes a lot more force and energy to get the bigger gear turning over when it is time to accelerate the bike up to speed and to deal with the many small accelerations that may be required during the event.

Accordingly, it was specified that all of the sprint workouts for the next three months should target and emphasize brief (10-20 second) interval efforts at higher RPM during the Progressive Power Training CompuTrainer sessions and the track sessions, as well as during recovery rides in a very small gear on the road. The program involved using easier gears at first to insure that the athletes would be able to meet the higher RPM target right away, and then it gradually raised the resistance at that same cadence over the following eight weeks. The principal test of achievement would take place in early July, just five weeks before Beijing.

Only one of the sprinters responded to our offer. This athlete tried just three Progressive Power Training workouts on the CompuTrainer and then decided to abandon the program early on. Instead, it was decided that it would be better to go to a harder 100 inch gear which was exactly the opposite of my specific recommendations. During the weekend of May 30, 2008 this sprinter did a “dress rehearsal” 200 meter time trial test in the 100 inch gear. The cadence in that bigger gear was lower than at the Worlds in Manchester. The times were getting worse, instead of better. This result was predictable. It does no good at all to raise the gear if that gear can not be turned over at the required cadence.
A Secret: Raising the gear first and then trying to increase the cadence does not work very well because the development of strength is speed-specific.

In Beijing this athlete qualified eighth fastest in the 200 meter qualifying time trial and was eliminated from the medal competition in the quarter finals (round of eight). The 200 meter TT cadence was lower than had been achieved in Manchester. This athlete was quoted on TV as saying, “It’s really hard to get that big gear going!” In the first round of eight the competition sprinted right around this rider with ease in the final lap of the sprint race (i.e. there was no “snap” in the last half lap of the race).

I also recommended a program for pursuit which called for all of the workouts for the next six weeks to target interval efforts at a higher RPM than had been achieved at the World Championships in Manchester during both the track sessions and the Progressive Power Training sessions, and also during any aerobic and threshold interval training rides. All of the other riding was to be “recovery” with short efforts at the higher RPM in a very easy gear.

As in the sprinters program, the pursuit program involved using easier gears at first to insure that it would be possible to meet the higher RPM target first and to develop and “memorize” that new sense of rhythm. The program then gradually raised the resistance at that same cadence over the following six weeks by adjusting the gearing for the workouts. In all of the key PPT sessions the athlete was to experience the highest possible wattage intensity that could be tolerated at that higher RPM without breaking form or “fighting the bike” for 10-12 pedal strokes per set with five minute rest intervals.

Instead of following this recommended program it was decided to have all of the workouts done on a fixed-gear track bike in a relatively hard (50x16) gear. Therefore, whenever the workout on a given day called for an easier effort at lower heat rate, the only choice was to ride at a lower cadence (around 70-90 RPM). On the track, the recommended easier gears were not used making it impossible to achieve the new, higher cadence target.

On August 15, 2008 in Beijing this athlete’s qualifying pursuit time was approximately four seconds slower than the time that was posted in March at the 2008 World Championships in Manchester, England, and the cadence was much lower than it was in Manchester.
was quoted as saying, “As soon as she got out of the start her body was just dumping lactic acid.” This athlete apparently was “cooked” by an overdose of heavy-duty training intervals and hard lower-cadence workouts with inappropriate recovery.

A big mistake made here was that most of the workouts for these athletes were in gears that did not allow them to practice learning the new rhythm and making that rhythm a part of their very being by turning over the pedals at the required higher RPM.

The main lesson to be learned is that Progressive Power Training calls for defining the appropriate individual rider-specific and event-specific cadences first, followed by the development of an ability to produce greater resistance at those chosen cadences.

Lance Armstrong became one of the greatest time trialists in the world when he increased his cadence from 85-90 RPM to 108 RPM. Kristin Armstrong won the time trial Gold Medal at the Olympic Games in Beijing using a cadence of 108 RPM. Nearly all of Kristin’s competitors were slogging along in big gears. Indeed, most of the cyclists in the professional peloton do their time trials at 85-95 RPM. And most of them are not winners!

The advantage of using higher cadences is that it keeps the legs fresher and it allows one to handle the inevitable accelerations with greater ease (i.e. more “snap”). Please note however that for some athletes it simply may not be possible to achieve higher cadences due to physical problems, physical imbalances, or unusual body type. In that case, the workouts should be conducted at the highest cadence that feels comfortable for that individual. Also, for triathletes the higher cadences may compromise performance on the run, and this possibility needs to be explored for each individual athlete.

Important Secrets: Cadence first, resistance next leads to increased power and speed on the bike. In developing strength, it is the intensity of the exercise and the recovery from that exercise that makes you stronger. It is not the amount of time spent exercising that makes you stronger. Finally, it is not possible to optimize the Progressive Power Training intensity requirements without the use of a special system such as the CompuTrainer or Velotron system.
DO NOT MAKE THE MISTAKE OF FOCUSING ONLY ON CADENCE

A local young boy who had a good sprint concluded one day that he could become a truly great sprinter by spending an entire off-season practicing at high (160 plus) cadences on a pair of rollers. For the entire following season his performances were poorer than before and he was consistently off-the-back. Obviously, the boy did not understand that the generation of power requires that one be able to increase the applied force on the pedals at the required pedaling velocity. Rollers simply are not capable of demanding the high resistances needed to improve one’s power output and speed on the bike.

The Secret: Working out at high cadences and low resistances will not improve one’s power and speed on the bike.

Many more Progressive Power Training secrets and the specifics of how to apply those secrets follow in the chapters to come.
CHAPTER 2

THE RELATIONSHIP BETWEEN STRENGTH TRAINING AND POWER TRAINING

Strength training in the gym can have very significant beneficial effects on new or relatively untrained cyclists. In just 6-8 weeks, a new or untrained rider can develop significant gains that will apply directly, albeit somewhat inefficiently, to improved performance on the bike. However, experienced cyclists who wish to go to the next level need something more than just strength training. It is a well-known and well-established scientific fact that the training effects specific to progressive resistance training mode in the gym do not necessarily transfer directly to complex activities such as generating power, acceleration, and speed on the bike. The reason for this is that leg strength in and of itself does not equal power on the bike.

THE DEFINITION OF POWER AS APPLIED TO CYCLISTS

The definition of power as it applies to cyclists is as follows:

\[ P = F \times v \]

Where, \( P \) = the Power generated in Watts (Joules/second), \( F \) = the Force applied to the pedals in Newtons (Kg- meter/sec**2), and \( v \) = the velocity of the pedals in meters per second.

The force (\( F \)) is related directly to that specific component of leg strength that can be recruited to make the pedals go around and around, and the velocity (\( v \)) is related directly to the cadence. It is not just pure leg strength that counts: It is leg strength that is tied specifically to the required motion and to the speed of that motion.

It is extremely important to recognize that strength is speed-specific. Strength developed at low speeds does not apply directly to performing at high speeds. This principle has been proven in
many sports scientific studies. Development of strength in the gym with squats at 10 repetitions per minute (analogous to 10 RPM) with one’s feet flat on the ground does not apply directly to the strength needed to generate power on the bike at 100 RPM with one’s feet going around and around in circles on the pedals.

According to the above equation, for a given power level one can achieve the same result either by riding at a low cadence and applying a greater force to the pedals or else one can generate the same power level by riding at a higher cadence while applying less force to the pedals. This aspect of power generation is extremely important and it will be discussed later in Chapter 3.

THE RELATIONSHIP BETWEEN WEIGHT LIFTING AND PERFORMANCE

In the past, cyclists have been encouraged to conduct weight training programs three or four days per week to increase muscle mass and to increase upper body strength, core strength and leg strength. Development of such strength is very important up to a point, but it does not guarantee that one will become a great cyclist.

Pure leg strength does not by any means translate directly into superior power on the bike, because as mentioned above the generation of power requires the simultaneous production of both force and speed at the pedals. The development and maintenance of core body strength can be important because it enhances the transfer of force from the handlebars to the feet. The development of upper body strength is not helpful if all it does is add useless body weight. In fact, only sport-specific upper body isometric strength is needed to control the bike.

A recent example of the impact of weight lifting on performance is that of one of America’s best 2008 Olympic hopeful match sprinters. This sprinter was using an Olympic weight lifting program. He is quoted in an interview as saying that his weight lifting trainer “has taken my once poor form Olympic lifts and changed them into what I would like to think of as a thing of beauty.” In the lead up to the U.S. Olympic trials, on this heavy-duty weight lifting strength program, he posted the following 200 meter time trial results in the World Cup, World Championship and U.S. Olympic Trials events:
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Time</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2, 2007</td>
<td>Sydney World Cup</td>
<td>10.412</td>
<td>18th</td>
</tr>
<tr>
<td>December 9, 2007</td>
<td>Beijing World Cup</td>
<td>10.452</td>
<td>17th</td>
</tr>
<tr>
<td>January 20, 2008</td>
<td>Los Angeles World Cup</td>
<td>10.50</td>
<td>9th</td>
</tr>
<tr>
<td>February 15, 2008</td>
<td>Copenhagen World Cup</td>
<td>10.472</td>
<td>15th</td>
</tr>
<tr>
<td>March 26, 2008</td>
<td>Manchester Worlds</td>
<td>10.419</td>
<td>30th</td>
</tr>
<tr>
<td>August 17, 2008</td>
<td>Beijing Olympic Games</td>
<td>Did Not Qualify</td>
<td></td>
</tr>
<tr>
<td>December 11, 2008</td>
<td>Cali, Colombia World Cup</td>
<td>10.49</td>
<td>7th</td>
</tr>
</tbody>
</table>

It should be noted that to be competitive among world-class Olympic athletes this athlete would need to have posted 200 meter times of 10.10 seconds or less. He has been falling at least 150-200 watts short of being there in every event for one entire year. From these results it is obvious that his heavy-duty weight lifting program has not had any significant effect on improving his wattage or his speed beyond a certain point.

This same sprinter was allowed to go to the 2008 Beijing Olympics (in spite of not meeting the sprint qualifying standards) to compete in the team sprint event by a process known as “coach’s choice.” On August 15, 2008 the three-man U.S team qualified eighth with a time of 45.346 seconds, fully 2.4 seconds slower than the fastest team (Great Britain). It is a fact that the United States of America currently is incapable of producing world-class sprinters, and I claim that this is mainly because of the flawed “traditional” training programs, which emphasize heavy-duty weight lifting.

During the week of April 7, 2008 the Momentum Cycling Team (featuring the above mentioned Olympic hopeful sprinter) was approached with an offer to provide them with a sport-specific, event-specific Progressive Power Training program, along with the use of $9,000.00 worth of equipment (a Racermate Velotron and two custom made Tiemeyer track bikes). The condition was that for the final three months of preparation they would need to replace their weight lifting program with a Progressive Power Training program. It was strongly suggested that this program could guarantee them the acquisition of medals at the 2008 Olympic Games. The offer was turned down.

At the 2008 Olympic games in Beijing, America’s fastest U.S. Olympic Trials sprinter qualified fifteenth in the 200 meter sprint qualifying round with a time of 10.470 seconds compared to the fastest time of 9.815 seconds posted by Chris Hoy of Great Britain. This rider was coached by the former USAC National Team Track Coach using a heavy-duty weight program. In Beijing he fell approximately 300 watts short of being world class, and he was eliminated from the competition in the first round of sprints.
Several of the riders that I have coached were body builders who also rode a bike. Two of them were personal trainers who insisted on continuing their body-building workouts while spending only nominal amounts of time on the bike. A third one believed that he could improve his power by concentrating solely on a program similar to the one used by Olympic weight lifters, again with only nominal time on the bike. None of these three gentlemen ever made serious improvements in their power over a five year period.

Two junior sprinters that I have coached made good progress until they were accepted into the USA Cycling (USAC) National Team Development program at the Olympic Training Center (OTC) where weight lifting was heavily emphasized. One of the boys increased his total body weight through weight lifting at the OTC by approximately fifty pounds in the first two years. He was not significantly faster! The other boy increased his total body weight by more than forty pounds in less than a year and he too was not significantly faster after training under USAC/OTC supervision.

My youngest son Tom is a body builder. He is ripped, he has big legs, and he can squat huge amounts of weight. Yet, when he comes home and we go out on a bike ride together I can ride circles around him! I am 75 years old and I do not lift weights. So what is that all about?

Some of the greatest Tour de France riders who ever lived did not do any extensive weight lifting. Nowadays, hardly any of the TDF superstars do very much weight lifting. They have learned that on-the-bike training and on-the-bike intensity is what is required.

Achieving the goal of getting faster is all about developing an understanding of how to apply some already known scientific principles to the problem. In the end, however, getting the results we want simply is all about using plain ordinary common sense.

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**THE SECRET TO INCREASING POWER GENERATION**

We have seen that in the past too much time has been spent developing strength, speed and intensity in the gym and not enough time has been spent developing strength, speed and intensity on the bike.

Unfortunately, it is a fact that current on-the-bike out-on-the-road or on-the-track training programs simply are incapable of demanding the degrees of intensity that are needed to produce the training effects that can induce serious improvements in power and speed on the bike.
Special equipment is needed to insure that intensities (wattages) can be demanded that are well beyond that which cyclists can produce by their own efforts.

Intensity is the name of the game, but it needs to be appropriate intensity, as will be spelled out in the chapters that follow. In the gym, intensity is measured by the number of pounds one can put on the barbell. On the bike, workout intensity should be measured by the ability to generate sustained power as measured in watts. We therefore need to be able to increase the demand by adding watts, not pounds, during the training program. And, this needs to be done in a manner that is totally independent of the cadence.

Please note: when training aerobically on the bike, intensity should be measured strictly by monitoring one’s average heart rate.

**Another Secret:** Much more on-the-bike intensity is needed to develop power. Moreover, the challenges that need to be demanded during on-the-bike power training workouts must be much more intense (albeit for very short periods of time) than can ever be achieved while riding a bike on the road or on the track, with or without motor pacing.

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**UNDERSTANDING THE PROPER APPLICATION OF SCIENCE TO CYCLISTS**

Understanding the proper application of science to cyclists requires that cyclists and coaches learn how to differentiate between “good science” and “bad science.” During the past thirty years a great deal of “bad science” has been published in the cycling literature. It has been my observation over the past 15 years that only a few coaches have been able to make truly good selections from among the available published information. The good news is that this situation has been improving in recent years.

An example of “bad science” includes the Karvonen formula which uses 220 minus your age for estimating maximum heart rate. This flawed formula continues to this day to appear in magazine articles and books written by coaches, even though it was shown to be totally invalid as long ago as 1988 because it can be in error by as much as plus or minus thirty beats per minute. The Karvonen formula currently is to be found on many coaching websites, and it continues to be used in the heart rate charts that are posted in nearly every gymnasium in America.
Indeed, more cycling coaches need to learn how to properly apply new technologies such as heart rate monitors or on-the-bike power measurements to optimize the training benefits to their clients. The fact is, not everything in the published literature is correct.

Another example of “bad science” is in the area of bike fit. In a 2007 major magazine article a coach who states that he is an Olympic and Pan Am Games coach recommends that to determine saddle height, the heel of the extended leg should “just make contact with the pedal while the crank is positioned at dead-bottom center.” He also recommends that another method is to multiply the inseam measurement by 0.883, and for frame size to multiply the inseam by 0.65. These ideas and these “multipliers” were published as long ago as 1987 and have since been proven to be dead wrong!

Another more relevant example of bad science is the idea that a cyclist needs to develop a huge fraction of his or her strength in the gymnasium. What follows below are some examples of riders and coaches who used their common sense and/or who were able to make the right selections between “good science” and “bad science.”

Tour de France winner and Championissimo Fausto Coppi when asked how he became so great answered, “Ride a bike, ride a bike, ride a bike.” Fausto understood that to become a great road cyclist, one must spend huge amounts of time out on the road, on the bike. He knew about the principle of specificity long before it was defined by the sports scientists.

Lance Armstrong and his coach Chris Carmichael defined what is needed to achieve the goal of producing world-class results in the Tour de France. The bottom line is that the training needs to be absolutely specific to the needs of the actual event. This is known as the Principle of Sports Specificity.

Chris Carmichael fully understood the importance of specificity. Surviving the Tour de France with the reserves needed to perform at the highest possible level when the hammer goes down requires the development of a huge aerobic engine. Chris knew that to develop that engine, Lance needed to put in hours and hours on the bike in a carefully defined (aerobic) heart rate range with nothing short of “numbing” consistency. Chris also knew that science has shown that any significant time off the bike results in a rapid decay in the strength of the aerobic engine. Regaining that lost ground can take much more time than the amount of time taken off. Therefore, achieving the desired result demanded an emphasis on both specificity and consistency. Lance is quoted as saying, “I never miss a workout, ever!”
Lance also needed to keep his weight down to improve his power-to-weight ratio, and he needed to teach his body to climb efficiently both in and out of the saddle and to time-trial at higher cadences than he had been using before. All of these capabilities could only be achieved by actually practicing them for hours and hours on the bikes that he planned to ride in the Tour. For example, he knew that the neuromuscular motor-pathways and the actual muscle cells that are employed on the TT bike are completely different than those employed on the road bike. Significant Improvements in one’s time trial speed can not be achieved by only riding on a road bike.

Improving one’s ability to climb mountains can only be achieved by climbing mountains. The neuromuscular motor-pathways and the actual muscle cells that are employed while climbing are not the same as those employed on flat ground. Not only did Lance climb mountains, each year he climbed those specific mountains that he would face in the tour, over and over again.

Unfortunately for Jan Ullrich, he and his coach Rudy Pevenage never got it when it came to meeting the requirements of preparing to become a Tour de France winner. It has been my observation that very few cycling coaches in this world have demonstrated more than a superficial understanding of the incredibly profound implications of applying the Principle of Specificity to their athletes.

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**APPLYING SCIENCE AND SPECIFICITY TO THE DEVELOPMENT OF POWER**

The Principle of Specificity has been described as the Ein = mc^2 of Sport. The statement that specificity is as deeply significant to sport as the Einstein equation is to science is truly profound. The Einstein equation, consisting of three letters of the alphabet, one number, an equal sign and two asterisks was responsible for the development of the atomic bomb! Who would ever have thought that such a simple equation could have such profound scientific and real-world implications?

The Einstein equation is the product of science. The atomic bomb is the result of our engineers and applied scientists developing a deep and profound understanding of the implications of that equation along with their know-how and their “art” in coming to an understanding how to apply this new knowledge in the real world.

The problem for us will be to understand just how P=F*v, the scientific formula for power, can be applied to the real-world in conjunction with the Principle of Specificity in learning how to enhance the development of power on the bike.
By doing squats in the gym, one is working only on an inappropriate non-specific form of “F” and little, if at all, on “v.” Working out at high cadence on the rollers with low resistance is working only on “v” and not at all on “F.” The secret is to work on (F*v) which then will simultaneously develop the proper sport-specific form of both “F” and “v.” In other words, one must develop and increase “F” at the appropriate value of “v” that is required in your specific style of riding or in your specific competition.

It should be pointed out that time trialing has totally different power development and specificity requirements than do hill climbing, riding fast on the flats, pursuit racing, surging, or sprinting. Therefore, the Progressive Power Training technology needs to be adapted to each different discipline and type of riding.

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**IMPROVING POWER COACHING**

In sport it is up to the coaches to use their know-how and their “art” in developing a deep and profound understanding of how to apply the relevant known scientific principles of their sport to the development of athletes in the real world. Unfortunately, many cycling coaches nowadays are also personal trainers who advocate significant doses of weight lifting in their training programs. I know of very few American cycling coaches who truly comprehend the significance of connecting the power equation P=F*v with the profound implications of the Principle of Specificity.

We need more local coaches who can master and apply the known and relevant scientific concepts in developing their clients. After all, new young talent first appears at the local level and that talent needs proper care and feeding right from the start. We need to treat such talent as if it were a National Treasure. We need to share our knowledge and get as many coaches as possible on the same page concerning how to get the job done.

One unfortunate situation is that many coaches the world over prefer to keep their coaching methods to themselves, thinking that by covering up their “secrets” they will maintain power over their athletes, thereby improving their prestige and income stream. I have recently talked to several high-level track coaches who I know personally, offering to share my ideas with them. My offer has been refused by every single one of them!

One of the coaches I talked to stated that it is his policy never to discuss coaching concepts with other coaches. He encouraged me to publish my ideas, but he had no interest in discussing or
reviewing my ideas prior to publication. Apparently, there is a fear out there that another coach might learn and take advantage of one’s “secrets.”

One notable exception to this kind of thinking is the approach of a man who arguably is the greatest living coach in America, Chris Carmichael. Chris has made no bones about making public everything he knows and everything he does. His books are legend, and neither he nor his coaching business, nor his clients, have suffered one bit from it. Indeed, Chris has only profited from sharing his knowledge publicly.

I firmly believe there is no downside to doing what Chris has done, because there are hardly any coaches or athletes in the world who are capable of following his plan to the letter anyhow. The real secret is how one applies the know-how on a day-to-day basis with the athletes, and this is not being shared. Many of the coaches who could benefit from Chris’ thinking in preparing their athletes have been incredibly ego-bound in holding onto to their own “flawed” methods. They have their heads in the sand and apparently are incapable of thinking outside the box. Jan Ullrich’s coach, Rudy Pevenage, is a good example of this. He had to be the greatest moron of them all, given the information that was out there, thanks to Chris Carmichael.
CHAPTER 3

KEY PRINCIPLES FOR THE DEVELOPMENT OF POWER

Our secret to achieving increased speed on the bike is to make use of the Progressive Power Training workouts while basing the overall program design on common sense and a sound understanding of the appropriate scientific principles.

For the program to be truly successful, one should seriously consider applying many of the twenty-six principles discussed below. The trick is to understand precisely how to apply these principles in such a way as to maximize the rate of development progress for each individual cyclist. That is where good coaching and common sense are a great advantage.

PRINCIPLE #1: SPECIFICITY

The Ancient Greeks knew what some of us in cycling seem to have forgotten: An athlete must be able to do in practice precisely what he or she intends to do in competition. This has been identified as the Principle of Specificity. One can not achieve the end result by spending a lot of time doing workouts that are not specific to the accomplishment of the exact task at hand.

Professional athletes the world over know this fact. For example, the incredible athletes who perform to perfection in the Cirque de Solis practice precisely the moves that they intend to perform in the theatre and they do it for hours and hours every day. Lance Armstrong practiced those activities that were specific to developing the energy systems and the pedaling skills that he needed to win the Tour de France for hours and hours most every day and he constantly paid attention to programming his mind for success.

As mentioned in Chapter 1, an important aspect of the Progressive Power Training specificity requirement is that to be truly successful there needs to be a total separation between cadence and resistance in the workouts, a requirement that can not be met without the use of special equipment. However, it is possible to make a limited amount of positive progress without the use of special equipment.
It is important to recognize that the Principle of Specificity needs to be employed in deciding just how to apply nearly every one of the principles discussed below.

**PRINCIPLE #2: THE APPROPRIATE APPLICATION OF INTENSITY**

As already has been shown, progressive resistance workouts in the gym are not necessarily sport-specific. However, Progressive Power Training workouts can be designed to be both sport- and event-specific. Specificity is the key to success.

The program that is being proposed here is not rocket science. Progressive Power Training simply is analogous to progressive resistance training, but on the bike. Most every athlete knows about the significance of using progressive resistance in the gym. However, it appears as if very few people know how to implement Progressive Power Training on the bike.

Those who are familiar with the value of weight training know that one of the keys to getting stronger is to maximize the intensity that can be handled without breaking form. In weight training the intensity demand is defined by the amount of weight that can be lifted. When a given amount of weight is being lifted successfully, your personal trainer or your coach simply adds more weight to increase the intensity demand. If the intensity demand is not increased, you will not get stronger. Your trainer also will insist that you do not break from while lifting those weights, a requirement that is vital to the success of the program.

The same thing is true with Progressive Power Training except that the true measure of intensity is the wattage demand that can be met. When a given wattage demand is being handled successfully without breaking form, it then becomes necessary for the coach to increase the wattage demand or else you will not get stronger (and faster). However, I have found that it is not possible to provide the increased wattage demands that are needed to induce truly significant speed improvements by simply riding out on a bike. One can not by oneself increase the intensity demand enough to make progress beyond a certain point. To make more progress, the wattage demands must be much greater than ever can be achieved on a bike out on the road or on the track, even with motor-pacing.

Finally, an essential key to gaining power on the bike is to increase your ability to handle extremely high wattage demands on the bike without breaking form. Putting your own bike on a CompuTrainer or Velotron (CTV) for the Progressive Power Training workouts appears to be one of the best options currently available. It allows one to perform true sport-specific and event-
specific training. The training must be done on one’s own bike because the specific muscle fibers and motor pathways that are being used on the bike are not at all the same as those that are used in the gym. It has to be done on the bike.

An important caution: as in the weight room, the intensity demanded in the exercise must not be increased too fast, or else one can most certainly be injured. Moderation is needed in both the gym and in the CTV workouts. Also, the intensity must not be so high as to cause a serious breakdown in form, as this most certainly will lead to injury.

PRINCIPLE #3: LESS IS MORE!

Many athletes and coaches have adopted the following concepts: “no pain, no gain!” or alternatively, “what doesn’t kill me will make me stronger!” Some coaches have their athletes doing killer intervals all year around. Some athletes (both coached and self-coached) trash out their legs and their bodies on a weekly basis out on their Saturday group ride. They make their “easy days” too hard, and then when it is time to do the hard training efforts, they simply can’t perform them as intensely as they should. They get sucked in to riding with a group that is in over their heads, thinking that if they ride with stronger riders, it will make them suffer more and they will get better.

This kind of thinking is dead wrong! Moderation is the key to success. I have lost count of the number of times I have slowed down a high-level elite athlete and then within a few weeks their race results have improved dramatically. A good coach will not induce overtraining syndrome!

One training mode that is particularly ineffective in producing positive training effects is the gym-rat “spinning” class. These classes can get your heart rate up close to maximum with low resistance using the “up-down-up-down-up-down” commands. The participants go away feeling totally trashed and think that is just great. Gyms the world over are profiting from “no pain, no gain” to no end. It is a useless waste of energy for anyone wanting to get faster on the bike.

One man who for a brief time was one of my clients, a personal trainer, believed that doing up to six spin classes a week would make him stronger and faster. Over a period of three years this man got dropped on every weekly Saturday group training ride and in every bike race he entered.
Again, an old friend of mine decided one winter to take several spin classes a week because he was intrigued with watching the moves of the cute female class leader. He did this instead of going out on his bike, even though he lived in San Diego (my home town) where the weather for riding all year around is absolutely the best in the country. This man was a multiple USCF Masters National Champion on the road and on the track and he also had won medals in the Master’s World Championship road races in Austria. The next spring, he and I raced together in Phoenix and for the first time in his life he got dropped! He was totally embarrassed!!

It is important to know that it is not the miles you do. It is how you do them. Riding long miles at a pace that is well below threshold heart rate can be truly beneficial. The traditional intense intervals must not be done more that two to three times a week, and then only for brief periods of time (measured in weeks). The new super-intense intervals that I am recommending may need to be done only once per week.

It has been my experience that only one truly intense Progressive Power Training interval session per week is needed to make positive progress. More than one session per week can be employed only if it can be demonstrated that the athlete can recover adequately between sessions. For some riders, the time between sessions must be as much as eight to ten days. Again, this depends on the intensity that is achieved in each session.

Full recovery between sessions is the key to insuring that one can perform with sufficient intensity to make optimal progress. If the athlete finds it impossible to perform better than in the previous interval session, more time may be needed between sessions for recovery.

Very often it turns out that “less is more.”

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**PRINCIPLE #4 ACCELERATION AND NEWTON’S EQUATION OF MOTION**

The ability to accelerate to greater speeds can be important when surging to attack, or catch up with a group that is ahead or when sprinting on the bike. Acceleration is defined by Newton’s Second Law of Motion:

\[ F = ma \]

In cycling terms, \( F \) is the force applied to the pedals to increase the cadence from either a dead stop or from a low 60-70 RPM to perhaps more than 160 RPM in the shortest possible time; \( m \) is
the mass of the rider plus the bike; and \( a \) is the acceleration. Rearranging this equation, acceleration is defined as:

\[
a = \frac{F}{m}
\]

This statement has profound significance for surging and sprinting because it shows that one can improve acceleration either by increasing the applied force, or by decreasing the mass of the rider plus the bike, or both. Here is how it applies to cycling:

When one is performing on the bike, only a fraction of the total muscle cells in the legs may be working to produce the required power. Some examples that prove this fact are as follows: (1) If a cyclist with no prior running experience tries to go out and run hard, the legs will get sore even though the cycling legs are good; (2) Different leg muscles are being used when riding with hands on the tops of the bars than when the hands are down in the drops; (3) Different leg muscles are being used when in aerodynamic time-trial position than when in road racing position. Any cyclist can easily demonstrate this fact for themselves on their own bikes.

Building up giant legs therefore does not necessarily result in more power. What is needed is to develop great strength in precisely those leg muscle fibers that actually are generating the power needed to make the pedals go round and round at high resistance and to expand the recruitment to as many more leg muscle fibers as possible to the specific task(s) at hand. This must be done without building up unneeded muscle mass in the legs that will never be used in generating power on the bike.

It is an easily demonstrated fact that the traditionally accepted weight programs that increase muscle mass do not necessarily lead to shorter acceleration times. Moreover, traditional weight training programs invariably result in unnecessary increases in upper body weight, thereby increasing \( m \) without increasing \( F \). This does not help when it comes to the need to accelerate the bike.

In the lead-up to the 2000 Olympic Games in Sydney, Australia Gold Medalist Marty Nothstein reduced his body weight by twelve pounds. That weight loss definitely increased his quickness in accelerating his bike, a fact which can be proven by a straightforward mathematical calculation using the equation \( F=ma \).
PRINCIPLE #5: TRADITIONAL WEIGHT TRAINING MAY COMPROMISE ACCELERATION

Weight training does not increase the number of muscle cells in the body, but it does increase the force that can be applied to the pedals by increasing the diameter and therefore the mass of existing muscle cells in the legs (the legs get bigger around).

The increase in leg muscle cell strength and the increase in leg muscle cell mass are both directly proportional to the square of the diameter of the muscle cells that are being trained as follows:

\[ F = \text{constant}_1 \cdot (\text{muscle cell diameter})^2 \]
\[ m = \text{constant}_2 \cdot (\text{muscle cell diameter})^2 \]

What these formulas show is that as muscle cell strength increases so does muscle cell mass in exactly the same ratio. According to these equations, \( F/m \) is constant as muscle cell mass is increased. Therefore, simply increasing muscle mass may not improve acceleration. Increasing muscle diameter (and mass) in those muscle cells that are not specifically recruited during accelerations (in the upper body, for example) does little to improve acceleration, and can even make things worse.

Since \( F/m = a \), it is important to think in terms of increasing the diameter and the mass of only those specific muscle cells that can be recruited to improve one’s acceleration on the bike. In other words, we need to increase \( F \) without increasing \( m \) by the same amount. This can be accomplished by strengthening only those muscle cells that are involved in the specific motion of creating power on the bike and by increasing the cycling-specific and event-specific muscle cell recruitment. The size and strength of those muscle cells that do not contribute to power on the bike should not be increased.

The example given in Chapter 1, where the squat strength of a group who did only squats was increased by 75% after eight weeks while the leg press strength (an exercise they did not do) was only increased by 35% should be obvious proof of the specificity concepts I am proposing for use on the bike.

The conclusion here is that what does work is to control increases in useless muscle mass while dramatically increasing cycling-specific and event-specific muscle fiber size and recruitment. This can be accomplished only by intense Progressive Power Training on the bike.
One way to minimize useless upper body weight gains while providing the upper body strength required for transmitting power to the legs and for controlling the bike would be to put more emphasis on isometric upper body work. Olympic and World Champion Sprinter Reginald Harris made good use of isometric upper body resistance training for controlling the bike during his reign as the “God” of Professional Match Sprinting.

**PRINCIPLE #6: CONTINUOUS CORE BODY TRAINING IS ESSENTIAL**

Core body strength is a key element in achieving sustained increases in speed on the bike. To go faster, you must be able to transfer force from the handlebars to the pedals and this must go right through the core of your body. You can easily prove this to yourself by riding up a hill either with no hands or else while just resting your hands on the bars as opposed to holding on to the tops of the bars and pulling back with a “tug” on the bars. Notice that the best riders when going all-out have a slight bend in their elbows which allows them to maximize the “pull” on the bars.

Core body work in the gym can be very helpful, including such programs as Yoga or Pilates. The Progressive Power Training (PPT) workouts also can contribute greatly to your performance by providing sport- and event-specific core body isometric resistance training. To achieve the best result with PPT you must practice pulling with maximum possible intensity in the very handlebar positions you plan on using out on your ride or in your specific event.

If you plan on improving your performance in the handlebar drops, work out in the drops. If you want to improve with hands on the tops or on the hoods of the handlebars during a climb, work out that way. If you are a triathlete or a pursuit rider you must pull on your aero bars in your preferred hand and arm position. Specificity rules!

**PRINCIPLE #7: STRENGTH IS SPEED-SPECIFIC**

It has been proven in numerous scientific studies that resistance training adaptations are specific to the velocities employed during training. Low-velocity training does not cause any significant improvement in high-velocity performance, nor does high-velocity training result in any significant improvement in low-velocity performance.

Examples of this fact were given in Chapters 1 and 2. Training at high cadence and low resistance on rollers does not make one faster, nor does training at low cadence (10 reps per minute) at high resistance in the gym make one faster. Training at 50 RPM on the bike will make
for stronger legs, but it is not the full answer to increased speed on the bike. You still need to be able to turn the pedals over fast at high resistance in order to go fast.

Choosing the right training cadence is the first priority in implementing a Progressive Power Training program. Cadence should be chosen based on the specific type of riding in which you want to improve your speed because strength developed on the pedals is cadence specific. Here are some guidelines:

<table>
<thead>
<tr>
<th>Activity</th>
<th>RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational Riding</td>
<td>80-100</td>
</tr>
<tr>
<td>Time Trialing</td>
<td>80-110</td>
</tr>
<tr>
<td>Road Races</td>
<td>80-120</td>
</tr>
<tr>
<td>Lance’s Time Trials</td>
<td>96-108</td>
</tr>
<tr>
<td>Lance’s Prologues</td>
<td>115-120</td>
</tr>
<tr>
<td>Road Sprinting (Standing)</td>
<td>115-120</td>
</tr>
<tr>
<td>Track Pursuit (Seated)</td>
<td>115-120</td>
</tr>
<tr>
<td>Track Sprinting</td>
<td>Zero-170</td>
</tr>
</tbody>
</table>

From the above discussion we can see that the development of strength must be done at the pedal speeds required by the sport to be meaningful. In cycling this means that strength programs to be effective must be conducted at ALL of the cadences required in the event. For example, in order to perform effectively in match sprinting, specific strength must be developed over the entire range of cadences from zero to 170+ RPM. This develops the ability to accelerate from a standing start (Zero RPM) up to race speed (160+ RPM) and then accelerate once again in the last 50 meters to the finish line. The other disciplines require training over much narrower cadence ranges, as shown above.

The absolute key to the successful implementation of a Progressive Power Training program is the separation or de-coupling of cadence and resistance. It must be possible to demand an extremely intense resistance that is independent of the cadence. This can not be done without the use of special equipment, because out on the bike it is difficult beyond a certain point to demand a sufficiently high intensity independent of the cadence.

The development of strength in the gymnasium by doing squats at 10 RPM applies to cycling only as a preliminary program to strengthen connective tissues (tendons and ligaments). Simply increasing muscle mass at 10 RPM is not sufficient for achieving the desired result. Moreover, the traditionally applied plyometric jumping exercises in the gym are not sport-specific to cycling and therefore are not fully effective in achieving the end result of applying maximum power to the pedals.

In another area, upper body strength gained from eccentric/concentric exercises is only partially transferred to isometric contraction. Therefore the upper-body strength needed to control the
bike, especially during an all-out surge or sprint at speed, can not be developed by the kinds of resistance programs that have traditionally been employed in the past. Controlling the bike is an operation requiring isometric strength at specific joint angles.

PRINCIPLE #8: ACHIEVING A HIGH LEVEL OF SUSTAINED POWER

We have seen that power is defined as:

\[ P = F \cdot v \]

In cycling terms, \( P \) is the power generation in watts, \( F \) is the force applied to the pedals and \( v \) is the velocity of the pedals (i.e., the cadence). Achieving a high level of sustained power involves increasing the sustainable angular force on the pedals while optimizing (and possibly increasing) the cadence as appropriate for the specific event or your desired riding style.

Development of the ability to sustain increased steady-state power generation (and speed on the bike) involves the following elements:

1) **Increasing useable sport-specific muscle mass (watt-lifting leg strength).** To go faster on the bike you need to increase the recruitment, the size and the strength of those muscles that make the pedals go around and around in circles. This is the result of Progressive Power Training.

2) **Development of the Aerobic Engine.** This is probably the next most important requirement. Appropriate aerobic training targets the growth, development and proliferation of both the capillaries and the mitochondria in the cycling-and-event-specific muscles that have been activated through Progressive Power Training. Development of the aerobic engine involves spending many, many hours training at heart rates that are at least 25 beats per minute below your Time Trial heart rate. Examples of the results one can achieve through aerobic training are presented in Chapter 5.

The density of both the capillaries and the mitochondria in those muscle fibers can be increased dramatically (by as much as 50 percent or more) by proper training. Also, the concentration of Krebs Cycle enzymes (catalysts which increase the rate of energy delivery) can be increased dramatically (by as much as a factor of two or more) by proper aerobic training. Proper training means keeping the acidity in the muscles low, because acidosis actually inhibits the very physiological changes that are desired. In an acidic
environment, the desired increases in capillary density and in mitochondrial density and enzyme concentrations simply will not happen!

One of the best sources of well-written information about aerobic (base) training is the book entitled "Base Building for Cyclists" by Thomas Chapple (Velo Press, 2006). The information in this book could not be any better if I had written it myself!

3) **Development of Lactate Threshold Power.** Threshold power actually is increased simply by proper aerobic training. However, the final touches in the development of increased lactate threshold power are achieved by introducing lactate threshold intervals into the program during the aerobic engine development program. Lactate threshold intervals involve riding at a heart rate that is approximately 5-10 beats per minute lower than your Time Trial heat rate for time periods of as little as 5 minutes to as much as 60 minutes. The shorter time periods are used for new or untrained (out of shape) athletes to bring them up to the point of being capable of doing several 20 minute efforts, and eventually, time periods of 30-60 minutes in length. The rest interval normally is a time period equal to the time period at threshold.

4) **Development of Optimal Event-Specific Cadence.** During all of the training the range of cadences one chooses to employ in the specific event(s) involved must be practiced repeatedly. The muscle fiber motor pathways and the muscle fiber firing sequences for smooth efficient pedaling must become "second nature." This can only be achieved by extensive practice. For example, different specific muscle motor pathways are needed for climbing than are needed on the flats. Different muscle cell firing rates are required for high cadence riding than for low cadence riding.

Progressive Power Training designed with proper attention to specificity will increase the force applied to the pedals all around the entire 360 degree circle. This can be done without inducing unnecessary increases in muscle mass. The indiscriminate non-specific resistance training that has been employed in the past is of little value.

We also have seen that the development of the maximum force (or resistance) one can apply to the pedals over the precise range of cadences required for the specific kind of riding or competitive event you wish to do is much more important than the pure development of the force one can apply off the bike via weight training in the gym.
5) **Increasing Power-to-Weight Ratio.** Increased weight impedes the ability to accelerate the bike to greater speeds when needed. Small accelerations occur constantly on any ride, and weight has a direct impact on this kind of acceleration performance. For every ten pounds of body weight gain, significant increases in power are required to sustain a given speed both in climbing hills and on the flats. Power-to-weight ratio can be optimized by avoiding the development of un-needed muscle mass and by decreasing overall weight without significant loss of power.

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**PRINCIPLE #9: INCREASING CADENCE CAN RESULT IN SIGNIFICANT ADVANTAGES**

Since $P = F \cdot v$, it is a fact that one can achieve a given power output either by increasing the force applied to the pedals or by increasing the cadence, or both. Working on increasing cadence at the required power output has definite advantages, as follows:

Increasing the cadence means that the required power output can be achieved with less force on the pedals. This in turn means that less leg strength ($F$) will be required at each pedal stoke to turn the pedals over, and this will reduce the need to develop such massive leg muscles along with the corresponding increase in body weight ($m$). Lower body weight also means better acceleration capability (Principle Number 4). Higher cadence at the required speeds means riding in lower gear ratios. This in turn makes it much easier to accelerate the bike quickly from relatively low speeds up to maximum speeds. Achieving maximum speed more quickly requires less energy, and can save energy when chasing down a break or in the final acceleration needed to come around and win in the last 50 meters of a sprint.

Another significant advantage of using higher cadences is that the requirement of less force on each pedal stroke results in less intense muscle contraction requirements and this in turn can result in less muscle fatigue.

If Lance Armstrong can transition from always riding his triathlon time trials in a big gear at 90 RPM to riding world-class Tour de France time trials at an average cadence of 108 RPM, there should be no question that one can do what is being suggested here. The only thing that could stand in the way of increasing cadence would be a physical limitation due to an inborn bodily imbalance or an imbalance resulting from an injury.
As mentioned earlier, Cycling Hall of Fame Coach Mike Walden (1990) is quoted as saying, “God did not make us to be having our feet going around in little tiny circles!” Therefore, we need to spend time training our feet to be going around at high resistance in little tiny circles and we need to do it with the greatest possible efficiency. This involves the development of cycling-specific neuromuscular recruitment, and it must be done at the very cadences and resistances that are required for the type of riding you wish to do.

What is needed is an increase in the number of sport-specific and event-specific muscle fibers that are recruited, and those muscle fibers must be trained to fire in precisely the right sequence and at precisely the right times to make the pedals go round smoothly with maximum force applied to as much of the 360 degree circle as possible.

Finally, the increase in recruitment must be achieved at the highest possible intensities throughout the entire range of required cadences. This capability can not be achieved by lifting weights in a gymnasium. It can however be achieved by using biofeedback from the Spin Scan function of CompuTrainer or Velotron equipment as described next.

Think of it this way: If for example you now are recruiting a million muscle fibers in your quadriceps to make the pedals go round and round, just think of what can happen if you could cause an increase in cycling specific muscle fiber recruitment to 1.2 million. This is the kind of increase we are talking about with Progressive Power Training. And then, we are causing increases in the diameters (strengths) of all of those cycling specific muscle fibers as well.

As mentioned above it is extremely important for the athlete to maintain proper form on the bike at the highest possible intensity levels. This is precisely the same concept that one uses when lifting weights in the gymnasium. Proper form must be maintained regardless of the intensity. Developing the ability to maintain smooth and even applied angular force (referred to as torque) throughout the entire 360 degrees of pedal stroke must be an absolute requirement. Improving one’s pedal stoke is a matter of improving the muscle fiber firing sequences by re-programming the subconscious mind.

The CompuTrainer / Velotron (CTV) Spin Scan function makes it possible to improve one’s form by using the technique of biofeedback. Pedaling efficiency is displayed by the Spin Scan
software over the entire 360 degree circle on a polar graphic display. The CTV software also displays a valid numerical measure of the rider’s average Spin Scan Efficiency (SSE), defined as the ratio of the average torque divided by the maximum torque:

\[ \text{SSE} = \frac{\text{Average Torque}}{\text{Maximum Torque}} \times 100 \]

If the average torque around the entire 360 degree pedaling circle is equal to the maximum torque, the SSE is equal to 100 percent. What this means is that a very large number of muscle fibers are being recruited at moderate intensities, and the load is being spread out over the entire leg. When (at the same wattage) the SSE is low, you are “stomping on the pedals” and fewer leg muscle fibers are being recruited at a much higher intensity. The net result is that those fewer muscle fibers are experiencing a much higher than necessary intensity level on each rotation of the pedals. This leads to early fatigue of the intensely recruited muscle fibers. When one is “stomping on the pedals” the Spin Scan polar graphic display looks like a sideways airplane propeller. The tips of the “propeller” are at those points on the 360 degree circle where the maximum intensity is occurring.

SSE values for each leg and an overall average value are displayed continuously and are recorded in the computer for later analysis by the coach. The continuous real-time display of SSE allows one to use the principle of biofeedback as a means of learning how to improve pedaling efficiency. By focusing the mind on increasing the SSE in real time one actually can “teach” the mind to make the legs to do the right thing. I teach my athletes to pretend that they have eggshells underneath their feet inside their shoes and that they must “lighten up” on the pedals so as not to crush those eggshells. They are encouraged to wiggle their feet around inside their shoes all around the entire pedal stroke as a means of “lightening up.” Successfully increasing one’s SSE using the biofeedback technique and making it a part of one’s very being can take many, many hours of practice. It is important to spend only a few minutes at a time focusing on improving SSE. Spending too much continuous time on it can lead to injury.

An average recreational cycling athlete will have an SSE of about 55-65 percent. At these lower efficiencies, it is easy to see that the rider is “fighting the bike” and “chopping” at the pedals. The polar graphical plot looks like a sideways figure eight airplane propeller. On the other hand, I have observed with one of my athletes that a sustained efficiency of over 95 percent can be achieved and Al Whaley, my 14 time Masters World Champion, has routinely achieved a sustained efficiency of over 85 percent. At these higher efficiencies the Spin Scan polar graphic display is nearly a perfect circle and the workload is being spread out over the entire leg at lower intensities.
When the SSE is high and the workload is being spread out over many more muscle fibers, they are being recruited at a much lower intensity level. The onset of muscular fatigue is therefore delayed. Also, a higher SSE value means that less total energy is being employed by the athlete to generate a given wattage output. Watching an athlete like Al Whaley pedal in smooth, relaxed perfect circles is like seeing poetry in motion! It is this kind of relaxed, smooth motion that you see in Olympic Champions.

The CTV Spin Scan function allows the coach to determine when a break in form has occurred during the high intensity on-the-bike Progressive Power Training workouts. If form is breaking down, the intensity can be adjusted between sets so that in each set the workout ends with the athlete right at the “brink of failure” to maintain proper form. Progression and success in this program can then be measured quantitatively by identifying when the athlete is able to handle a significant increase in intensity without breaking form.

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**PRINCIPLE #12: THE BENEFITS OF SHORT-TERM MAXIMUM CONTRACTION INTENSITY**

This principle calls for the application of cycling-specific forces that are much, much greater than those required during competition over times that are much, much shorter than are needed in competition. These workouts, when used in conjunction with subsequent longer workouts, lead to the ability to apply greater forces for much longer times. The challenge here is to maximize the intensity one can handle without incurring serious injury. *The way to do this is to taper into the program gradually at first.*

According to the principle of maximum contraction (see [www.maxcontraction.com](http://www.maxcontraction.com)) it is the intensity of the exercise, and it is not the number of sets and repetitions, nor is it the duration of the exercise that determines how much one’s strength will increase. It is possible to elicit significant increases in strength in the gym with only one set of one repetition lasting only about 5-10 seconds, provided the intensity is sufficiently great. One does not need to spend hours per day and multiple days per week in the gym to dramatically increase muscle strength. Once the targeted strength levels have been achieved, one need only perform one maximum contraction exercise every two weeks to maintain the strength gains achieved using the max-contraction program. These same principles have been applied in designing the Progressive Power Training program.
A cycling-specific example would be a workout involving only 5-10 pedal strokes at extremely high resistances (much higher than ever will be encountered on an actual group ride or in competition) and in the precise range of cadences required for the desired event or ride. The goal should be to experience the maximum possible intensity at those specific cadences.

Precise data needs to be recorded by the coach identifying the maximum power outputs achieved during the workouts at each specific cadence employed. It is extremely important not to make these workouts too intense for the given stage of an athlete’s development. Too much intensity, too soon, will result in injury. Patience is needed.

To my knowledge such brief, extremely intense progressive on-the-bike workouts can only be achieved using CompuTrainer or Velotron equipment. It can not be done out on the road or on the bike at a velodrome, even with motor pacing, nor can it be done on a stationary wind or magnetic trainer, on a “Spinning” bike, or on a bike ergometer unless it can be specifically programmed to force such short-term extreme intensities.

The CTV system allows one to develop and modify internal software programs that can easily be tailored “on the run” to the specific needs of each athlete. The software programs must be continuously modified to force the athlete to experience the required extreme high intensities for the short times needed to make significant progress.

PRINCIPLE #13: MUSCLE FIBER RECRUITMENT IS POSITION-SPECIFIC

We already know that strength is speed-specific (Principle #6) and we now need to recognize the important fact that meaningful muscle cell recruitment is position-specific. It should be obvious from this that workouts on anything but the cyclist’s own bike in precisely the most powerful position possible is a must for ALL key cycling workouts.

It is less than optimal to do workouts on equipment that can not duplicate precisely the same position as the rider’s own bike. One therefore should avoid using bikes, Lifecycles, “spinning” bikes or ergometer bikes that are not set up exactly like one’s own bike. Your derriere, your feet and your hands must be in exactly the same position is space as they are on the bike you plan to use in competition or out on your favorite target ride. Being off by only a few millimeters can make a significant difference.
This is just another reason why weight training workouts in the gym are irrelevant to the development of significantly increased speeds on the bike. The recruitment simply is not the same.

Whichever bike you want to perform better on (road bike, TT bike, track bike, mountain bike, BMX bike) is the one to use for the Progressive Power Training workouts.

**PRINCIPLE #14: THE PROPER ROLE OF MOTOR PACING**

Motor paced workouts can be of immense value in improving one’s speed on the bike. However, motor paced workouts can be dangerous if the person driving the car or the motorcycle is not experienced, and they also can be very time consuming. Moreover, the progressive levels of extremely high intensity with meaningful feedback on the preservation of form that are required to develop truly significant increases in power output, while improving pedaling smoothness and pedaling efficiency can not be achieved in motor paced workouts.

One good application of motor pacing results in acclimatization of the athlete to riding at high speeds in the draft for long periods of time with only moderate stress. This is an experience that simulates riding fast within the shelter of the peloton at low heart rates while conserving as much energy as possible. There is a significant psychological benefit to getting used to seeing and “feeling” the scenery passing one by at high speed.

Superb race-specificity is achieved when the rider is motor paced up to race speed and then is required to come around the motor and face the wind while accelerating in the final 50 meters (7-15 pedal strokes) before the finish line. These are called “come-arounds” and they can be practiced either on the road or on the track. The measure of progress is the maximum speed that can be achieved during the final acceleration period.

Motor paced workouts on the track can provide some truly powerful specificity. They allow the athlete to experience the relevant speeds, accelerations, and G-forces, and to learn how to follow the best “line” in time trials and to practice all of the specific tactics needed to win.

The main role of motor-paced workouts should be to bring the rider up to speeds that are equal to or greater than race speeds in event-specific race gears, without excessive expenditures of energy, so that the actual short-term training efforts can be made at maximum speeds and wattage outputs. The main difference between motor-paced workouts and Progressive Power Training workouts is that the intensities (wattages) that can be imposed upon the athlete normally
are much lower with motor-pacing than with Progressive Power Training on CompuTrainer or Velotron equipment.

Motor paced interval workouts simply allow the athlete to avoid the fatigue of accelerating up to speed so that the main focus can be on delivering as much energy as possible at or near actual race speeds.

**PRINCIPLE #15: THE IMPACT OF AERODYNAMICS**

The effects of improvements in aerodynamics can be significant. However, there is much more to aerodynamics than simply minimizing frontal area or minimizing the flow of air around the rider and bike. What is more important is to minimize the creation of excessive turbulence and drag as the air separates from the rear of the rider and bike without losing significant power at the pedals. One therefore must make a compromise between improving aerodynamics and losing power at the pedals.

Given that recruitment is position-specific, any improvements in aerodynamics will require patience and time on the new setup to achieve optimal gains. It simply is not possible to achieve the full benefits without extensive practicing in the new position on the bike.

Acquiring relative power outputs for various positions on the bike during an individual one-day wind tunnel test may be misleading because there is no time for the new muscle cell firing patterns and motor pathways to be “trained.” What is valid is the measurement of relative aerodynamic drag. To test whether the choice of a lesser aerodynamic drag is beneficial, it may be necessary to allow time for adaptation by training for awhile in the new position and then return to the wind tunnel to determine if being more aero is causing any significant loss of needed power.

**PRINCIPLE #16: DEVELOPMENT OF THE PC ENERGY SYSTEM IS ESSENTIAL**

In short all-out surges to rejoin or bridge up to a group in front of you and in all-out sprints lasting ten seconds or so, the principal energy system employed is the phosphocreatine (PC) energy system. The wonderful thing is that the PC energy system utilizes no oxygen and creates no lactic acid. In-situ PC must be available at the working cell level to be effective during a surge or sprint, and the PC in the working cells may be used up completely so that the cellular PC concentration at the end of the surge or sprint could be zero. This is what happens when one’s legs “turn to rubber” during a maximal effort.
Sport-specific training can result in a significant increase in the in-situ PC concentration in the working cells. This makes it possible to increase the length of time one can perform at maximum wattage output by as much as five seconds or more. It should be obvious that this could be extremely significant in catching back onto a group ahead or in any final sprint in a bike race. An extra few seconds in an all-out sprint could mean the difference between winning and not placing at all.

PC specific training also increases the concentration of the enzymes (catalysts) that speed up the rate of delivery of adenosine tri-phosphate (ATP) and energy to the working muscle cells, and it also speeds up the rate of PC regeneration after the surge or sprint. This makes for faster surging / sprinting and faster recovery of the PC stores after each effort.

PRINCIPLE #17: SURGING AND SPRINTING REQUIRES A STRONG AEROBIC ENGINE

At the end of each all-out maximum effort in a surge or a sprint, the in-situ cell-level PC concentration is effectively gone, and must be restored before the next effort. In a criterium race with many “prime” sprints, in a track points-race or in a Madison race complete recovery between sprints is a must. The energy system that restores the PC is the aerobic energy system, and it therefore is mandatory that the aerobic energy system be in good condition to do the job. Traditional sprint coaching often has neglected the need for development of the aerobic engine.

What happens if the aerobic system is weak? After each surge or sprint the body’s ability to restore the PC becomes less effective, so that in the later surges and/or sprints the PC energy system simply is not available at full strength.

Development of an adequate aerobic energy system requires many hours spent training at specific sub-maximal heart rates. This important training is money in the bank when it comes to recovering between surges and sprints.

If the aerobic system is not maintained on a continuing basis, it will deteriorate rapidly, and restoring the aerobic engine to its original level can take a long time. It therefore is important not to neglect the maintenance of this important system at any time during the preparation process. Aerobic training is a year-round requirement if you want to achieve increased speeds on the bike.
PRINCIPLE #18: THE ROLE OF THE LACTIC ACID ENERGY SYSTEM

Development of the lactic acid energy system is important for those wishing to ride all-out for as much as a minute or more. The lactic acid energy system begins to be invoked when an all-out effort lasts longer than 10 seconds or so. When this happens, blood lactate levels can increase dramatically and can reach a maximum after 45-60 seconds of all-out riding. During these longer all-out efforts, the muscle glycogen stores are used up rapidly and there is a concurrent increase in cellular acidity. The increased acidity results in inhibition of muscle contraction capability, and then one’s performance rapidly deteriorates. What is important is to train the body to generate less lactic acid so that blood lactate values are lower during all-out efforts lasting longer than 10 seconds, up to one minute or more.

The rate of removal of lactic acid from the bloodstream and its conversion to harmless CO2 and water can be improved by specific targeted intense training intervals at heart rates that are above lactate threshold. When the appropriate physiological adaptations have taken place, the concentration of lactic acid in the bloodstream will be less at every heart rate and wattage output, and this makes it possible to sustain a greater intensity of effort for a longer time.

Training the lactic acid system involves extremely intense interval efforts. Such training must be used judiciously and the timing of the interval training relative to any important big event must be planned carefully. Otherwise, overtraining syndrome and impaired performances will invariably be the unintended result.

Serious benefits can be achieved by developing a strong upper-body aerobic system as well because the proliferation of upper-body muscle-cell mitochondria results in an enhanced capacity for the removal of lactic acid from the bloodstream during all-out efforts. The lactic acid that is being generated in the legs will be removed by the upper-body mitochondria. This means that the rider’s blood-lactate and heart rate will be lower and the rate of recovery from each effort will be enhanced.

Some of the exercises my clients have used to achieve upper body aerobic fitness include swimming and the use of the Upper Body Ergometer (UBE) machine in the gym.

PRINCIPLE #19: CONSISTENCY

A rider can not develop speed using a spotty and inconsistent training schedule. To get results there can be no excuse for inconsistency except in the case of injury. If injury occurs during the
training program, then something could be wrong with the coaching, perhaps the result of increasing the intensity too soon. Coaching feedback should be available on a day-to-day basis with an eye toward preventing any lapses. Close supervision of the intensity workouts is highly recommended for riders wanting to minimize the possibility of incurring overtraining syndrome or injury.

Without question, day-to-day consistency during the training and preparation period must be given the highest possible priority. Focusing on consistency along with slow, gradual, positive progress is more important than focusing on any urgency to increase the volume or the intensity applied during training.

It can take at least five years of paying incredible attention to consistency and gradual improvement if one is to reach maximum potential. Therefore, a great deal of patience is needed on the part of both the rider and the coach, no matter how difficult it may seem.

For a relatively untrained recreational rider or racer, significant improvements can be realized in just 6-8 weeks, because of the much lower starting point. This is exactly the same phenomenon that is observed in the gym, when an untrained person begins working out in a resistance program with a personal trainer. Achieving one’s maximum possible individual performance level can take much longer.

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**PRINCIPLE #20: RECOVERY**

Recovery is the absolute key to success in a Progressive Power Training program. The desired increases in muscle strength and in muscle-cell recruitment patterns come mainly during the recovery process and not during the actual workouts. The key to success in coaching riders is to not expose them to overtraining syndrome during the Progressive Power Training process. Every rider is different in their recovery needs. Failure to attend to this important aspect of preparation will invariably lead to failure to perform.

The super-intense workouts that are needed to achieve a high level of fitness must not be conducted more than twice per week, depending on the intensity applied. One truly intense workout per week is sufficient for making forward progress when super-maximum intensities are applied. Any more will lead to an inability to recover and get stronger.

For recreational riders and racers, the super-intense workouts are not recommended because they can lead to overuse syndromes and possible injury unless close coaching supervision of the
workouts is available. In this case, two workouts per week may be acceptable because of the lower intensity, but our experience is that one workout per week can lead to significant progress, as long as plenty of recovery is factored into the program.

The best formula for recovery is easy to moderate intensity aerobic training on the bike and active recovery activities. Ice baths are recommended immediately after the super intense workouts, followed by massage at some point between workouts.

**PRINCIPLE #21: NUTRITION AND BODY COMPOSITION**

Controlling and minimizing body fat percentage is another key to success. Every pound of unnecessary excess body weight can limit a rider’s quickness, acceleration and achievable top speed. It therefore should be an objective to optimize body fat percentage to the lowest value possible without compromising health and performance capability.

The desired result can only be achieved by specifying a very gradual long-term fat-loss program in conjunction with an improved total body muscle-mass program. It simply can not be done on a “crash” basis or else it will fail.

I recommend Chris Carmichael’s book “Food for Fitness” which emphasizes how to manage eating to optimize the training benefits. Optimizing body fat requires a carefully planned and disciplined long-term approach. It can not be achieved overnight.

**PRINCIPLE #22: NO TWO ATHLETES ARE THE SAME**

In the past many coaches have made a practice of suggesting that all of their athletes do the same workouts. The coach simply writes out a program and distributes it to all of the riders who are on his program, expecting them to carry out the orders. This simply does not work. The needs of each athlete are different. Every athlete has differing strengths and weaknesses that need specific attention.

One rationale for requiring all riders to perform the same workouts would appear to be one of pitting them against each other in terms of relative performance in order to make them constantly be competing against each other. Although useful on an occasional basis, this kind of thinking can be totally counter-productive.
Superior coaches will recognize the need for individual treatment of each and every athlete in terms of the overall program as well as in the design of the specific workouts that are included in each of the individualized training programs.

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**PRINCIPLE #23: MIND OVER MATTER**

It has jokingly been said, "If you don’t mind, it doesn’t matter!" It turns out that winning a bicycle race, and especially sprinting, is mostly mind over matter in the end. In the 1986 World Championship match sprint finals, Lutz Hesslich came around to win from behind Michael Hubner’s rear wheel with only 80 meters to go to the finish line. In a post-race interview, Hesslich was asked, "How do you do that?" His answer: “It is all in the mind. I tell myself … I am here … I am there!!!” He was holding up his hands with one hand behind, and then he moved it quickly to in front of the other hand. In effect, Hesslich claimed to have literally propelled his bike forward through space with his mind!

In the 1997 Master’s World Championships on the 250 meter velodrome in Manchester, England, American sprinter Al Whaley came off of Australian Geoff Stoker’s rear wheel coming out of the final turn with only 65 meters to go and came across ahead at the finish line. The crowd gave him a standing ovation during his victory lap. Al was specifically coached during practice and in his training races to adopt Lutz Hesslich’s mind-over-matter method. It really works!!

An athlete’s mental attitude is important not only in the actual competitions, but also during the long and tedious preparation periods. It is the mind that defines whether an athlete is capable of maintaining the needed dedication, consistency, patience, long-term goals and day-to-day focus to transform both the mind and the body into a faster unit.

This same “mind over matter” mental attitude and focus can help any cyclist to become a better rider, especially when the “hammer” goes down.

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**PRINCIPLE #24: PRACTICE, PRACTICE, PRACTICE**

Improvements in sport specific muscle cell recruitment patterns and in sport-and-event- specific neuromuscular firing patterns can only be achieved with extensive practice.

Improving cadence, smoothness and improved pedaling efficiency takes practice. It takes hours and hours of practice with intense focus and intense concentration in order to make improvements in these three important aspects of cycling. One must develop the ability to
maintain these attributes of smoothness, increased cadence and pedaling efficiency without breaking form even when the resistance goes off the chart.

Mary Lou Retton did not make “10’s” in her Olympic gymnastic events without doing the hours and hours work needed to insure that every single muscle cell in her body would be recruited at just the right times and in just the right muscle-cell firing sequences, to perfection. Michael Phelps did not break form in his world record-breaking efforts in Beijing, even when he was performing at the maximum possible intensity. These results can only be achieved through extensive practice.

This same principle applies to anyone who is truly serious about improving their speed on the bike.

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**PRINCIPLE #25: THERE ARE NO MIRACLES IN SPORT**

I am convinced that truly outstanding performances can be achieved by doing appropriate hard work. Of course, some cyclists have realized “outstanding” performances, beyond what was normal for them, by taking drugs or by blood doping.

Lance Armstrong spent every winter doing the necessary hard work, while Jan Ullrich was taking time off and partying. Chris Carmichael is quoted as saying, “Every year, Lance wins the Tour [by the training he does] between November and January. He makes the biggest gains in the off-season.” Think of it.....the race is in July! I believe that if Jan had been willing to do the same hard work, there would have been no need for him to even think about becoming involved in doping.

Sometimes athletes dream that even though they have not performed during training to a level that would be fast enough on their important rides or races, a miracle will happen and they suddenly will be able to perform much better on the day of their big event. Somehow they just keep on “testing” themselves during their favorite group rides or in weekly races, and they never get better.

When this happens, it is much more effective to go back to the drawing board and do the work that is needed to demonstrate during training that the desired strength, power production and speed(s) have been achieved. When this has been done, there is no need to entertain unrealistic expectations about miracles, because the results have already been achieved in practice.
The program outlined in this book involves the new concept of doing sport-specific and event-specific Progressive Power Training on the bike. In my research for the book I have been unable to identify anyone in the world who is practicing this concept. Many coaches currently are advocating progressive resistance training in the gym as a means of improving cycling performance. My experience is that beyond a certain point, switching to Progressive Power Training on the bike can result in spectacular improvements in performance on the bike, well beyond what can be achieved by continuing with workouts in the gym.

It’s all a matter of being committed to doing the necessary hard work! Very simple.

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**PRINCIPLE #26: SUCCESS IS PEACE OF MIND**

UCLA Bruin basketball Coach John Wooden, arguably the greatest basketball coach who ever lived, taught his athletes that success has nothing to do with outcome (I happen to be prejudiced about Wooden because I am a graduate of UCLA). John’s thoughts on success can be paraphrased as follows:

“Success is *Peace of Mind*, which is the direct result of knowing in your heart that you have done everything possible to become the very best that you are capable of becoming.”

He taught his athletes to not pay any attention at all to the scoreboard during the game, but instead to focus on being at their very best every millisecond of the game. The real test of success is whether or not you can say to yourself on the way home after the game is over that you gave it your all, and you held nothing back.

Failure is when on the way home from your big event you are kicking yourself all around the block and you are saying to yourself, “If only I had done this or if only I had done that!” By focusing on preparation and performance rather than on outcome, UCLA won ten NCAA championships, seven in a row, during John Wooden’s tenure as the coach. By focusing only on performance during the games, the results took care of themselves.

Peace of mind can be earned by sticking to the program and doing everything you know of in the practices to get ready for the big event. It means many, many hours of practicing the fundamentals in sport-specific and event-specific drills and workouts.

There is no greater achievement in life than to have *Peace of Mind*. 

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CHAPTER 4

THE SCIENTIFIC AND TECHNICAL BASIS FOR THE NEW PROGRAM

This chapter describes the scientific and the technical basis that has been used in designing the workouts that will lead to the development of the ability to ride at faster sustained speeds and to surge, sprint and recover more quickly.

ATP ENERGY SYSTEM SCIENCE

Adenosine triphosphate (ATP) is the single most important molecule in the body for delivering energy directly to the working cells. It has been called the “energy currency” for all forms of biologic work. The energy liberated by the breakdown of ATP is described by the chemical equation:

\[
\text{ATP} \rightarrow \text{ADP} + \text{P} + \text{ENERGY}
\]

Where ADP is adenosine diphosphate and P is a phosphate molecule. This reaction requires no oxygen, it produces no lactic acid, and it is by far the fastest energy producing chemical reaction in the body. Every other energy producing chemical reaction in the body generates ATP molecules first which then decompose as shown above to liberate the needed energy.

There is only enough ATP inside the cells to provide the energy needed in a maximum exercise of only a few seconds. All of the additional energy needed is provided by molecules that can break down to form ATP. The molecule named creatine phosphate or phospho-creatine (PC) is stored within the working cells and is the next fastest source of energy when it breaks down in-situ to form ATP.

PC ENERGY SYSTEM SCIENCE

The phospho-creatine (PC) energy system is the main energy delivery system employed during brief all-out sprints. The PC energy system is unique in that it uses absolutely no oxygen and
most importantly, it produces absolutely no lactic acid. It is the second fastest energy delivery system in the entire human body.

When extreme demands are placed upon the human body, Mother Nature rises to the occasion by invoking the PC system. However, PC is in limited supply. Normally there is only enough PC available to last for about 10 seconds or so of all-out effort. Near the end of the effort the concentration of PC in the working muscle cells actually can go right to zero. After that, the PC system is out of gas, your legs turn to rubber, and there is no more speed left in them.

Increasing the concentration of PC in the working muscle cells and increasing the concentration of creatine kinase enzyme, the catalyst that speeds up the delivery of PC energy, can be extremely valuable when one needs to surge or to sprint. Increased enzyme concentrations also will reduce the time needed to recover between surges or sprints. The **PC Drill (PC)** workouts and the **Progressive Resistance Speed (PRS)** workouts can make this happen.

Proper execution of a progressive PC Drill program can dramatically increase the amount of PC available in the working cells. This in turn can increase the amount of time that one can perform an all-out sprint by several seconds. Just two seconds more can add as much as 40 meters to one’s sprint before the legs go. It could be the difference between winning and not even placing.

When the PC drills are carried out, it is important not to allow acidity and inflammation to develop in the muscle cells because when the cells are acidic and inflamed the desired physiological adaptations simply will not take place. Increased acidity also inactivates the energy-transfer enzymes and makes them less effective. It therefore is important to follow the PC drill workout instructions to the letter by not allowing the heart rate to increase very much beyond the base level.

In the past, sprinters (and gym-rats) have believed that orally ingesting PC (often referred to as “creatine” in the gyms) will make them a better sprinter. One problem is that oral PC distributes itself all over the entire body, not just in those cells that are going to do the work. A big disadvantage is that water is stored along with the ingested PC, adding useless body weight. There is no serious scientific evidence that ingested PC is of much value for sprinters.

The progressive PC drill workouts place both the added in-situ PC and the corresponding enzymes in the very muscle cells that are actually doing the work (precisely where they are needed) without adding any useless and unnecessary water weight.
Development of a strong aerobic engine is an important key to going faster on the bike. A strong aerobic engine will permit you to deliver and sustain a higher wattage output provided you have already developed sufficient sport-specific muscular strength in the legs. Aerobic training increases the concentrations of the important catalytic fat burning enzymes and Krebs cycle enzymes. This in turn increases the rates of aerobic energy generation from fats and aerobic (as opposed to anaerobic) energy generation from carbohydrates.

Aerobic training also leads to significant increases in the number of capillaries and energy-producing mitochondria in the working muscle fibers. Increased capillary density increases the ability to transfer oxygen and nutrients to the mitochondria and to remove the chemical reaction by-products more rapidly.

Aerobic training is serious money in the bank when it comes to recovering between sprint matches on the track or between “primes” in a criterium race. It is the aerobic energy system that provides the energy needed to reverse the chemical reactions and to restore the in-situ PC and ATP concentrations in the working muscle cells between efforts. This in turn preserves the ability to be competitive in the later rounds of the match sprint competition, or in the final sprint of a bike race.

If the aerobic system is weak, the PC muscle cell concentrations that are being depleted during successive all-out efforts can not be fully restored, and the efforts will become shorter and weaker as time goes on. Moreover, when the PC concentrations become depleted, the anaerobic lactic acid system kicks in, and then enzyme-inhibiting acidity builds up to slow down the rates of PC and ATP energy delivery. Not good news!

As mentioned in Chapter 3, development of an adequate aerobic energy system requires many hours spent training at specific sub-maximal heart rates. When the aerobic engine is strong, stored muscle cell glycogen is spared in favor of burning fat during normal riding. This is what makes it possible to go really fast when the hammer goes down near the end of the ride.

When training aerobically it is important not to allow your heart rate to go above the specified aerobic maximum rate (somewhat lower is fine). If you ride too hard and generate significant acidity and inflammation during such a ride, the important physiological adaptations that need to take place simply will not happen. Inflammation and acidity in the muscles effectively inhibits such changes from occurring. On long rides it may be necessary to slow down in the last hour or
so to prevent the heart rate from going above the target. And, it is vital to use self discipline to avoid getting sucked into “hammering” on an aerobic training ride.

Science has shown that it takes many months to develop a strong aerobic engine, and if the aerobic system is not maintained on a continuing basis, it will deteriorate rapidly. Restoring the aerobic engine to its original level can take a long time. Just one month of neglect of the aerobic system training could require as long as three months of specific aerobic training to restore it to its original condition. It therefore is important not to neglect the maintenance of this important system at any time during the preparation process.

Serious benefits for cyclists can also be achieved by developing a strong upper-body aerobic system as well. The proliferation of upper-body muscle-cell mitochondria results in an enhanced capacity for the removal of lactic acid from the bloodstream during all-out efforts. The lactic acid that is being generated in the legs will be removed by the upper-body mitochondria. This means that one’s blood-lactate and heart rate will be lower at all levels of effort, and the rate of recovery from each hard effort will be enhanced.

The upper body aerobic system is best developed through swimming, but it also can be improved by the use of an Upper Body Ergometer (UBE) machine, which can be found in most gymnasiums. My clients have used both methods to good advantage.

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**ANAEROBIC ENERGY SYSTEM SCIENCE**

The anaerobic energy system comes into play when the intensity of a prolonged (longer than 10 second) effort exceeds the ability of either the PC energy system or the aerobic energy system to provide the needed energy. When the energy demand is low, the aerobic system is able to provide 38 molecules of ATP per molecule of carbohydrate consumed and very little lactic acid is produced. However, when the energy demand is extremely high, the anaerobic energy system comes into play and it can only provide 2 molecules of ATP per molecule of carbohydrate consumed, and lactic acid is rapidly produced as a by-product.

Since each molecule of ATP delivers only one unit of energy, high demand causes the carbohydrates to be consumed by as much as 19 times faster than when the aerobic system is dominant. It is just like that giant “sucking” sound of fuel consumption that you get when your car accelerator is floored! In this mode a significant fraction of the carbohydrates (glycogen) stored in the muscle cells can be consumed in as little as 5-10 minutes depending on the intensity of the effort and one’s ability to tolerate the pain.
The way Mother Nature works is this: when a prolonged increased demand for energy is called for, the body does everything it can to meet that demand, so it invokes the very inefficient anaerobic lactic acid system as the last resort.

The body’s lactic acid clearance system may be what is known in chemical engineering science as a mass-transfer limited process. This means that the rate of removal of lactic acid is not necessarily limited by any chemical reaction. Instead, it may be limited by the rate at which it can be transferred from the blood stream across a cell membrane so that it can then be eliminated from the system by a chemical reaction which converts it to CO2 and water. If the rate is not limited by mass-transfer across a membrane, then it most certainly is reaction-rate limited. In either case the following principles apply:

When lactic acid is being generated, all of the lactic acid actually is being removed at precisely the same rate that it is being generated, and when the lactic acid removal is either mass-transfer limited or reaction rate limited, the rate of removal is directly proportional to the concentration of lactic acid in the blood stream. Therefore, in order to insure that all of the lactic acid is being removed at the same rate that it is being generated, Mother Nature causes the concentration of lactic acid in the blood stream to increase so as to make that happen.

When lactic acid (or lactate) concentrations become elevated, there is a corresponding increase in the concentration of hydrogen ions (H+). The increased hydrogen ions cause an inhibition of muscle cell contractions and performance degrades accordingly.

The rate of transfer of lactic acid across the cell membranes and the rates of the removal reactions can be increased by appropriate training. When this happens, the concentration of lactic acid in the bloodstream that is required to cause the rate of removal to match the rate of generation will be less, and this makes it possible for one to sustain a greater intensity of effort for a longer period of time.

Remarkably, the heart muscle utilizes lactic acid as one of it main fuels for generating needed energy and converts it to CO2 and water in the process. When the concentration of lactic acid builds up in the bloodstream, it is just like pumping more gasoline into the carburetor, and the heart muscle responds by increasing the heart rate just as your car engine increases its RPM when you step down on the accelerator.
As mentioned above, serious benefits can be achieved by developing a strong upper-body aerobic system. The proliferation of aerobic upper-body muscle-cell mitochondria results in an enhanced capacity for the removal of lactic acid from the bloodstream during all-out efforts.

THE ROLE OF ENZYMES

Enzymes play an absolutely critical role in sport. An enzyme is a catalyst that serves to speed up those chemical reactions that deliver energy to the working muscle cells. Enzymes also serve to speed up the recovery and restoration of the energy delivering molecules after the effort is over. An enzyme catalyst is not a part of the energy-delivering chemical reaction: it is neither a reactant nor is it a product. When present at the site where the chemical reaction is taking place, the enzyme accelerates that reaction. This is important in sport, because faster energy delivery means a faster cyclist.

The following example involving the phospho-creatine (PC) energy system (the main and most important system employed in sprinting) illustrates how it works:

\[
PC + ADP \rightarrow C + ATP \quad \text{(The Catalyst is Creatine Kinase)}
\]

\[
ATP \rightarrow ADP + P + ENERGY! \quad \text{(The Catalyst is ATPase)}
\]

In the first reaction, the adenosine diphosphate (ADP) molecule strips the phosphate atom off of the phospho-creatine (PC) molecule and forms adenosine triphosphate (ATP) plus creatine (C). In the second reaction the ATP in turn releases the phosphate atom and produces energy. This is the most fundamental energy-delivering chemical reaction in your body. The rates at which the above two reactions can proceed are directly proportional to the concentrations of enzymes present at the chemical reaction site.

Both of the above reactions are reversible. That is, both the ATP and the PC are restored by the backward reactions when new energy is supplied via the aerobic energy system. This is the net result of the heavy breathing that takes place after a hard effort is over.

The concentrations of the enzymes at the reaction sites - and hence the speed of energy delivery to the working muscle cells - can be increased dramatically by appropriate training (Ann. N.Y. Academy of Science 301:3, 1977).
Figure 1 shows how the Krebs cycle enzymes can be increased by consistent aerobic training (the Krebs cycle produces ATP from carbohydrates and fats). Note that it can take as much as two years to double the Krebs cycle enzyme concentrations. Also note that if one stops training completely, those benefits can go away in as little as one month. This is just one of the reasons why aerobic engine training is so important to success in becoming faster for all cycling disciplines.

![Effects of Training on The Aerobic System](image)

Figure 1. Krebs cycle enzymes and the effects on training the aerobic system

From an engineering point of view, doubling the Krebs cycle enzyme concentrations can produce a 26 percent increase in speed on the bike, or approximately 5 miles per hour in TT mode. Tripling the Krebs cycle enzyme concentrations can potentially increase your speed by 44 percent (approximately 9 miles per hour in TT mode). This arises because of the fact that the energy requirement increases as the cube of your bike speed. It takes many years of consistent aerobic engine development to be able to ride a TT at 30-35 mph.
MAINTENANCE OF PREVIOUSLY DEVELOPED ENERGY SYSTEMS

As with weight training, some of the energy systems, once developed, can be maintained by doing a limited session once per week. This is true of the Lactate Threshold (LT), the PC energy system and the anaerobic lactic acid (AL) energy system.

It is, however, not true of the aerobic energy system. For every day in which the aerobic engine is not trained, one can lose as much as three percent of one’s aerobic fitness. The rule of thumb for maintaining the other three energy systems is as follows:

**LT:** One or two 20 minute LT efforts per week.

**PC:** One PC Drill or Sprint Session per week.

**AL:** One AL interval session (30 to 60 second intervals) per week.

One must be careful not to overdo the anaerobic lactic acid (AL) intervals. Too much emphasis on AL intervals can lead to overtraining syndrome. Also AL intervals actually tear down the aerobic energy system. This is why it is important to develop a strong aerobic engine before beginning serious AL workouts. Such work is normally reserved for the six to eight week period leading up to a major event.

MUSCLE CELL AND MUSCLE FIBER CONTRACTIONS

Muscle fibers containing many muscle cells are activated by the nervous system to contract and provide force. In addition, motor units containing many muscle fibers also may be activated to cause numerous fibers (and cells) to contract simultaneously. After firing, the muscle cells normally will relax completely, releasing the contraction, and they then recover and become ready for the next contraction.

For simplicity of expression in the discussions that follow, the term “muscle-cell” will be used interchangeably with the terms “muscle fiber” and “motor unit” even though the terminology is not entirely accurate.

When muscle cells contract they do not just partially contract: each individual cell (and fiber) contracts one hundred percent. It then can relax and recover one hundred percent, and all of this action can take place in mere milliseconds. If these processes are not working just right, serious
problems can be the result. For example, if every muscle cell in your calf decides to fire at once, and the cells do not relax right away, the result is a serious and very painful cramp!

If the muscle cells are not firing properly, the cyclist ends up “stomping on the pedals” “pedaling in squares” and “fighting the bike” in order to propel it forward. Appropriate training, along with proper nutrition and electrolyte maintenance, can have beneficial effects on the smoothness, efficiency, and speed of both the contraction and the relaxation / recovery processes. It should be noted that during prolonged intense anaerobic efforts the muscle cells become acidic and inflamed. When this happens, the contraction processes are inhibited and it then becomes impossible to perform optimally.

Nutritionally, attention needs to be given to calcium intake, magnesium intake, sodium intake, and potassium intake. If the athlete is required to perform in a hot climate, sodium intake is particularly crucial. A high-sodium energy drink such as PowerBar Endurance can help eliminate any problems in hot weather.

MUSCLE CELL AND MUSCLE FIBER FIRING PATTERNS

Only a fraction of the total muscle cells in the legs are active at any given time in producing the cycling motion. When one uses a pedaling style that is not smooth and one is “punching and stomping” on the pedals, even fewer cells are being activated, and those cells will be experiencing a much higher intensity level. This can lead to early fatigue.

When the pedaling style is smooth and circular, the work load is being spread out among muscle cells over the entire leg and the intensity experienced by each cell will be lower, leading to a delay in fatigue as compared to what happens when “pedaling in squares.”

What is important is appropriate recruitment. We need to enlist the recruitment of as many muscle fibers and motor units as possible that can be made capable of propelling the bike forward. We need to expand the recruitment of every possible muscle fiber and motor unit that can achieve that end. At the same time, we need to minimize any increases in muscle mass that can not be recruited to propel the bike forward. This is precisely where Progressive Power Training comes in.

It is extremely important to train the muscle-cell firing patterns to be perfectly smooth. The result will be a smooth, fluid, circular pedal stroke, and this needs to be maintained even at the highest
workloads. The appropriate measure of pedaling smoothness is the CompuTrainer Spin Scan Efficiency (SSE).

MAINTAINING AND IMPROVING FORM

When one watches the finish of a world-class competition among track and field runners the true champions rarely break form as they cross the finish line. The “also-rans” can be seen to be chopping away with their arm swings and their strides, with tense neck and facial muscles, just struggling to “fight” their way to the finish. The ability to maintain super-smooth form all the way across the finish line is absolutely vital to success.

In cycling, fighting the bike is a no-no, because it just causes one to go slower. However, we see it happening all the time! The intense Progressive Power Training workouts recommended in this book all require that form be monitored by tracking the SSE values throughout the effort. Working on improving one’s ability to maintain form can be accomplished by using the bio-feedback information provided by the Racermate Spin-Scan software. This is one of the huge advantages of using the CompuTrainer / Velotron (CTV) system.

When an athlete is working on form, both the brain and the muscle-cell firing patterns are being re-programmed to cause every active muscle fiber to fire at just the right time and in just the right sequence. Repeated practice sessions cause the programming to become permanently embedded in the brain, so that the athlete does not need to think about it any more. It just happens naturally.

Studies have shown that it takes at least six weeks of focused practice to develop a new habit. Maintaining that new habit requires the continuation of occasional repeat practice sessions, or else the new habit will slowly go away.

MAINTENANCE OF PREVIOUSLY DEVELOPED MUSCLE STRENGTH

Once a given degree of muscle strength has been developed it can be maintained by activating those muscles as little as once per week. Olympic Cycling Weight Training Coach Harvey Newton contended that strength developed in the gym could be maintained by lifting only once per week. According to Coach Newton, after a warm-up set with lighter weights, only one set of one repetition should be needed to do the job using the same amount of weight you were able to lift at the end of the winter strength development program.
The developer of the Max Contraction concept (www.maxcontraction.com) suggests that only one set of one super-intense repetition is needed either once every week or once every two weeks to maintain strength. You will be able to tell if you are losing strength if it no longer feels like you could do more than that one repetition. When that happens, simply go back to the basic strength development program for a short period of time.

THE PROPER USE OF HEART RATE MONITORS AND POWER METERS

Heart rate monitors are useful only for training sessions at lactate threshold (LT) and below. This mainly allows one to make sure that the training intensity is not too great.

When the efforts are anaerobic (above time trial heart rate) a heart rate monitor is of little use because of the significant lag in time for the heart rate to stabilize. This is where power meters such as the SRM or Power Tap and the Computrainer / Velotron power displays are of great value.

THE ABILITY TO TOLERATE STRESS IS FINITE

There are three types of stress that one must deal with in training:

1) Physical Stress
2) Mental Stress
3) Emotional Stress

The big problem is that all of these three stresses are additive and a human can stand to tolerate only a finite total amount of stress. Therefore, if emotional stress is taking up one hundred percent of one's total stress handling capacity, it becomes impossible to carry out the workouts in the physical stress category that will make one a faster rider.

Improving one's cycling speed demands that the stresses in categories (2) and (3) be minimized during training.
CHAPTER 5

SPORT-SPECIFIC COMPUTRAINER / VELOTRON WORKOUTS

This chapter is written specifically for those athletes who are using either CompuTrainer or Velotron equipment in their program. All of the detailed Progressive Power Training workout descriptions are presented in the Appendix I. The Progressive Power Training program currently requires the use of *.CRS course files, which can be used in the Challenge PC1 software for CompuTrainer or in CompuTrainer or Velotron Coaching software. The 3D software also can be used but I have had much greater success using the 2D Challenge PC1 software in conjunction with the Coaching software. A description for how to use the 3D software can be found in “How to Use the CompuTrainer 3D System” on page 72.

HOW TO GET STARTED

If you plan on using a CompuTrainer you need to check the kind of rear skewer that is on your bike. The new fancy aero rear skewers do not work, so you will need to replace them temporarily with one of the older type of skewers that fit on the trainer and hold rear wheel of the bike securely. Track bikes with old style nuts on the axles are O.K. If you decide to use a track bike, put on a small gear and plan on increasing the intensity using the CompuTrainer software, and not with the gear.

It is important to work your way into the Progressive Power Training program by first finding the appropriate starting intensity. The main objective here is to avoid injury during this “cut and try” period. Here is one way to start out:

1) The workouts listed in the Appendix I are designed for use with the Challenge PC1 and Coaching Software applications. Samples of the CRS course files (e.g., PRS.crs, PSOP.crs and PSS.crs) for the corresponding PRS, PSOP, and PSS workouts are shown on the last section of Appendix I and they can be modified as needed by using
Microsoft Notepad or WordPad. These files need to be placed in the Courses folder of the application you are using, be it CompuTrainer or Velotron.

2) Be sure to warm up first and perform the tire friction calibration procedure described in the CompuTrainer Standard Warm-up workout in the Appendix I. Comparing records of wattage readings between workouts can be confusing if identical calibration procedures are not followed every time.

3) In the Progressive Stallout Power Workout (PSOP) start by choosing a short uphill distance of about 40-50 meters in the initial “cut and try” session.

4) For the first effort use your road bike and put it in an easy gear (say, 53x21). When the starting gun goes off, raise your cadence to the desired target level (for example, 80-120 RPM for roadies; 150-160+ RPM for sprinters) and just ride through the course (it should be relatively easy). On each of the subsequent efforts keep shifting to harder and harder gears until you feel yourself struggling to maintain the targeted RPM right to the finish. This will be your starting point for the Progressive Power Training program.

5) Check to see how many pedal strokes are needed on the uphill part of the course. If it is taking more than 6-10 pedal strokes, shorten the course. Too long a course will prevent you from maximizing the intensity. It is the intensity, and not the number of pedal strokes, that will make you stronger.

6) Do 4-6 efforts with a full five minutes of active rest between efforts. During the rest periods, save the course files and examine them using the Coaching Software (see page 65).

**HOW TO DETERMINE THE PROGRESSIVE POWER TRAINING INTENSITY LEVELS**

As you continue the program you should choose one of the repeat efforts during each workout session to test yourself at a higher intensity level to see if you can handle it without breaking form. The intensity can be raised either by going to a harder gear at the same percent grade or by increasing the percent grade. When you can do the harder effort successfully and without breaking form start there in the next session.
RECOVERING FROM THE PROGRESSIVE POWER TRAINING WORKOUTS

It is extremely important to recognize that you get stronger during the recovery period and not during the workout itself. During the workouts, micro-tears are created in the muscle cells and when those damaged cells repair themselves, you get stronger. It can take more than just a few days for the healing process to take place.

Ice baths can help to accelerate the process: after your workout, fill the tub with enough water to cover the legs after the ice is added. Add two to three bags of ice and get in for 10 minutes. Don't panic, because after the first 10 seconds, it will not be so bad! The ice bath reduces the inflammation that can result from the tearing down of muscle during the workout by enhancing the flow of blood deep in the muscles.

Active recovery on your "off" days can be extremely valuable. One of the most difficult things for a highly motivated athlete to do is to go out and ride easy for active recovery. Here is a recent quote: "I have to say my hardest days are my easy days. I find them more mentally draining because I have to force myself to go easy. It's very weird to tell yourself that going slow makes you faster."

One intense progressive power workout per week will produce positive results. For some athletes two intense workouts every 7-10 days can be tolerated. More is not necessarily better.

MAINTAINING SPORT-SPECIFIC POWER OUTPUT

Once you have achieved your desired level of sustainable power output by following the Progressive Power Training program, that power level can be maintained by doing only one workout per week consisting of only one or two efforts at the same level of intensity that was achieved at the end of the program.

One problem is that if you miss a weekly workout your fitness may go down. You will be able to know after each maintenance workout effort if your fitness is deteriorating when it becomes necessary for you to struggle to finish the 6-10 pedal strokes without breaking form. When that happens, just repeat the program for 2-3 weeks to get your strength back.
SAVING AND REVIEWING THE COMPUTRAINER WORKOUT INFORMATION

It is important to save and review the Progressive Power Training workout information for each and every effort. By doing this one can make appropriate adjustments “on the fly” to the CRS course files between efforts. If an effort is too easy or too hard, either the gear or the uphill grade can be adjusted up or down, and if it takes too few or too many pedal strokes to finish the uphill portion of the course, the distance can be adjusted up or down.

Notice that the workouts are so short (only about 5-10 seconds or so) that it is impossible to see what has happened by viewing the screen “live.” Capturing and reviewing in details what happened is the only way to see what adjustments need to be made.

To save your Progressive Power Training workout, please refer to your CompuTrainer or Velotron users manual. The procedure for saving workout files is differs between a CompuTrainer and a Velotron.

The following steps allow you to retrieve and view the file:

1) Open the Coaching software
2) Click on "Source"
3) Click on "Saved File"
4) Click on "Start"
5) Click on "Charts"
6) Browse to the location of your saved CRS workout file
7) On the screen you will see all of the files you have saved
8) Click on a saved file, and the workout graph will be displayed on the screen
9) You will be able see all of the key data at the bottom of the screen
10) If you scroll back and forth you can read off values at any point in the workout
Progressive Resistance and Speed Workout: Recreational Female Cyclist

Figure 2 shows the Progressive Resistance and Speed (PRS) workout of a recreational woman rider. Note that her cadence (yellow) increased at first but she was unable to maintain cadence on the uphill segment. She maintained and increased her wattage (green) and her spin scan pedaling efficiency (purple) improved near the end. On the downhill section, her RPM increased from 87 to 121 RPM. Then, on the uphill section the RPM dropped from 121 to 95. This was not a seriously intense workout, but it did cause her to work harder in trying to maintain her cadence. The entire effort lasted about eight seconds, while the high resistance part lasted only about five seconds. Her peak power was 557 watts. Her spin scan efficiency ranged from 62 to 73 percent and improved near the end (this is a very good for a beginner).

Figure 2. Progressive resistance and speed (PRS) workout of a recreational female cyclist
Progressive Resistance and Speed Workout: Professional Athlete

Figure 3 is the Progressive Resistance and Speed (PRS) workout of a professional athlete who was working on increasing his cadence and power output in short time trials. Notice that he was unable to maintain cadence (yellow) near the end of the "race."

Figure 3. Progressive resistance and speed (PRS) workout of a professional athlete
Progressive Standing Start Workout

Figure 4 is a Progressive Standing Start (PSS) workout in which the rider jumped out of the saddle when the gun went off and pedaled as hard as possible right to the finish. Note that the entire workout lasted only 4 seconds. Also note that he was unable to maintain cadence near the end of the “race.”
Stallout Workout: Professional Triathlete

Figure 5 is the typical profile for a stallout workout. On the downhill section his RPM increased from 111 to 129 RPM. Then, on the uphill section the RPM dropped from 129 to 112. This was not a seriously intense workout, but it did cause him to work harder in trying to maintain his cadence. The entire effort lasted about six seconds, while the high resistance part lasted only about three seconds. His peak power was 886 watts. His spin scan efficiency (SSE) ranged from 64 to 70 percent and was improving near the end (good).

![Figure 5. Stallout workout for a professional triathlete](image)
Stallout Workout: Sixty-Nine Year Old Recreational Rider

Figure 6 is a stallout workout for a sixty-nine year old recreational rider. This rider wanted to see how high he could get his cadence during the “downhill” section of the workout, and then try to maintain the RPM. He achieved a maximum of 147 RPM and then it declined to 107 RPM near the end of the high resistance section, which lasted about five seconds. His maximum wattage was 601 and it dropped only slightly to 564 watts near the end (very good!). His SSE on the high resistance section maxed at 76 percent and then drifted down only slightly to 73 percent at the end (good). It is obvious that he had to work very hard to finish the “race.” This was an excellent workout session.

Figure 6. Stallout workout for a sixty-nine year old recreational rider
ANALYZING THE COMPUTRAINER WORKOUT INFORMATION

At the bottom of the screen you will see that all of the key data are displayed, including the maximum Watts, the maximum RPM and the SSE. These three values should be recorded in your training log so that you can monitor your progress from week to week.

On the display select only the following three items for plotting on the graph:

1) Watts
2) RPM
3) SSE

Here are some of the adjustments that should be made after analyzing the results:

1) If the target workout RPM is not reached on the downhill portion of the course, you can choose to use a smaller gear, you can increase the steepness of the downhill grade, or you can increase the length of the downhill portion of the course.

2) If either the Watts or the RPM goes through the maximum long before the “race” has ended, decrease the length of the uphill portion of the course. If the course is too long it will be difficult to maximize the intensity. As you become stronger, as measured by the achievement of maximum wattage near the end of the race, then the course can be lengthened to allow for more pedal strokes.

3) If either the grade or the gear is made harder between efforts and the maximum wattage does not go up (when compared to the previous effort) or the target RPM can not be sustained or the SSE is deteriorating during the course of the effort, then one should either go back to the previous values for the next effort, or else terminate the workout session altogether. If the level of difficulty is increased and the maximum wattage does not go up, the conclusion is that you have reached your limit on that day.

The principles of progressive resistance require that care be taken not to overload the athlete more than a relatively small marginal amount beyond his or her capability. Gradual positive progress will result in optimal long-term improvements, and greater confidence in the program. Increasing the load too rapidly and not allowing for sufficient recovery between workout sessions will result in poor progress or even backward progress.
HOW TO MAKE CHANGES TO THE WORKOUTS (*.CRS COURSE FILES)

Sample CRS course files (e.g., PSOP.crs) are shown in Appendix I and they can be modified as needed by using Microsoft Notepad or Microsoft WordPad. To make changes to a CRS workout file:

1) Access Microsoft Notepad. They can be found by clicking on “Start; All Programs; Accessories; Notepad.” The best way is to place the Microsoft Notepad icon on your desktop. For example, when Notepad is initiated, a window will pop up.

2) In the Notepad Window click on “File; Open.” Another window will pop up allowing you to specify which folder you want to access. At the top where it says “Look in:” browse to the folder on your computer containing the CRS course files.

3) At the bottom of the window under “File Name:” type in *.crs and all the CRS course files will become visible.

4) Find the target file (e.g. Stallouts.crs), highlight it and click on “Open.” The text file will become visible, and it can then be edited.

5) Under [COURSE DATA] each line of the workout specification contains numbers in the following sequence:

<table>
<thead>
<tr>
<th>DISTANCE</th>
<th>GRADE</th>
<th>WIND</th>
</tr>
</thead>
<tbody>
<tr>
<td>nn.nnn</td>
<td>nn.n</td>
<td>nn.n</td>
</tr>
</tbody>
</table>

   The distances are in kilometers, the grade is in percent (plus or minus) and the wind is in kilometers per hour (plus or minus).

6) Simply edit and change the numbers as desired.

7) File the changed workout either under the same name or else create a new name using “Save As.”

8) The next time you access the CRS course workout the new specifications will apply.
By following the eight steps described above, modifications to the CRS workout files can easily be made between sets as needed to “fine-tune” the workout.

**HOW TO USE THE COMPUTRAINER 3D SYSTEM**

The CTV courses also can be implemented using the 3D software, but the software system needs to be “tricked” into providing the proper intensity. When designing the workout file, if the needed intense segment is specified with the desired grade and length, it will not “switch” to the final grade increase until the end of that segment. Therefore, one needs to insert an additional segment in front of the final segment with the shortest possible length allowed by the software (6 meters) so that the whole grade transition takes place in that short segment. Then, you can form up the last segment with the desired segment length and with the final desired grade intensity level.

You need to be sure your name is identified in the workout file so that it will automatically be documented when saved. Saving workout/performance files varies per application used, so be sure to check the documentation for the version you are using to correctly save your workout/performance files.

**OVERALL CTV PROGRESSIVE POWER TRAINING PROGRAM**

For cyclists who are relatively untrained it is possible to see dramatic improvements in maximum wattages in a relatively short period of time. For more mature cyclists the improvements may not be as dramatic, but they are no less important. It can take as much as five years of gradual Progressive Power Training to reach one’s maximum potential. Patience and consistency are the keys to success.

For those serious cyclists who are just beginning the program, it is recommended that an initial six to eight week training period involving progressive resistance workouts in the gym be undertaken. The main purpose of these workouts will be to increase the strength of the tendons, ligaments and auxiliary muscles so as to minimize the possibility of injury when conducting the intense on-the-bike sport-specific program.

Lunges are the preferred leg exercise. Also, core body exercises should be a serious focus all year around.
For cyclists who already have a long and consistent (5-10 year) weight lifting training life the program of progressive resistance training in the gym may not be needed at all.

Here are the elements of the comprehensive CTV progressive power program:

1) Aerobic System Training
2) Progressive Stall-Out Power Workouts (PSOP)
3) Progressive PC Drill Workouts (PC)
4) Progressive Isolated Leg Training Workouts (PILT)
5) Progressive Resistance and Form Workouts (PRF)
6) Progressive Standing Starts (PSS)
7) VO2Max and Form Workout (VO2MF)
8) Progressive Resistance / Speed Workouts (Cadences) / (PRS)
9) Speed and Power Maintenance Workouts

Some thoughts about how to perform each of these workouts follow:

**WORKOUTS DESIGNED FOR THE DEVELOPMENT OF POWER AND SPEED**

The following three progressive power training workouts are so fast, so intense, and so brief that it is not possible to monitor form effectively in real time during the efforts:

1) Progressive Stall-Out Power (PSOP)
2) Progressive Resistance Speed (PRS)
3) Progressive Standing Starts (PSS)

However, as mentioned above, the CTV Coaching Software allows one to view after the fact how form (as measured by the SSE) progressed during each effort. One then can determine if form was breaking down during each effort.

After displaying the SSE performance between each individual workout effort, the coach can make adjustments to the duration and the intensity demanded by the CTV software “on the fly” between sets so that the athlete is always working at or near the brink of failure to maintain form while performing at the maximum possible intensity. Success is then measured by the ability to maintain form at higher and higher intensities (wattages).
Increasing the intensity in such a way as to cause a serious break in form is not at all productive because it simply teaches one bad habits. Focusing on form during these practices is vital to optimizing your performance.

**WORKOUTS DESIGNED FOR THE DEVELOPMENT OF FORM**

Three of the workouts that are documented in the Appendix I emphasize the use of the Spin Scan Efficiency Number (SSE) as real-time biofeedback to work on improving your form during the efforts:

1) Progressive Isolated Leg Training Workouts (PILT)
2) Progressive Resistance and Form Workout (PRF)
3) VO2 Max and Form Workout (VO2MF)
4) Lactate Threshold Workout (LT)

By focusing your mind on the SSE number and the Polar Graphical Plot during these workouts you can use the biofeedback technique to increase the SSE and to produce a more circular Polar Graphical Plot. Getting your muscles to modify their firing patterns so as to increase the efficiency is a mental thing. It involves re-programming your mind by concentrating on seeing an improvement. Repeated successful efforts will program the mind to bring about the desired changes and make them feel natural.

When doing the above workouts one should not attempt to focus on improving the SSE for more than a few minutes at time. Just alternate between focusing on improving the SSE number for a few minutes and then just pedal “naturally” for a few minutes. The goal is to make the improved SSE a part of your very being so you don't even need to think about it.

Most athletes can produce an SSE number of only about 55 to 65. Two of my clients can routinely produce SSE numbers pf 85 to 96! Improving your SSE number will mean that you will need less wattage to go the same speed and you will be going faster at the same wattages.

**PROGRESSIVE RESISTANCE / SPEED WORKOUTS (CADENCES) (PRS)**

The progressive resistance / speed workout is the most important sport-specific workout in the series. This workout is the one to use as final preparation for your specific kind of riding using the range of cadences indicated below:
Recreational Riding        80-100 RPM
Time Trialing        80-110 RPM
Road Races        80-120 RPM
Lance’s Time Trials        96-108 RPM
Lance’s Prologues        115-120 RPM
Road Sprinting (Standing)        115-120 RPM
Track Pursuit (Seated)        115-120 RPM
Track Sprinting        Zero-170 RPM

A good way to start this program is to begin in a small gear and then go to harder and harder
gears with each effort until you find that your form is beginning to falter or else the maximum
observed wattage no longer increases (or even decreases) when the gear is made harder. On a
fixed-gear track bike, one must do this by increasing the uphill grade between efforts.

The uphill distance should be adjusted so that it takes no more than 8-10 uphill pedal strokes to
cross the finish line. If the distance is too long, the maximum intensity can not be achieved and
sustained right to the finish line. As you become stronger it will be possible to extend the uphill
course length.

The measure of progress is the maximum wattage and the number of pedal strokes that can be
achieved without losing form.
Following the progressive PC drill program will result in increased in-situ concentrations of Phospho-Creatine within the working cells and will allow you to sprint longer before your legs “turn to rubber.” You also will be able to recover faster between surges or sprints. These workouts should not be done using a heavy-duty resistance. If the resistance is too great it will cause your heart rate to go way up between efforts and it will inhibit the very adaptations that you want to achieve. One of the benefits of doing these workouts (when done properly) is that your legs will feel just great the next day.

Below are sample PC Drill workouts for a relatively out-of-shape rider and for that same rider after following the program for a few weeks. Figure 7 shows the heart rate recovery trend of an out-of-shape rider prior to beginning PC Drill workouts. After several workouts one should be able to do 30 successive efforts without any increase in recovery heart rate. At that point, the workload demand is increased. This program results in the ability to go all-out for longer and longer times to re-accelerate when coming out of the corners or when chasing down a breakaway.

Figure 7. The time versus heart rate profile of an out-of-shape rider
Figure 8 shows the progress made by the same athlete after just a few weeks of training following the PC Drill workout guidelines. The progress is dramatic in just a short period of time.

**PROGRESSIVE ISOLATED LEG TRAINING WORKOUTS (PILT)**

Progressive isolated leg training is a wonderful way to achieve significant improvements in left leg / right leg balance and in pedaling efficiency. The PILT workout should be done on a road bike and not on a track bike or "spinning" bike, since riding on a fixed gear does not result in the same degree of progress.

When executing the PILT workout, the main objective is to make the pedal go around as smoothly as possible, maintaining constant tension on the chain all around the circle. It is called “feeling the chain.” The PILT workout is designed to teach your legs to lift the pedal up and over the top smoothly. When your form breaks down, you will be able to hear the freewheel "banging" each time your foot comes up and over the top.

Figure 8. The time versus heart rate profile after a short period of doing PC drill workouts
In actual fact it is your mind that is being programmed to cause each muscle cell and muscle fiber to fire in just the right sequence and with just the right timing to create a smooth round pedal stroke.

If you have never done isolated leg training before, you may find that after only a minute or so you will be struggling to make the pedals go around smoothly. What will happen is that you will become smoother and you will be able to hold that smoothness longer and longer in just a few workouts. As you get stronger and smoother you should try increasing the resistance to cause your legs to recruit more and more muscle fibers.

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**PROGRESSIVE RESISTANCE AND FORM WORKOUTS (PRF)**

The objective of the PRF workout is identical to the PILT workout except it is done with both legs instead of with just one leg. Also, the intensity of the workout should be as high as you can possibly stand without creating injury. The resistance is increased until your form just begins to break down and you feel as if you are “pedaling in squares” and “fighting the bike.” Then you back off.

This workout can include efforts that are done either seated or standing up on the pedals. It is important to include the standing-up efforts if you wish to be able to stand up on the pedals during climbs or accelerations (just like Lance does). All it takes is practice, practice, practice.

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**PROGRESSIVE STANDING STARTS (PSS)**

The progressive standing start workout strengthens the muscles, increases recruitment and programs the mind to activate those motor pathways that are needed to stand up on the pedals and accelerate the bike as smoothly and as quickly as possible without losing form. The PSS workout also increases the stores of PC in those muscle cells that are used specifically during standing accelerations (they are not the same as the muscle cells that are used when sitting down in the saddle).

During these workouts one should focus on maximizing the efficiency of the pedaling technique. In the starts one can learn to simultaneously pull up on the rear foot while pushing down on the front foot, and to come up and over the top with one foot while “scraping through the bottom” with the other foot, all at one and the same time.
The progressive stall-out power workout is designed to maximize the intensity, period. This workout can be very dangerous and can cause injury if done incorrectly, so please be cautious when trying it.

What happens is that you will find that you are incapable of maintaining the target cadence and your cadence can drop to zero before the workout is over (stall-out). If the distance of the uphill section is well chosen you will just barely approach stall-out at the same time that you cross the finish line.

For starters, choose a really short uphill distance and a grade that you know you can handle without stalling out before the finish. Then, increase the gear, the grade or the distance (or all three) with each subsequent effort until you have reached your limit, and are approaching stall out just as the “race” ends and you are crossing the finish line. The distance should be set so as to not take more than 10-15 pedal strokes to near failure.

The measure of progress is the ability to increase the gear, the grade and/or the distance you can tolerate before failing to make it to the finish line without stalling out.

The best sport-specific maintenance workout is the Progressive Resistance / Speed (PRS) Workout. This workout maintains your speed-specific strength at the same cadence(s) that you will be experiencing in your event(s). Once you are satisfied with the power levels you have achieved by doing the basic program, maintaining the gains that you have made is very simple.

For maintenance you need to perform one set consisting of only one effort once every week to ten days. The intensity level should be the same as your last good effort. It may be possible for you to maintain your power level by doing the workout once every two weeks. This you can determine by trial and error.

There is one caveat to this suggestion, and that is consistency. The workouts must be done with clocklike consistency every week (or every 10-14 days if applicable). If you miss one or more maintenance workouts in a row your power level will not be sustained. You will know if you are losing power if the workout becomes too difficult to do. In that case, simply go back and do the program for two or three weeks to get it back.
A strong aerobic engine is absolutely important for any cyclist regardless of their specific discipline. As mentioned in Chapter 3 the best source of information on developing the aerobic engine is in the book “Base Building for Cyclists” by Thomas Chapple.

Developing and maintaining the aerobic system requires loads of time on the bike riding in a modest heart rate range. It is important during aerobic training sessions not to allow your heart rate to go too high and to limit the production of lactic acid and the corresponding hydrogen (H+) ion acidity in the muscle cells. Acidity inhibits and prevents the physiological adaptations which lead to a stronger aerobic system from taking place.

A good rule of thumb for aerobic training is to ride at heart rates that are at least 20 to 25 beats per minute below your time trial heart rate. For a fit athlete it can be 20 bpm or more below and for all others it should be 25 bpm or more below the TT heart rate. If you know your maximum heart rate the rule of thumb is to ride at 35 to 40 bpm or more below your maximum. To achieve this goal it may be necessary to slow down near the end of the training ride to prevent the heart rate from going above the limit. Development of the upper body aerobic system can have serious positive effects on one’s ability to perform in or near the anaerobic zone. Swimming and use of the Upper Body Ergometer (UBE) in the gym can be beneficial in achieving upper body aerobic fitness.

The key to developing and maintaining a strong aerobic engine is consistency over an extended period of time. Neglect of aerobic training needs for even a week or two can seriously compromise the strength of one’s aerobic system as is illustrated in Figure 9 (Ann. N.Y. Academy of Science 301:3, 1977).
Figure 9. Krebs cycle enzymes and the effects on training the aerobic system

The Figure 10 illustrates how training your aerobic engine can increase your sustainable power output. The training for this individual was strictly aerobic during the period from December 1997 through April 1998. There were absolutely no anaerobic intervals during that time period for this athlete. And yet, his sustainable power output was increased from 336 to 385 watts in just four months. Our Secret: The aerobic engine rules!

Figure 10. Heart rate versus power improvement in response to aerobic training over time
CHAPTER 6

RESULTS ILLUSTRATING THE IMPACTS OF THE WORKOUTS

IT ALL BEGAN WITH AL WHALEY

Approximately fifteen years ago I was honored to become the coach of a gentleman named Alphonso (Al) Whaley who as of now is a fourteen time Masters World Champion and who also has set a number of World Records on the track. Al paired up with a Paralympic athlete named Pam Fernandes and I coached the two of them for more than a year in preparation for the 2000 Para-Olympic Games. Together they scored a gold medal, a silver medal and a World Record on a tandem track bike at the 2000 games in Sydney, Australia. Pam Fernandes was blind, a Type I diabetic, and had a kidney transplant.

Al Whaley was the first athlete to be given Progressive Power Training workouts on the CompuTrainer beginning in 1994. Because he was already reasonably fit from his weekly group training rides and from Friday night racing at the Alkek Velodrome, he normally would only need to fine-tune his power output before the Worlds. Preparation for the 2000 Sydney Games was a bit different. That involved a 14 month training program for both Al and Pam.

Since Al is a sprinter, he needed to be able to perform at ALL cadences from zero to over 170 RPM. I made his Progressive Stall-Out (PSOP) workouts so intense that I had to stand by and be ready to pull the plug out of the CompuTrainer handlebar computer unit just before he totally stalled-out and became unable to make even one more pedal stroke (pulling the plug reduces the resistance to zero immediately).

Al’s Progressive Resistance and Speed (PRS) workouts were conducted at 160+ RPM. He had to first get his cadence up to over 160 RPM on the down-hill segment of the workout and then when he was hit by the high-resistance segment his job was to not allow the RPM to go below 160 RPM before the end of the “race.” The measures of Al’s progress were the maximum wattage achieved and the length of the uphill portion of the workout. Figure 11 shows Al’s progress in just six once-per-week PRS workouts.
For most of the year Al was a 40-50 hour per week ordinary working stiff. He therefore was able to begin serious training only 6-8 weeks before the Master’s World Championships every year when his employer allowed him some flexibility in his work schedule. It always kind of scared me to death because it was like, "O.K. Bill, give me yet another miracle this year."

I have to say that there is no way we could have been successful in those early years without the use of Progressive Power workout concepts.

![Al Whaley's Sprint Power Progress](image)

**Figure 11.** Al Whaley’s sprint power progress over a six progressive resistance and speed (PRS) workout period
One of my clients approached me in August, 2006 with the following problem: He was participating in the Friday night races in Category 4 at the Alkek Velodrome in Houston, Texas and wanted to win a medal in the rider of the year contest. One of the perks of achieving that goal would be an automatic upgrade to Category 3 for next year’s season. His problem was that owing to light turnouts for the races, the officials had decided to combine the Category 4 riders with the faster and stronger Category 1, 2 and 3 riders in order to have a bigger field of riders. My client found himself getting dropped from the field in every event.

After only five weekly workouts following my Progressive Power Training program (see the Figure 12) he had increased his maximum power output by 39% and he was no longer getting dropped. At season’s end in mid-October, he had gained his medal and his upgrade to category 3. He was so pleased that he made a shadow box containing his medal and a photo of the two of us and he presented it to me as a gift. The inscription says, “To my coach Bill Edwards: Thanks, Bill for all you have done for me.”

Here is a quote from that same client:

“I was having trouble keeping up with the field in the Friday night track races until Coach Bill Edwards helped me using his special CompuTrainer workouts. I knew I had good muscle but for some reason I could not seem to go any faster. After only five weekly workouts with Bill I was able to keep from getting dropped as soon in the races and I earned a medal in the 2006 Category 4 rider of the year competition. With the increased strength I was able to raise the gear from 90.0 inches to 92.6 inches. Before I did Bill’s training, I just got slower whenever I tried to use a harder gear. In the bigger gear I eventually became able to attack and I even began winning some of the events!”

Please note what this athlete said: simply putting on a harder gear first with no specific preparation that would enable him to turn it over faster made him SLOWER, not faster!!!

Here are some more thoughts about this rider from the gentleman who announced nearly all of the Friday night track races:
“He was not very competitive on the track and was getting dropped in nearly every event before starting Bill’s program in August 2006. Beginning in September I noticed that he was staying in the pack longer and longer before getting dropped and during the month of September and the first half of October 2006 he eventually was able to stay in all the way to the finish, even winning some events. The following year I noticed that he not only was staying in the pack, he was able to attack and he began making a difference and was winning more of the events.”

What happened to this client is that he increased his power output while doing cycling specific / speed-specific and event-specific Progressive Power Training workouts for only five weeks. This is not one bit different than what happened in the research study mentioned in Chapter 2 when the subjects performed Progressive Resistance Training in the gym with weights and increased their average squat strength by 75% in only eight weeks! This kind of improvement for relatively untrained or out-of-shape subjects is commonplace in the gym.

Conclusion: Lifting watts instead of weights really works, and specificity rules!!

Figure 12. Adam’s sprint power progress over a five progressive resistance and speed (PRS) workout period
This example illustrates the profound impact that PPT workouts can have upon muscle fiber recruitment. Ryan is an athlete who wanted to qualify to participate internationally in an event known as the “Team Sprint” or alternatively “Olympic Sprint.” This event was first introduced into championship racing in 1996. It is a three-man team time trial held over three laps of a velodrome.

Like the team pursuit event, two teams race against each other starting on opposite sides of the track. At the end of the first lap, the leading rider in each team pulls up the banking leaving the second rider to lead for the next lap; at the end of the second lap, the second rider does the same, leaving the third rider to complete the last lap on his own. The team with the fastest time is the winner.

The first rider needs to have an extremely fast start. The second and third riders need to be able to get into the draft immediately so as to not get dropped on the first lap, while the third rider needs good endurance qualities to maintain high speed to the finish. Kilometer track time trial specialists are usually chosen for third spot.

Ryan wanted to qualify as rider number one, so we worked on Progressive Standing Start (PSS) workouts on the CompuTrainer. Figure 13 illustrates the improvements Ryan was able to make on the very same day in a single workout session. Each Progressive Standing Start effort was an attempt to produce maximal output for 10 pedal strokes with a 10 minute rest interval between efforts. What happened here can be explained by the fact that Ryan was able to increase the recruitment of additional muscle fibers. His legs were already quite strong, but he was not utilizing the optimal muscle fiber firing patterns at first. Then, in subsequent efforts, he was able to “teach” his legs to produce more wattage.
Figure 13. Ryan’s start power progress over an eight progressive standing start (PSS) workout period

When Ryan went to the trials he produced a “personal best” first lap time on a borrowed bike (his personal bike had fallen off the roof-rack and was run over by another car).

The above examples might suggest that Progressive Power Training is only for track riders. The reality is that it works for all classes of riders simply by “tuning” the workouts so as to mimic the specific event or the specific riding style of the individual rider. The bottom line is that to go faster you need to have stronger cycling-specific legs and you need to engage maximal recruitment of the available muscle fibers. Progressive Power Training simply maximizes the recruitment of muscle fibers in the legs, thereby allowing you to produce more power and ride faster.
CHAPTER 7

SAMPLE PROGRESSIVE POWER TRAINING PLANS

In this chapter I will try to pass along the information you need in order to develop your own individualized training plan. I prefer this to giving you “cook book” training recipes.

For purposes of the following discussion I have defined heart rate training zones as follows (please see the book “Heart Rate Training Made Easy” by Bill Edwards, PhD):

All training zones are defined relative to your Time Trial Heart Rate (TTHR) which is the average heart rate you can maintain for the last 5 minutes of the 8 minute Modified Field Test (see CMFT protocol in Appendix I), or the average heart rate you can maintain for 20 minutes, going as hard as you can possibly go.

Zone 1 – Blue Zone – Active Recovery at HR less than TTHR - 60 BPM
Zone 2 – Green Zone – Aerobic Training Zone at HR less than TTHR – 25 BPM
Zone 3 – Grey Zone – No Man’s Land at HR = TTHR – 25 to TTHR – 10 BPM
Zone 4 – Yellow Zone – Lactate Threshold Zone at HR = TTHR -10 to TTHR – 5 BPM.
Zone 5 – Red Zone – Anaerobic Zone at HR = TTHR up to TTHR + 15 BPM

SETTING UP THE WEEKLY WORKOUTS TO BE DONE

The principles involved in setting up your own weekly PPT program are as follows:

(1) No more than two or three intense (“Super-Aerobic”) workouts in the Yellow Zone or Red Zone per week. This includes any weekend group rides or races that you like to do.

(2) When doing the PPT workout intervals, stop immediately if performance deteriorates.

(3) All other rides during the week should be either in the high end of Green Zone [heart rates less than 25 BPM lower than your Time Trial Heart Rate (TTHR)] or else in the active recovery Blue Zone.
The Green Zone and Yellow Zone riding must be done with clock-work consistency.

Here are some possible weekly Training configurations:

- **Moderate Recreational Rider**
  - Four days per week of Green Zone riding (AM)
  - One day per week of PPT workouts (PSOP, PRS, PSS)
  - One day per week of Blue Zone riding
  - One day off or else a short Blue Zone ride

- **Hard Core Recreational Rider**
  - Three days per week of Green Zone riding (AM)
  - One day per week of PPT workouts (PSOP, PRS, PSS)
  - One day per week of Yellow Zone intervals (LT)
  - One day per week of hard group riding with “Yellow Zone pulls,” and “attacks”
  - One day off or else a short Blue Zone ride

- **“Recreational” Bike Racer**
  - Three days per week of Green Zone riding
  - One day per week of PPT workouts (PSOP, PRS, PSS)
  - One day per week of Yellow Zone intervals (two days if not racing that week) (LT)
  - One day of racing or hard group riding with “hard pulls,” “attacks” and “sprints”
  - One day off or else a short Blue Zone ride

- **Professional Bike Racer (Racing Often)**
  - Two or Three days per week of Green Zone riding
  - One day per week of PPT workouts (PSOP, PRS, PSS) followed by Green Zone
  - One day per week of Yellow Zone intervals (two days if not racing that week) (LT)
One or two days of racing with “hard pulls,” “attacks” and “sprints”
One day off or else a short Blue Zone ride

The single most important consideration in designing a training program is Recovery. Namely, “how fast do I recover from each given day of Red Zone or Yellow Zone workout intensity?” If your recovery is really good, then you might consider doing two PPT workouts each week. However, this should not be continued for more than just a few weeks. My experience is that one PPT workout per week results in good progress for most athletes, and the one-per-week program can be continued for many weeks.

HOW TO SET UP YOUR DAILY WORKOUT WEEK

It is best to do the most intense workouts early in the week because this allows more time for recovery prior to any weekend race or group ride “bash.” The more moderate Yellow Zone efforts can be done later in the week. It is important to recognize, however, that some athletes do not recover in just a day or two and in that case the “weekly” plan should be extended to a “10-day plan” allowing more Green Zone and Blue Zone training between the intense workout days. On a day when there are Red Zone interval efforts such as PPT, it is O.K. to do the PPT efforts first, and then go out for a moderate Blue Zone or Green Zone ride afterwards.

A SAMPLE SEVEN DAY CYCLE MAY LOOK AS FOLLOWS:

<table>
<thead>
<tr>
<th>Monday</th>
<th>Day off or short Blue Zone ride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuesday</td>
<td>Red Zone intervals possibly followed by Blue Zone or Green Zone riding</td>
</tr>
<tr>
<td>Wednesday</td>
<td>Longer Green Zone ride</td>
</tr>
<tr>
<td>Thursday</td>
<td>Yellow Zone (LT) Intervals</td>
</tr>
<tr>
<td>Friday</td>
<td>Green Zone ride with 2x15 pedal stroke all-out sprints</td>
</tr>
<tr>
<td>Saturday</td>
<td>Yellow Zone (LT) Intervals</td>
</tr>
<tr>
<td>Saturday (alt)</td>
<td>Group Ride including short time in the Yellow Zone &amp; Red Zone</td>
</tr>
<tr>
<td>Sunday</td>
<td>Longest Green Zone ride</td>
</tr>
</tbody>
</table>

A SAMPLE TEN DAY CYCLE MAY LOOK AS FOLLOWS:

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day off or short Blue Zone ride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 2</td>
<td>Red Zone intervals – Super Hard Workout!</td>
</tr>
<tr>
<td>Day 3</td>
<td>Long Green Zone ride</td>
</tr>
<tr>
<td>Day 4</td>
<td>Longer Green Zone ride</td>
</tr>
</tbody>
</table>

Bill Edwards Copyright 2010
Day 5  Yellow Zone (LT) Intervals
Day 6  Long Green Zone ride
Day 7  Longer Green Zone ride
Day 8  Yellow Zone (LT) Intervals
Day 9  Long Green Zone ride
Day 10 Longer Green Zone ride

If a long Green Zone ride occurs on a weekend you can substitute a Group Ride. If that follows an intense Red Zone or Yellow Zone day then just ride moderately in the group.

**SETTING UP THE OVERALL TRAINING PLAN**

The overall training plan normally goes in four week cycles. The training volumes (time on the bike) and the number of intervals can be increased gradually during each four week cycle. The cycles are periodized so that the type of workout (PSOP, PRS, PSS) may change from cycle to cycle. Every fourth week you need to cut back your training volume (but NOT your intensity levels) to about 50-60% of normal for at least 6 days. This is to allow your body to regroup so that the physiological training adaptations can be consolidated. For example:

1. If you are training for 10 hours per week, cut back to 5-6 hours.
2. If you are doing two twenty minute Yellow Zone Lactate Threshold intervals, cut back to two 10-12 minute LT Intervals with the rest between intervals, RI = 10-12 minutes.
3. If you are doing 6-8 PPT efforts cut back to 3-4 efforts at maximum intensity.

In the weeks following your “rest” week, increase the volume over and above the previous three week period, if possible. Here is a sample overall eight week program:

<table>
<thead>
<tr>
<th>Week No.</th>
<th>PPT Workout</th>
<th>LT Workout</th>
<th>AM Workouts</th>
<th>Group Ride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1:</td>
<td>PPT (4 Intvls)</td>
<td>1x20 Min@TT-10</td>
<td>8 HRS</td>
<td></td>
</tr>
<tr>
<td>Week 2:</td>
<td>PPT (5 Intvls)</td>
<td>2x20 Min@TT-10</td>
<td>9 HRS</td>
<td></td>
</tr>
<tr>
<td>Week 3:</td>
<td>PPT (6 Intvls)</td>
<td>2x20 Min@TT-10</td>
<td>10 HRS</td>
<td></td>
</tr>
<tr>
<td>Week 4:</td>
<td>PPT (3 Intvls)</td>
<td>2x12 Min@TT-10</td>
<td>6 HRS</td>
<td>Hard Ride</td>
</tr>
<tr>
<td>Week 5:</td>
<td>PPT (5 Intvls)</td>
<td>1x20 Min@TT-5</td>
<td>10 HRS</td>
<td></td>
</tr>
<tr>
<td>Week 6:</td>
<td>PPT (6 Intvls)</td>
<td>2x20 Min@TT-5</td>
<td>11 HRS</td>
<td></td>
</tr>
</tbody>
</table>
Week 7: PPT (7 Intvls)  2x20 Min@TT-5  12 HRS  
Week 8: PPT (4 Intvls)  2x12 Min@TT-5  6 HRS  Hard Ride

This progression repeats with increasing Green Zone volumes if possible.

Once again, recovery is the most important thing to consider in developing an overall training plan. If the above plan is not giving you adequate recovery, then reduce the cycle to a three week cycle. In other words, weeks 1 and 2 are increasing volume of intervals and hours and the 3rd week is an easier week (just eliminate weeks 3 and 7 above and re-number the sequence). A three week cycle is most often needed by the older Master’s athletes, in my experience.

For the individual PPT workouts the following is one possible sequence:

<table>
<thead>
<tr>
<th>PPT Workout Description</th>
<th>No. of Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Seated PSOP</td>
<td>6-8</td>
</tr>
<tr>
<td>(2) 1 Seated PSOP, then 3-7 PSS</td>
<td>3-4</td>
</tr>
<tr>
<td>(3) 1 Seated PSOP, then 3-7 Standing PSOP</td>
<td>3-4</td>
</tr>
<tr>
<td>(4) 1 Seated PSOP, then 3-7 Seated PRS</td>
<td>3-4</td>
</tr>
<tr>
<td>(5) 1 Seated PRS, then 3-7 Standing PRS</td>
<td>3-4</td>
</tr>
<tr>
<td>(6) 1 Seated PSOP, 1 Seated PRS, 1 Standing PRS (Maintenance)</td>
<td></td>
</tr>
</tbody>
</table>

Please note the following:

- The overall plan begins with seated Stallouts (PSOP). This first PSOP program should last a full 6-8 weeks.

- Item (6) is a maintenance program to keep your power at the final levels achieved.

- To improve your hill climbing the PPT workouts should be done with the front wheel elevated to the expected % grade level (remember, specificity). A front fork elevation stand is available from CompuTrainer for just this purpose.

| HOW TO MEASURE YOUR PPT WORKOUT PROGRESS |

It is of vital importance to record the results of the PPT workouts every time they are done. Here are my preferred items of data:
- Maximum Wattage
- Maximum Cadence
- Cadence at End of Effort
- Note as to whether or not Wattage declined significantly after the maximum
- Note as to whether SpinScan declined after the Maximum Wattage appeared

Without this information it is impossible to know your progress over time.

After executing the above program you can maintain your strength and power output by doing only one of each of the efforts you wish to maintain. For example, you could do one seated PRS effort and one standing PSOP effort, or any combination of efforts that suits your purpose. You will be able to tell by logging your maximum wattages whether or not your power is being maintained. If it declines, then consider doing another 8 week PPT session.

Note: You also can maintain your Yellow Zone LT fitness by doing just one 20 minute LT interval once or twice per week. Use discipline and do not go above TTHR–5 BPM.

AN IMPORTANT NOTE OF CAUTION

I have found that every athlete is unique. No two persons should have the same identical training program. Every athlete has different strengths, different weaknesses and different goals. Therefore, training plans such as are suggested above are just “cook book” ideas that may not be applicable to your needs. This is where coaching comes in! A good coach who understands Progressive Power Training will not just send you one of his “standard” training programs and then suggest that you should force yourself to do “his or her” program. He will listen to you carefully and adapt the daily efforts to your lifestyle and to your specific goals.

Also, it is very easy to overdo the PPT workout program such that the desired improvements (or rates of improvement) will not be forthcoming. Sometimes “Less is More.” Some of my greatest and most rewarding successes as a coach have been to slow a rider down and see him or her just get faster and faster on the bike. Remember this!

SUMMARY

- Heart Rate Zones play an important part in developing a training program.
• Several “cook book” overall training plans are presented

• A periodized PPT training program is suggested for getting started.

• Once developed, your newly achieved PPT power must be maintained

• Be careful not to over do it. “Less is More.”
CHAPTER 8

WHAT CAN ONE ACCOMPLISH WITHOUT A COMPUTRAINER?

COMPARISON OF “NATURAL” WORKOUTS VS. COMPUTRAINER PPT WORKOUTS

PPT can be practiced to some degree without using any special equipment other than an ordinary indoor trainer. You definitely will get better and stronger, but the exceptional results we are talking about earlier in this book simply will not happen in that case. There is no question that it is possible to get to a higher level of performance by doing the “conventional” Zone 5 training workouts (VO2max, Lactate Tolerance, and Sprints), but it is not possible to get to the level that PPT is referring to.

In the gym it is possible for your personal trainer to suggest a load that you simply can not handle. For example, suppose he says, “Here is an 800 pound barbell. Now let’s see you do some squats.” You know you can’t do it because the load is too way great. By way of comparison, when using a bicycle in normal training mode it is impossible to superimpose a load on you that is too great for you to handle. It is an important fact of life that in order to “progress” you need to be challenged with loads that are much higher than you are used to and that are more than you can produce naturally on your own.

Recently an article appeared in VeloNews [May 2010, Page 96] describing a workout that is being done by HTC-Columbia rider Tejay van Garderen. The workout is specifically designed to simulate the final run-in and sprint finish of a professional road race. The workout begins with 20 reps of squats at 80 percent of body weight. Immediately after the squats, he hops on the bike and does 2 minutes of hard tempo at an effort level of 7 on a scale of 1-10 (this is close to lactate threshold effort). When the two minutes are up he does an all-out sprint for 30 seconds at maximum possible wattage. That’s one set. Then, he does three or four more sets. Not a “fun” workout!

It is a nice workout. It is perfectly event-specific, and I do believe it can help a lot in making a rider better. Here’s what I think the workout does. It brings a rider "up to speed" by developing
the required energy systems up to a point and it gives a rider the "experience" of feeling the intensity required for the "run-in" and finish of a race.

What it does not do is increase the maximum power output above that which one can generate on his own for that final surge that Tyler Phinney has referred to. Tyler said that he can stay in the top 5 or 10 until the end, but he doesn't have the "suds" for that final surge to the line. A rider needs to be challenged in training way beyond what he can do on his own in order to have those "suds." That is where PPT comes in. It is the intensity, and not the time spent dealing with the intensity, that gets us there. PPT intensity expands the neuromuscular recruitment of more muscle fibers, makes them stronger (bigger in diameter) in the most cycling-specific manner possible.

USA Cycling National Team sprinters Adam Duvendeck and Gideon Massie are perfect examples that prove what I am suggesting. They have been doing extensive squats and "natural" event-specific sprint workouts almost all year round, and for the past three years their top speed has not improved, what-so-ever! Reason: they simply are not challenging their legs to produce more cycling and event-specific watts than they can possibly generate naturally. The squats certainly can improve one's neuromuscular recruitment, but they also increase muscle mass in- and recruitment of unneeded muscle fibers that have nothing to do with making the pedals go around faster at high resistance.

**SPRINT WORKOUTS**

Intense sprint training (10-20 second all-out efforts) can increase your "sport-specific" muscle fiber strength (muscle fiber diameter) and it can increase the recruitment of more and more sport-specific muscle fibers simply by activating more neuromuscular motor pathways.

In a properly done sprint workout each effort is done with the maximum possible intensity and there needs to be at least 5 minutes of rest interval (RI) between sprints. During such an "all-out" sprinting effort the "in-situ" PC in the working muscle fibers can go right to zero. It then takes at least 5 minutes for the PC to be completely restored so that you can be ready for another intense all-out effort.

When doing an intense sprint workout it is important to know when to quit doing any more sprints. This is because it does no good to continue when your performance begins to deteriorate. The proponents of watt meters claim that you can decide to quit when your maximum wattage starts decreasing. It is just as effective to use the maximum speed function on your bike computer to make such a decision. You simply reset the bike speed computer’s maximum speed to zero before each sprinting effort, and you must quit doing sprint intervals when your maximum speed begins to decrease. It’s much cheaper to use a speedometer than it is to use an expensive watt meter for this purpose.

**WORKOUTS ON AN INDOOR TRAINER**

Progressive PC Drill Workouts can be done on an ordinary indoor trainer (see Appendix I) and they can develop the PC energy system in two ways: (1) PC workouts can increase the amount of available “in-situ” PC stored in your working muscle fibers; and (2) PC workouts can increase the concentration of PC enzymatic catalyst which in turn speeds up the rate of delivery of the PC energy. Increasing the amount of available “in-situ” PC allows you to sprint longer before your
legs “turn to rubber” after which you simply can’t go fast any more. Increasing the amount of PC enzyme catalyst can result in even more speed in the delivery of ATP (energy) to your working muscles.

PC Drill training can provide significant benefits to recreational riders, recreational bike racers and professionals as well. The reason for this is that the PC energy system has a distinct advantage in that it utilizes absolutely no oxygen and it produces absolutely no lactic acid. In addition, the stored PC can be completely replenished in about 3-5 minutes after a short, intense all-out sprinting effort. What this means is that there is no real cost to invoking the PC energy system to do short (5 seconds or so) surges to “catch up” during a hard group ride or race. An all-out effort that takes 5 seconds or so can cost little in terms of energy drain, and it will not “fry” your legs with lactic acid buildup.

Following the progressive PC drill program will result in increased in-situ concentrations of Phospho-Creatine within the working cells and will allow you to sprint longer before your legs “turn to rubber.” You also will be able to recover faster between surges or sprints. These workouts should not be done using a heavy-duty resistance. If the resistance is too great it will cause your heart rate to go way up between efforts and it will inhibit the very adaptations that you want to achieve.

One of the benefits of doing these workouts (when done properly) is that your legs will feel just great the next day. It actually is a “fun” workout!

SUMMARY

• Workouts in which the intensity is developed by the athlete “naturally” can result in significant improvements, but they do not produce the same dramatic gains that can be achieved with Progressive Power Training.

• Sprint workouts in which the attempt is made to maximize intensity for 10-15 seconds “naturally” are recommended for those not having access to a CompuTrainer. These workouts should be done weekly on the same schedule that PPT workouts are indicated on the training plans given in Chapter 7.

• PC Drills, when executed systematically and with discipline, can be very beneficial in improving one’s ability to surge strongly for longer and longer periods of time. This can be very helpful in being able to “keep up” on a fast group ride.
The workouts that follow include those that may be executed only with CompuTrainer or Velotron equipment as well as those that can be executed either with an indoor trainer or without any special equipment (other than your bike).

The workouts are tagged with CTV for CompuTrainer / Velotron only, and BT for bike on a wind or magnetic trainer and RB for out on the road.
1) Do NOT plug in the CompuTrainer Handlebar Computer.

2) Set the Handlebar Computer Wattage at 100 Watts.

3) Ride for 5 Minutes at 100 Watts / 90 RPM in a 39x19 gear.

4) Calibrate the Handlebar Computer for Tire Friction.

   For normal workouts, if the friction reading is between 2.5 and 3.5 proceed. If it is outside this range, either increase or decrease the tire friction and re-calibrate the unit. If hard sprints, stall-outs or starts are planned, increase the friction reading above 3.5 to insure that no tire slippage occurs during the workout.

5) Ride for 5 more minutes at 100 Watts / 90 RPM in 39x19 and then recalibrate for tire friction. Enter the final friction setting into the handlebar computer unit.

6) Begin increasing the handlebar computer wattage by 20 watts every minute on the minute (i.e., 120, 140, 160, 180, 200, etc.) until the resistance feels heavy enough to quit the warm-up. Do NOT over-do the warm-up wattage. Simply increase the wattage until it “feels right“ for your present state of fitness.

7) Record the maximum Wattage achieved during the warm-up for your training log.

8) Put it in 39x15 and cruise slowly at 60 Watts for 3 Minutes.
1) UN-PLUG the CompuTrainer Handlebar Computer.

2) Set the Handlebar Computer Wattage at 100 Watts.

3) Ride for 5 Minutes at 100 watts and 60 RPM in a 39x19 gear.

4) Ride for 5 Minutes at 80 watts and 60 RPM in a 39x19 gear.

5) Ride for 5 more minutes at 50 Watts and 60 RPM in 39x19.

6) Get off the bike and do the following stretches:

   Quad Stretch
   Hamstring Stretch
   Calf Stretch

7) Attend to any needed hydration and re-fueling within 15 minutes if this was not done during the above 15 minute cool-down period.
1) Perform the CompuTrainer (CT) Standard Warm-Up (WU).

2) Choose your Pre-set CT course file (e.g., power.crs) having the following initial settings (settings must later be fine-tuned for each athlete):

<table>
<thead>
<tr>
<th>Distance</th>
<th>Grade</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.030</td>
<td>-5.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.040</td>
<td>15.0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

This initial course is 30 meters at 5 percent downhill-grade resistance followed by 40 meters at 15 percent uphill grade.

3) Choose the gear appropriate for your level of fitness to achieve 6-10 pedal strokes before "stalling out" (starting point might be 53x21).

4) Press start, and while staying seated on the bike, accelerate up to the required cadence (say, 120-160 RPM) as quickly as you possibly can while the grade is -5.0 percent. When the grade turns up to the specified resistance level (say, 15.0 percent) work hard to keep smooth without breaking form. Concentrate on maintaining form and keeping the cadence from dropping to zero before the race ends (i.e., stall-out).

5) Keep your upper body as still as possible while pulling on the handlebars, and driving the pedals around and around in circles. Concentrate on smoothness, lifting each foot up and over the top, while simultaneously pulling the other foot through at the bottom of the pedal stroke.

6) Try to achieve a personal best on the maximum wattage achieved during each workout. Increasing both the maximum wattage and the gear is your measure of progress. Record these values (gear, starting cadence, final cadence and maximum wattage) in your training log book.

7) Spend at least 5 Minutes of easy pedaling between efforts.
8) Adjust the either the grade or the gear on your bike (or both) if it is too hard or too easy. Adjust the distance so as to barely finish the race before stalling out. The course should not be made longer than about 8-10 pedal strokes. Make each effort as intense as you possibly can stand. A significant objective is to barely make it to the finish without breaking form.

9) Go back to step 3 to repeat the efforts. 4xPRP-120 means 4 efforts starting at 120 RPM with 5 minutes rest between efforts.

10) Perform the CompuTrainer Standard Cool-Down (CD). This is an extremely important part of your training.
1) Perform the CompuTrainer (CT) Standard Warm-Up (WU).

2) Continue the Warm-up at 100 Watts for 3 Minutes Standing Up in 53x12.

3) Choose your Pre-set CT course file (e.g., starts.crs) having the following initial settings (settings must later be fine-tuned for each athlete):

<table>
<thead>
<tr>
<th>Distance</th>
<th>Grade</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.040</td>
<td>15.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

This course is 40 meters at 15 percent grade resistance.

4) Choose the gear appropriate for your level of fitness (a reasonable starting point might be 53x21 or 53x23).

5) Press start, jump out of the saddle and accelerate the bike as hard as you possibly can. The race should last only for 8-10 complete pedal strokes, and you should be able to barely finish the course without stalling out.

6) Keep your upper body as still as possible while pulling on the handlebars, and driving the pedals around and around in circles. You can move a little bit from side-to-side to keep your body over each pedal during the down-stroke. Concentrate on maintaining smoothness, lifting each foot up and over the top, while simultaneously pulling the other foot through at the bottom of the pedal stroke.

7) Try to achieve a personal best on the maximum wattage and the maximum RPM achieved after each effort. Increasing the gear, the maximum wattage and the maximum RPM are your measures of progress. Record these values in your training log book.

8) Spend at least 5 Minutes of easy pedaling between efforts (just pull out the plug on the handlebar unit).
9) Adjust the either the course distance or the gear if it is too many or too few pedal strokes, and adjust the grade or the gear on your bike if the effort is too hard or too easy. Make each effort as intense as possible.

10) Go back to step 6 to repeat the efforts. 5xSS- 8 means 5 Standing Starts of 8 complete pedal strokes each.

11) Perform the CompuTrainer Standard Cool-Down (CD). This is an extremely important part of your training.
1) Perform the CompuTrainer (CT) Standard Warm-Up (WU).

2) Choose your Pre-set CT course file (e.g., speed.crs) having the following initial settings (settings must later be fine-tuned for each athlete):

<table>
<thead>
<tr>
<th>Distance</th>
<th>Grade</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.030</td>
<td>-5.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.040</td>
<td>10.0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

This course is 30 meters at 5 percent downhill-grade resistance followed by 40 meters at 10 percent grade.

3) Choose the gear appropriate for your level of fitness (a reasonable starting point might be 39x19 or 39x21).

4) Press start, and while staying seated on the bike, accelerate up to the required cadence (say, 120 RPM) as quickly as you possibly can while the grade is -3.0 percent. When the grade turns up to the specified resistance level (say, 8.0 percent) work hard to maintain the cadence without breaking form until the race ends. The race should last only for 10-12 complete pedal strokes. If not, adjust the distance.

5) Keep your upper body as still as possible while pulling on the handlebars, and driving the pedals around and around in circles. Concentrate on smoothness, lifting each foot up and over the top, while simultaneously pulling the other foot through at the bottom of the pedal stroke.

6) Try to achieve a personal best on the maximum wattage achieved during each workout. Increasing both the maximum wattage and the gear at the specified cadence is your measure of progress. Record these values (gear, cadence, and maximum wattage) in your training log book.

7) Spend at least 5 Minutes of easy pedaling between efforts.
8) Adjust the either the distance or the gear on your bike if it is too many or too few pedal strokes, and adjust the grade or the gear if it is too hard or too easy. Make each effort as intense as you possibly can stand without breaking form.

9) Go back to step 3 to repeat the efforts. 4xPR-120 means 4 efforts at 120 RPM with 5 minutes rest between efforts.

10) Perform the CompuTrainer Standard Cool-Down (CD). This is an extremely important part of your training.
1) Perform the CompuTrainer Standard Warm-Up (WU)

2) Choose a flat 20-40 Kilometer CompuTrainer course and press Start.

3) Choose Gear for Sprint Workout:
   Choose a gear that will allow you to crank out at least 15 strokes in 6 seconds (150 RPM). If you can't make 15 strokes in 6 seconds the gear is too hard. If you can turn over more than 15 strokes in 6 seconds, the gear may be too easy.

4) Sprint every minute on the minute beginning with 6-second sprints (as you get fitter go to 8, 10, 12, 15, and finally, 20 second sprints every minute on the minute). Maintain a target of at least 150 RPM for all of these efforts.

5) Monitor your heart rate just before each sprint is about to begin (this is your recovery heart rate). Note your recovery heart rate after the first two sprints, and when the recovery rate has gone up by 10 beats per minute above your starting value, stop the workout and cool down.

   During the recovery period pedal very slowly (60 RPM) and try to let your heart rate go down as far as possible before it is time to sprint again.

   You should in time be able to work your way up to doing as many as 30 sprints before your recovery heart rate rises by 10 beats per minute. When you can do 30 sprints, go to a longer sprint. You also should be able to turn over 150 strokes per minute in a harder gear.

6) 15 Minute Warm Down in 39x19 (Don't skip this warm down. It is extremely important!).
   Note that for 150 RPM:
   - 6 sec = 15 strokes
   - 8 sec = 20 strokes
   - 10 sec = 25 strokes
   - 12 sec = 30 strokes
   - 15 sec = 38 strokes
   - 20 sec = 50 strokes
1) Begin Warm-up with 15 Minutes in Small Ring with increasing pace.

2) Continue Warm-up with 15 Minutes in 53x12 at a moderate pace.

3) Choose a gear that allows you to keep your cadence in the 85-95 RPM range while controlling your heart rate to within the prescribed target range.

4) Ride continuously at or below a target heart rate of TT-25 beats per minute for at least 2-6 hours. You may need to slow down in order to keep your heart rate from going above the target value.

5) Try to ride continuously for the entire workout with as little stopping as possible. It takes 30-60 minutes for the benefits of this kind of training to begin again after every time you stop. The greatest benefits to your aerobic system occur during the fifth or sixth hour of training.

6) Spend 15-20 Minutes riding easy in Small Ring to cool down before dismounting. This is an extremely important part of your training.

Expected benefits:

- Increases capillary density in slow-twitch muscle fibers.

- Increases growth of mitochondria (the energy producing cells).

- Increases transport of oxygen and nutrients to the working cells.

- Increases the concentrations of key fat burning enzymes.

- Increases the concentrations of Krebs cycle enzymes.

- Results in a decrease in heart rate at every power output.

- Results in a decrease in resting heart rate.
Please Note: On the CompuTrainer choose a 40 Kilometer flat course and press start.

1) Begin the Warm-up with 15 Minutes in 39x19

2) Continue the Warm-up with 15 Minutes in 53x12

3) Put it in 53x17, 16 or 15 and ramp up the speed until your heart rate is at the target value for the workout (5-10 beats per minute below your Time Trial heart rate, specified as TT-5 or TT-10). Allow 2-3 minutes for your heart rate to stabilize before beginning the timing.

4) Ride continuously at the target heart rate for 20-30 minutes. You may need to slow down in order to keep your heart rate from going above the specified target value.

5) During the effort, monitor the Spin Scan Efficiency (SSE) and the Polar Spin Scan Plot by concentrating on it for only a few minutes at a time during the work period. Use this biofeedback to improve your pedaling efficiency. A more circular plot means higher efficiency.

6) Spend 15-20 Minutes in 39x19 for cooling down at 15 mph.

7) Repeat the effort by going back to step (3) if called for in the training schedule (e.g., 2x20 Minutes @ TT-10).

8) Always end training rides with 15-20 minutes of spinning in 39x19 at 15 mph. This is an extremely important part of your training.
1) Perform the CompuTrainer Standard Warm-Up (WU).

2) Plug in the CompuTrainer and select SpinScan mode.

3) Choose Gear for Workout based on Current Level of Fitness

Choose a gear that will allow you to crank out at least 48-60 RPM (4-5 strokes every 5 seconds) at a reasonable SpinScan Grade Selection (say, 1% - 5% range)

4) Press Start and begin riding. Clip out the right foot and pedal with the left leg only. Use the handlebar unit Plus (+) key to increase the grade resistance until your RPM slows down to the 50-60 RPM range. If you can't make 48 RPM (4 strokes every 5 seconds) the grade is too high. If you can turn over more than 60 RPM (5 strokes every 5 seconds) the grade may be too easy.

5) Work to keep the pedaling as smoothly as possible (constant chain tension). Begin with 2 minutes on each leg with one minute of rest using both pedals during the rest period between efforts, and then gradually increase the time on each leg up to 5 minutes over several workouts. If you are breaking form, use shorter times.

6) The measures of progress are the grade achieved in the given gear and the time of the effort. This information should be recorded in your training log book.

7) Do at least 2-3 sets (2-3 times on each leg)

8) On your schedule, 2xILT-2 means 2 efforts of 2 minutes on each leg, and 4xILT-3 means four efforts of 3 minutes on each leg, etc. First do the left leg, then take a one minute break using both legs, then do the right leg. Always keep pedaling during the rest periods.
9) Try including short 6-10 second surges and sprints using one leg at a time during the ILT periods. Wait until after your body has become accustomed to the normal ILT workouts before doing this.

10) Perform the CompuTrainer Standard Cool-Down (CD). This is an extremely important part of your training.
1) Perform the CompuTrainer Standard Warm-Up (WU).

2) Plug in the CompuTrainer and select SpinScan mode.

3) Choose Gear for Workout based on Current Level of Fitness

Choose a gear that will allow you to crank out at least 48-60 RPM (4-5 strokes every 5 seconds) at a reasonable SpinScan Grade Selection (say, 3% - 5% range). Then reduce the grade to zero.

4) Press Start and begin riding. Increase the grade until your cadence is in the 48-60 RPM range. Note the SpinScan Efficiency number (SSE) and the appearance of the SpinScan polar graphical plot (the more circular the better).

5) Increase the grade rapidly by holding down the (+) key on the handlebar unit. It should no longer be possible to maintain 48 RPM. Continue increasing the grade until your form begins to break as indicated by the SSE number and by the appearance of the polar graphical plot, then back off until your form begins to get better again. Continue for 10-20 pedal strokes before rapidly decreasing the grade to zero for recovery. It is O.K. if the cadence goes down significantly, but it must only be held for 10-20 pedal strokes before rapidly decreasing the grade to zero again.

6) Work to keep the pedaling as smooth as possible and to even improve the pedal stroke by observing the SSE and the polar plot on the SpinScan screen.

The measures of progress are the grade achieved in the given gear and the ability to use harder gears. This information should be recorded in your training log book.

7) Active rest between sets should be at least 5 minutes. Keep pedaling during the rest periods. Then return to (4) and repeat. Do at least 2-3 repeats per session, depending on the intensity achieved.
8) On your schedule, 3xPRF-10 means 3 efforts of 10 pedal strokes at the level of incipient failure to retain form.

9) Perform the CompuTrainer Standard Cool-Down (CD). This is an extremely important part of your training.
1) Perform the CompuTrainer Standard Warm-Up (WU).

2) Plug in the CompuTrainer and select SpinScan mode.

3) Choose Gear for Workout based on Current Level of Fitness

   Choose a gear that will allow you to crank out at least 72-84 RPM (6-7 pedal strokes every 5 seconds) at a reasonable SpinScan Grade Selection (say, 3% - 5% range). Then reduce the grade to zero.

4) Press Start and begin riding at 72-84 RPM. Increase the grade by pressing (+) on the handlebar unit until your heart rate is near your Time Trial heart rate as determined during the Modified Field Test (MFT). Allow at least 2-3 minutes for your heart rate to stabilize. Note the SpinScan Efficiency number (SSE) and the appearance of the SpinScan polar graphical plot (the more circular the better).

5) When your TT heart rate has stabilized, increase your cadence rapidly to 120 RPM or more. Continue increasing the RPM until your form begins to break as indicated by the SSE number and by the appearance of the polar graphical plot, then back off on the RPM until your form begins to get better again. Continue for 3 minutes before rapidly decreasing the grade to zero by pressing (-) on the handlebar unit (for rest and recovery).

6) During each effort, work to keep the pedaling as smooth as possible and to even improve the pedal stroke by observing the SSE and the polar plot on the SpinScan screen.

   The measures of progress are the grade achieved in the given gear and the ability to use harder gears without breaking form. This information should be recorded in your training log book.

7) Active rest between sets should be at least 4 minutes. Keep pedaling during the rest periods. Then return to (4) and repeat. Do at least 2-3 repeats per session.
8) On your schedule, 3xVO2MF means 3 efforts at the level of incipient failure to retain form.

9) Perform the CompuTrainer Standard Cool-Down (CD). This is an extremely important part of your training.
This workout stirs up the blood circulation in your legs and accelerates healing and recovery. During the 1980's the Russians did this twice a day, once upon arising in the morning before breakfast, and once before bedtime. It really works!

1) Put your bike on a stationary trainer or on rollers

2) Start pedaling in an easy gear at low cadence

3) Just let your legs go down one at a time, being really lazy

4) Do only 20-30 minutes. You cadence will naturally increase.

5) At the end of the time your legs will be turning over really smoothly

6) Stop at 20-30 minutes and go on with your day or evening
Please Note: If you are using the CompuTrainer choose a 40 mile flat course and press start.

1) Begin Warm-up with 15 Minutes in 39x19 at Increasing Pace

2) Continue Warm-up with 15 Minutes Easy in 53x12

    Choose the best gear for the workout. The resistance should be firm but not at all hard (this is a neuromuscular recovery workout).

3) Use 39x17, 18 or 19 (or your favorite gear) and ramp up the speed until your cadence is 96 RPM (8 pedal revolutions every 5 seconds).

4) Continue increasing the speed until your cadence is 108-120 RPM (9 or 10 pedal revolutions every 5 seconds). If the gear is too hard, make it easier by going to a larger rear cog.

5) Spend 15-30 Minutes at high cadence as prescribed. 2xHC-15 means 2 efforts of 15 minutes each. Go easy at a low cadence of 60-70 RPM in the small ring for 10 minutes between efforts.

6) Always end training rides with 15-20 minutes of spinning in 39x19 at 15 mph. This is an extremely important part of your training.
Perform the test when well rested, preferably at the end of an “Easier Week” in your training schedule and after at least two easy days of training.

Do not eat any solid foods for at least 2 hours before the test. Just 45 minutes prior to the test, consume a high carbohydrate sports drink containing at least 50 grams of carbohydrates.

1) Choose a flat 40 mile CompuTrainer course and press Start

2) Warm up for 15 minutes at a moderate pace, then do 2x2 minute hard efforts at high cadence (100-110 RPM) with a recovery interval of 4 minutes between efforts (RI=4). Next, ride for 5 minutes easy, then do one 25-stroke all-out sprint, followed by five minutes of easy riding at 15 mph in 39x19. Prepare mentally for effort No. 1.

3) Begin Effort No. 1: From a standing start, ramp up the speed while standing up (no sprinting), then move gradually into a seated position when you reach 80 RPM. Do not start out too fast. Aim to reach your maximum speed at the end of the first two minutes, and not before.

4) Next, choose a gear that allows you to stay in the 80-95 RPM range while riding in that fast, “feel good” speed range that you feel you can maintain for the full 8 minutes of the test.

5) Work on achieving your maximum sustainable speed while settling into a steady breathing rhythm. Shift gears so as to maintain a 90-95 RPM cadence. Focus on breathing out as much as possible. Work on forcing the pace as much as possible for the remainder of the time.

6) Keep track of your average speed and your average heart rate during the last 5 minutes of the effort (from the appearance of minute 3 through the appearance of minute 8).

7) Recover for 10 minutes at 15 mph in 39x19 easy.
8) Repeat steps (2) through (7).

9) Cool down for 15-20 minutes at 15 mph in 39x19 easy. Good Job!

10) Record all of your data in your training log and send a copy to your coach.
Below are copies of the CRS course files. These are needed by CompuTrainer or Velotron to execute the PPT workouts as described in Chapter 5. These text files can be edited using Microsoft WordPad or Notepad and need to have the precise format shown below. The CRS course files need to be stored in the courses subfolder of the application you are using so the CompuTrainer or Velotron can access these workouts.

1) Progressive Stall-Out Power Course

[COURSE HEADER]
UNITS = METRIC
DESCRIPTION = 15.0 Stallout
FILE NAME = Stallout.crs
;DISTANCE GRADE  WIND
; COMMENTS
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[COURSE DATA]
0.030 -5.0 0.0
0.040 15.0 0.0
[END COURSE DATA]

2) Progressive Standing Start Course

[COURSE HEADER]
UNITS = METRIC
DESCRIPTION = 15.0 Start
FILE NAME = Start.crs
;DISTANCE GRADE  WIND
; COMMENTS
[END COURSE HEADER]

[COURSE DATA]
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[END COURSE DATA]
3) Progressive Resistance Speed Course

[COURSE HEADER]
UNITS = METRIC
DESCRIPTION = 10.0 Resistance
FILE NAME = Resist10.crs
;DISTANCEGRADE WIND
; COMMENTS
[END COURSE HEADER]

[COURSE DATA]
0.030  -5.0  0.0
0.040   10.0  0.0
[END COURSE DATA]
APPENDIX II

VIDEO LINKS – AIDS TO HELP YOU WITH PROGRESSIVE POWER TRAINING WORKOUTS

The following video links are visual examples and demonstrations on how to do progressive power training workout drills.

Video 1: http://www.youtube.com/watch?v=DZDqDPNesPw&feature=related

Video 2: http://www.youtube.com/watch?v=PlfwX-3qIBU&feature=related
ABOUT THE AUTHOR

BILL EDWARDS

Coach Bill Edwards has been involved in competitive cycling for more than 62 years and has actively coached cyclists since 1980. Bill’s principal coaching mentors include United States Hall of Fame Coaches Mike Walden and Chris Carmichael. During his 38-year professional career Bill served as PhD Senior Staff Chemical Engineer at the Shell Oil Research Laboratory in Houston, Texas.

Bill is the coach of 14-time Masters World Champion Match Sprinter Al Whaley who, along with Paralympian Pam Fernandes, won a Gold Medal and a Silver Medal on a tandem bicycle at the 2000 Paralympic Games in Sydney, Australia. Al & Pam set a World Record and two Paralympic records in the process.

Bill has coached six U.S. National Team members, eleven U.S. National Champions, two Master’s World champions and one professional cyclist on the Saturn team. He was the USAC Regional Coach for the eleven-state Southern Region from 1987-1992 during which time he reported to National Team Director and Lance Armstrong’s coach Chris Carmichael. He was selected as a U.S. Olympic Festival coach in 1989, 1990, 1991 and 1995, and held the position of head coach at the 1991 Olympic Festival. Bill is well known throughout the state of Texas as a highly qualified cycling coach. From 1991 - 2006 he was the Chairman of the Board, the Team Director and Coach of the Southern Elite Youth Cycling Race Team, a 501(c)(3) team dedicated to identifying and developing talented young athletes. Southern Elite was the number one team among 98 teams in the State of Texas in 2001 and 2002.
Bill began his racing career in San Diego, California as a Junior in 1946 and advanced from category III to II to I (known then as “C”, “B”, and “A”) by age 17. He competed as a senior in Southern California during the 1950’s while attending UCLA. After age 55 Bill continued racing, winning USCF Texas Masters State Championship Road Race and Time Trial events. In 1997 Bill won a bronze medal in the National Senior Olympics in Tucson, Arizona. More recently (in his old age) he has won numerous events in the Texas State Senior Olympic Championships in his age category, often posting TT times that were faster than most of the younger age category riders. In 1998 he took a brief leave from coaching, followed his own training advice, and won four Gold Medals at the U.S. Masters National Championships (see below).

Notable Recent Race Results:

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Distance</th>
<th>Medal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998 Masters National</td>
<td>500M TT</td>
<td></td>
<td>Gold</td>
</tr>
<tr>
<td>1998 Masters National</td>
<td>Match Sprint</td>
<td></td>
<td>Gold</td>
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<tr>
<td>1998 Masters National</td>
<td>Points Race</td>
<td></td>
<td>Gold</td>
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<tr>
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<td>2 Km TT</td>
<td></td>
<td>Gold</td>
</tr>
<tr>
<td>1997 National Senior</td>
<td>5 Km TT</td>
<td></td>
<td>Bronze</td>
</tr>
</tbody>
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Bill’s Coaching Goals:

1) To encourage young people to explore cycling, and to introduce them to an excellent way of pursuing a lifelong, healthy and rewarding lifestyle;

2) To identify talented young athletes and help them to become competitive at the National level and beyond through involvement with the Southern Elite Youth Cycling Team;

3) To be an inspiring role model to recreational cyclists and serious competitive cyclists of all ages.

Visit Bill Edwards’ web site at www.performanceedge-r.com