

NSCA's

May 2002  
Volume 1, Number 5  
[www.nscs-lift.org/perform](http://www.nscs-lift.org/perform)

# Performance Training

*Journal*

## **Cycling**

Intervals:  
What, Why  
and How

**Strength Train  
to Ride Better**



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# NSCA's Performance Training Journal

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## Mission

As the worldwide authority on strength and conditioning, we support and disseminate research-based knowledge and its practical application to improve athletic performance and fitness.

## From The Editor

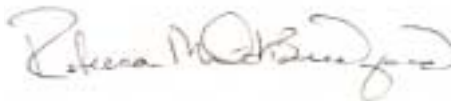
NSCA has been producing the finest professional publications in the strength and conditioning field for almost 25 years. *NSCA's Performance Training Journal* is our attempt to reach out to a wider audience, and fulfill our mission to disseminate "... research-based knowledge and its practical application to improve athletic performance and fitness." In addition to general strength and conditioning topics, the journal focuses on six sports throughout the year: racquet sports, golf, cycling, swimming, running/walking and skiing/snowboarding.

If you enjoy reading *NSCA's Performance Training Journal*, please sign up for a free subscription at [www.nscalift.org/perform/subscribe.shtml](http://www.nscalift.org/perform/subscribe.shtml) — these subscriptions are how we justify the journal's existence.

Do you have questions, comments, suggestions? Please send them to me at [RMilot-Bradford@nscalift.org](mailto:RMilot-Bradford@nscalift.org). As we wrap up our first six issues, we will be looking at ways to improve the journal, so let me know what you think.

One change you'll notice in this issue: the Ask The Experts column has been dropped for lack of questions. We may reinstate this feature in the future, if there is enough interest to warrant it.

Happy training!



Rebecca Milot-Bradford, M.B.S.  
Editor-In-Chief

## Talk To Us

Share your questions and comments. We want to hear from you. Write to *Performance Training* Editor, NSCA, 1955 North Union Blvd., Colorado Springs, CO 80909 or send email to [RMilot-Bradford@nscalift.org](mailto:RMilot-Bradford@nscalift.org).

## Time on the Bike

**A**s a cyclist, you are aware of the dedication and commitment necessary to achieve your goals, whether it is completing a century ride, finishing an Ironman-length triathlon or placing in the local criterium race. Cycling, like many other sports, requires a great time commitment; you must put in the necessary mileage to improve performance, often spending hour upon hour on the bike. This situation presents you with a lot of time to be “in your head.” Even if you ride with a training group and can interact with other riders, much of time you are still left “alone” with your own thoughts. How do you, or should you, make use of this time? What are effective mental strategies to occupy the time and enhance performance?

Athletes have been found to use two types of cognitive strategies to deal with this “time in their head,” each being equally effective depending on your goals, the

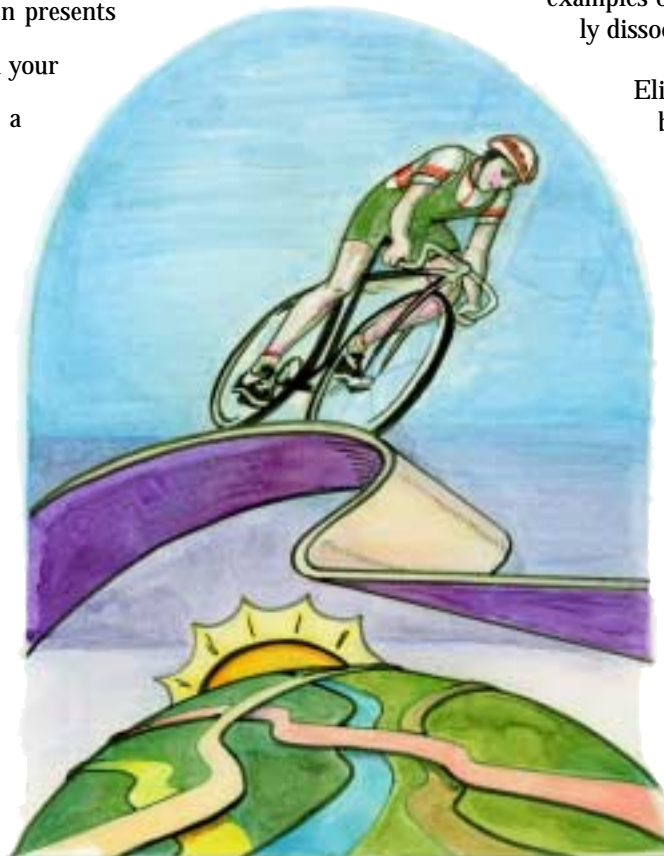
situation, and individual characteristics. Associative strategies are thought processes where you focus on internal sensations such as breathing, muscular fatigue, heart rate, or perceived exertion; you essentially monitor your body’s feedback to physical exertion. For example, you are using an associative strategy when you monitor your pace or cadence to keep your heart rate within a specific range.

Dissociative strategies, conversely, are thought processes that distract you from sensations of physical discomfort and fatigue. Have you ever found yourself putting together a grocery list, planning the rest of weekend, or singing a song to yourself while on a training ride? These are examples of dissociation—you are mentally dissociating from what you are doing.

Elite and recreational athletes use both strategies, but each is used purposefully because of the effect it has on performance. It is suggested by some that the level of intensity is a critical factor in determining what strategy is most appropriate. As intensity increases, adopting more associative strategies and decreasing dissociative strategies seems to enhance endurance performance.

As further support to this suggestion, research has found that marathoners who used dissociative strategies during races were more likely to “hit the wall.”

It seemed they were not regulating their pace adequately and underhydrat-



ing during the race—they were not attending to bodily feedback. So, in competitions or “critical,” intense training situations, it may be beneficial to attend to bodily sensations to better manage performance.

Additionally, because of the low skill complexity of cycling, and other endurance sports, there are times when it may be effective to use dissociative strategies. When the task is not excessively physically demanding, it is probably not necessary to attend to internal sensations and feedback. Instead, you can turn your thoughts towards things that serve to distract you from the present situation. Two hours into a steady-state training ride, where your body is performing on automatic pilot and is not overly taxed, occupying one’s mind with random thoughts unrelated to cycling is probably an effective cognitive strategy.

The bottom line—it is important to be trained in using both associative and dissociative strategies in order to manage pain and discomfort as well as to enhance performance. As has been noted, each has value. As an athlete, it is important to practice using both associative and dissociative mental strategies. Additionally, it is critical to identify the situations where each is most effective and to use these strategies accordingly.

### About the Author

*Suzie Tuffey received her Master’s and Ph.D. in Sport Psychology/ Exercise Science from the University of North Carolina-Greensboro. She has worked for USA Swimming as the Sport Psychology and Sport Science Director, and now is Associate Director of Coaching with the USOC where she works with various sport national governing bodies (NGBs) to develop and enhance coaching education and training. Additionally, Suzie is an NSCA-certified personal trainer.*

## Muscle Contraction Theory

**W**hat really happens when muscles contract? How does it occur and what can individual exercisers do to control it or enhance it? Those are all questions that need to be answered if we are to understand the mechanisms behind human performance<sup>1</sup>. First we must understand the structure of the basic muscular system in order to make sense of how it operates. In short, all a muscle can do is get shorter or longer, and since the muscle is attached to bone, the result is movement of our limbs.

### Structure

The muscle is really made up of many thousands of microscopic fibers called filaments. However, that is getting too far ahead of the picture. We will return to filaments later but let's begin our search at the large level that is visible to the naked eye. The **Muscle** we see on the surface is primarily a long cylinder, tapering at both ends where it attaches to tendon. If we look further inside, we see that this muscle is comprised of several bundles of even smaller groups of similar objects called **Fascicles**. A look inside a single fasciculus reveals several yet smaller groups of bundled objects, called **Myofibrils**, which are in turn made up of even smaller objects—the **Filaments** mentioned earlier. The filaments are long string-like microscopic structures divided into even smaller pieces called **Sarcomeres**, which are stacked end to end along the entire length of the muscle. There are literally hundreds of thousands of sarcomeres and they are made up of tiny opposing fingerlike projections called **Actin** and

**Myosin**. Finally then, actin and myosin make up the basic contracting fibers that cause the entire muscle to shorten. Hundreds or thousands of these single muscle fibers are grouped together and controlled by one nerve ending which are collectively called a **Motor Unit**<sup>2</sup>.

### Mechanism

The previous description may sound complicated but it really only takes a few simple steps to achieve muscular contraction. First, an electrical signal called an **Action Potential** is sent from the brain to the motor unit it wishes to contract. When the signal reaches the motor unit the signal enters the fibers, causing the release of calcium. Calcium then allows the actin and myosin fingerlike projections to combine and pull against one another, which causes the filaments to slide past one another and thereby shorten. This process is known as the "Sliding Filament Theory"<sup>3,4</sup> and is the predominant theory governing muscular contraction. Of course this process requires some type of fuel but that is another column on another day.

### Conclusion

It should be apparent from the preceding description that muscular contraction involves both a neural and a physical event. In this way the system may be regulated from either side. A greater number of brain signals will cause a more forceful contraction, and likewise, a greater number of muscle fibers will result in more applied force. Different muscle fiber types will respond to brain signals in a specific manner<sup>5</sup> and will require training specific to the outcome. In the next column we will discuss training the physical portion of the contraction system, specifically how it relates to muscle hypertrophy and gaining size through resistance training.

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# Interval Training for the Cyclist: What, Why and How

Mike Niederpruem, M.S., CSCS

Interval training is perhaps one of the more common training methods used to improve physical performance, but at the same time, because of the almost infinite combinations of variables utilized in creating an interval training program, it is one of the least understood by athletes and coaches alike. Simply put, interval training can be defined as alternating efforts of high intensity activity with efforts of low intensity (active recovery).

## Why Do Intervals?

The rationale for interval training is that an athlete can perform more work (i.e., go faster or produce more power) during short periods of time than he would be able to for a longer, continuous period of time.

For example, a cyclist might be able to ride a fixed-distance time trial, at a maximum sustainable effort, for 30 minutes continuously at an average speed of about 25 miles per hour (depending on his level of physical development, training experience, and other factors). However, if this same cyclist performed an interval workout, it might look like this:

Sets	# of Repetitions (Reps.)	Duration of each Rep.	Recovery betw. Efforts	Recovery betw. Sets	MPH
2	5 per set	3 minutes	3 minutes	10 minutes	28

As you can see from this example, the cyclist was able to ride significantly faster during each of the 3-minute intervals than he could by riding the entire 30 minutes continuously.

## Exercise Physiology 101

Before we can begin discussing all the variables involved in creating specific interval training programs, we need to briefly review some basic physiology of exercise. There are three energy systems in the human body that can be optimized or enhanced through the use of interval training:

1. **ATP-PCr System**—This energy system refers to high-energy phosphates (ATP - adenosine triphosphate, and PCr - phosphocreatine) that are stored inside the muscles, and are an immediate source of energy for short duration (5 - 20 seconds), high intensity exercise. Practical examples include race starts, sprints, etc.
2. **Lactic Acid System**—As the ATP-PCr system becomes depleted, anaerobic glycolysis begins resynthesizing the high energy phosphates by using muscle glycogen (the storage form of glucose—the final product of carbohydrate digestion and the main form of carbohydrate within the blood) as a source of energy. As a result of this process, lactate is produced, and high levels of lactate accumulate in the blood between 1 and 3 minutes of continued high-intensity exercise. Practical examples include 500 meter and 1 kilometer time trials, break-aways or attacks lasting up to 3 minutes, etc.
3. **Aerobic System**—If the effort continues, lactate continues to accumulate, and you will no longer be able to maintain a high intensity level. If you continue to ride at a lower intensity level, a third energy system, the Aerobic system, is activated. The aerobic system is, by far, the most efficient energy system for sustained endurance activity and provides the

greatest amount of energy as well. As the duration of the activity exceeds three minutes and beyond, more and more of the energy is derived from this energy system. Generally, long-duration efforts relying almost exclusively on the aerobic system are referred to as submaximal exercise.

The good news is that all three energy systems can be trained, either individually or in combination, and by incorporating appropriate interval progressions into your training plan, you will see measurable improvements, not only in your physical ability, but your racing performance as well.

## Learning the Vocabulary

In our first example, we used a number of different terms in defining and quantifying an interval workout. Familiarity and understanding with these terms and the others listed below will help facilitate your efforts at designing effective interval training programs:

**Intensity**—how hard you are supposed to go, so to speak, for the duration of each effort.

Intensity can be prescribed by heart rate (in beats per minute), speed (miles or kilometers per hour), ratings of perceived exertion (a subjective rating for how hard you feel you are working), or in more advanced situations, by power (Watts) or by blood lactate levels.

**Duration**—the length of time for each work interval; can be in seconds for the ATP-PCr energy system, up to minutes for the Lactic Acid and Aerobic energy system.

**Repetitions**—the total number of efforts performed; can be prescribed in sets. For example, one set of 10 efforts, or 2 sets of 5 efforts each.

**Recovery**—most, if not all, recovery will be active recovery. This means that in between the intervals, you will be riding along slowly. Another type of recovery is passive recovery, where you may actually get off the bike and sit for the time of recovery. Recovery can differ

between efforts as opposed to sets. Usually, recovery between sets is 2 or 3 times longer than recovery between intervals. For example, if the recovery between intervals is 3 minutes, then the recovery between sets might be between 6 - 10 minutes.

Additionally, recovery times in between efforts are usually expressed as a ratio of time of effort to time of recovery, sometimes referred to as “work : rest.” For the ATP-PCr energy system, this can range from 1:3 to 1:10; for the Lactic Acid System, 1:2 to 1:3; for the Aerobic System, 1:1 to 1:1.5.

## How to Perform Intervals—Getting Started

What follows are numerous examples of interval training programs for the various energy systems. As mentioned previously, these can be performed individually or in combination. First, regardless of your level of physical development or experience, it is important that you have a sufficient “base” or foundation. This means that a majority, if not all, of your recent training (the last 4 - 8 weeks) has been low intensity, long-duration activity. Performing interval training prematurely or too often can increase the risk for injury, overtraining, or both.

Second, determine your current level of physical development by comparing yourself to the chart below. These are general guidelines, and you may not fit into one specific category. If in doubt, choose the lower level. If, after a week or two, it feels too easy, then it is easy to move up to the next level. It has been my experience in the last 15 years of coaching that most people over-estimate their ability, and thus, are chronically training too hard, too often.

	NOVICE	INTERMEDIATE	ADVANCED
<b>Years of Experience with Structured Training</b>	New to the sport, or up to one year	1 to 3 years	3+ years
<b>Time Available for Training</b>	Less than 8 hours/week	8 - 12 hours/week	12 - 18+ hours/week

# Training the ATP-PCr Energy System

## NOVICE

Sets	Reps	Duration (seconds)	Recovery betw. Efforts	Recovery betw. Sets	Intensity	Frequency
1	5	5 - 10	15 - 30 s minimum; 1 - 5 minutes maximum	Not Applicable (NA)	Max	1x/week
2	4	5 - 15	Same as above	5 minutes	Max	1x/week
2	3	10 - 20	Same as above	5 minutes	Max	2x/week

## INTERMEDIATE

Sets	Reps	Duration (seconds)	Recovery betw. Efforts	Recovery betw. Sets	Intensity	Frequency
1	5	5 - 10	15 - 30 s minimum; 1 - 5 minutes maximum	NA	Max	1x/week
2	4	5 - 15	Same as above	5 minutes	Max	2x/week
3	3	10 - 20	Same as above	5 minutes	Max	2x/week

## ADVANCED

Sets	Reps	Duration (seconds)	Recovery betw. Efforts	Recovery betw. Sets	Intensity	Frequency
1	5	5 - 10	15 - 30 s minimum; 1 - 5 minutes maximum	NA	Max	1x/week
2	4	5 - 15	Same as above	5 minutes	Max	2x/week
3	3	10 - 20	Same as above	5 minutes	Max	2 - 3x/week

### Notes:

1. Because these efforts are so short, there is insufficient time for the heart to respond. Therefore, using HR as a means for prescribing intensity is not appropriate. Nonetheless, these efforts need to be performed at maximum sustainable intensity on the part of the cyclist.
2. There is a wide range of time allowed for recovery between these types of efforts. Allow longer periods of recovery when you are just beginning these types of intervals, and as you improve, shorten the recovery time. Also, if you find that you are unable to complete subsequent efforts, then you probably aren't allowing enough time between efforts for recovery.

# Training the Lactic Acid Energy System

## NOVICE

Sets	Reps	Duration (minutes)	Recovery betw. Efforts	Recovery betw. Sets	Intensity (Max HR)	Frequency
2	3	2	2 minutes	6 minutes	92 - 94%	1x/week
2	4	2	2 minutes	6 minutes	92 - 94%	1x/week
2	3	3	3 minutes	10 minutes	92 - 94%	2x/week

## INTERMEDIATE

Sets	Reps	Duration (minutes)	Recovery betw. Efforts	Recovery betw. Sets	Intensity (Max HR)	Frequency
2	4	3	3 minutes	10 minutes	92 - 95%	2x/week
2	4	4	4 minutes	12 minutes	92 - 95%	2x/week
1	8	4	4 minutes	NA	92 - 95%	2x/week

## ADVANCED

Sets	Reps	Duration (minutes)	Recovery betw. Efforts	Recovery betw. Sets	Intensity (Max HR)	Frequency
2	5	3	3 minutes	10 minutes	95%+	2x/week
2	5	4	4 minutes	10 minutes	95%+	2x/week
1	10	4	4 minutes	NA	95%+	3x/week

### Note:

1. Using percentage of maximum heart rate is only one possible method for determining intensity. These ranges are only general recommendations. For further clarification in determining the ideal training intensities, please contact a licensed coach, certified personal trainer, exercise physiologist, or other trained fitness professional.

# Training the Aerobic Energy System

## NOVICE

Sets	Reps	Duration (minutes)	Recovery betw. Efforts	Recovery betw. Sets	Intensity (Max HR)	Frequency
1	3	6	6 - 9 minutes	NA	82 - 90%	1x/week
1	4	6	6 - 9 minutes	NA	82 - 90%	1x/week
1	4	8	6 - 9 minutes	NA	82 - 90%	2x/week

## INTERMEDIATE

Sets	Reps	Duration (minutes)	Recovery betw. Efforts	Recovery betw. Sets	Intensity (Max HR)	Frequency
1	3	8	8 - 12 minutes	NA	82 - 90%	1x/week
1	4	8	8 - 12 minutes	NA	82 - 90%	2x/week
1	4	10	10 - 15 minutes	NA	82 - 90%	2x/week

## ADVANCED

Sets	Reps	Duration (minutes)	Recovery betw. Efforts	Recovery betw. Sets	Intensity (Max HR)	Frequency
1	4	10	10 - 15 minutes	NA	82 - 92%	2x/week
1	4	12	12 - 16 minutes	NA	82 - 92%	2 - 3x/week
1	5	12+	12 - 16+ minutes	NA	82 - 92%	2 - 3x/week

### Note:

1. Using percentage of maximum heart rate is only one possible method for determining intensity. These ranges are only general recommendations. For further clarification in determining the ideal training intensities, please contact a licensed coach, certified personal trainer, exercise physiologist, or other trained fitness professional.

## Considerations

### Combining Types

You can combine interval types. Usually, you should only focus on two different types at one time. For example, one day a week dedicated to the ATP-PCr energy system, and the other dedicated to the Lactic Acid energy system. Remember, interval training is both physically and psychologically challenging, and more is not always better. Even the most highly trained cyclists will limit their interval training to three times a week, with the very rare exception of one or two weeks perhaps of four sessions per week.

### Progression

It's usually a good idea to perform the same session of intervals at least twice before making adjustments to make the interval session more difficult. This way, any improvements are observable.

### Discipline specificity

By making adjustments to the cadence at which you perform intervals, they can be made more specific to a particular cycling discipline. Road cycling usually occurs in the range of 80 - 110 rpm's; mountain biking in the range of 75 - 100 rpm's; track racing in the range of 85 - 150+ rpm's.

The strategic use of intervals (and their subsequent progression) as part of a structured training plan can have a positive and powerful impact on a cyclist's development physically, as well as improving their race results.

## Suggested Reading

*British Cycling Federation Coaching Education Course Resources.*  
British Cycling: Manchester, England; coaching@british-cycling.org.uk

*Carmichael Training Systems Member Training Manual*, vol. 1.  
Carmichael Training Systems: Colorado Springs, CO; proshop@trainright.com

McArdle, Katch and Katch. *Exercise Physiology: Energy, Nutrition and Human Performance.* Lippincott, Williams and Wilkins: ISBN 0-7817-2544-5; 2001

*USA Cycling Club, Expert and Elite Coaching Manuals.* USA Cycling: Colorado Springs, CO; coaches@usacycling.org

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*Mike Niederpruem, M.S., CSCS, is currently the Director of Coaching Development at Carmichael Training Systems. Mike received both his undergraduate and graduate degrees from Indiana University. Previously, Mike was responsible for creating the coaching education curriculum at USA Cycling, and he also recently served as the National Coaching Director for the British Cycling Federation.*

# FitnessFrontlines

Edmund R. Burke, Ph.D., CSCS

## Do you really know how hard you are exercising?

A new study by Glen E. Duncan, Ph.D., research fellow at the University of Florida Health Science Center in Gainesville, shows that it is a lot easier to determine that you walked for 30 minutes or for two miles than it is to figure out how vigorously you walked. According to a study published in the *Journal Preventative Medicine*, people often overestimate the intensity of their workouts. In the study, 94 men and women recorded how long and how hard they thought they exercised for two weeks, and then they checked their estimates against a heart rate monitor. The participants recorded accurately their exercise time, but almost half said they exercised moderately for at least 10 minutes, while, according to the heart rate monitors, only 15 percent actually did. Miscalculating your intensity level can have repercussions. Underestimating the intensity of your workouts could lead to overeating and weight gain if you think you've burned more calories than you have. Secondly, one may not reach a training intensity sufficient enough to ensure cardiovascular benefits. So how can you tell if you're exercising at that moderate level? The best way: Use a heart-rate monitor in your exercise program.

*Preventative Medicine*. October pp. 18 - 26, 2001.

## Feeling a little down, lift weights . . .

Lifting weights may help lift clinical depression, says a new study from the Harvard Medical School and the Jean Mayer U.S. Department of Agriculture Human Nutrition Research Center on Aging at Tufts University in Boston. Symptoms of depression receded in three-quarters of the men and women who followed a 20-week strength-training program to build up their upper bodies (arms and shoulders) and lower bodies (legs and buttocks). In contrast, depression receded in only a third of the control group, which did no weight lifting but attended lectures on health. The benefit was most pronounced for those with more severe depression, reported researchers Maria Fiatarone Singh and Nalin Singh. The study also found that the benefits persisted despite the fact

that after the first ten weeks the exercisers were on their own and no one was directly supervising them.

*Journal of Gerontology: Medical Sciences* 56A: M497, 2001.

## Does strength training increase resting metabolic rate?

It doesn't matter if you're young or old. Strength training not only builds muscles; it also boosts your resting metabolic rate. And that's important, because it means that your muscles burn extra calories all day, whether you're sitting at a desk or lounging on the couch. They do if you're a man, that is. Strength training didn't boost resting metabolic rate in women in a six-month study at the University of Maryland. Strength-training exercise is good for women because it increases their muscular strength and endurance, reported researcher Jeff Lemmer. But the study shows that it looks like women can't count on strength training to help burn off extra calories like men can. The study showed that women's muscle mass increased only half as much as the men's. But the researchers did know if that explains why the men's RMR went up and the women's didn't. However, while men can gain in calorie burning from weight training, women can still gain in strength and increased fitness from resistance training.

*Medicine and Science in Sports and Exercise* 33: 532,2001

### About the Author

*Edmund R. Burke, Ph.D., CSCS, is Professor and Director of the Exercise Science Program at the University of Colorado at Colorado Springs. He served as Coordinator of Sports Sciences for the U. S. Cycling Team leading up to the Olympic Games in 1996 and was a staff member for the 1980 and 1984 Olympic Cycling Teams. Dr. Burke is a Fellow of the American College of Sports Medicine and a Certified Strength and Conditioning Specialist (CSCS) with the NSCA. He has authored or co-authored fifteen books on training, fitness and nutrition.*

# Resistance Training for Cyclists

Gregg Fuhrman, M.P.T., CSCS

**C**ycling is primarily an endurance sport with the major energy contribution coming from aerobic energy production. Resistance training, or weight lifting, is primarily an anaerobic activity characterized by short bursts of high intensity work. At first glance it would appear that these two activities are at the opposite ends of the fitness spectrum. In fact, Chris Carmichael, personal coach to Lance Armstrong, has compared the relationship of weight training and cycling to that of “oil and water.”

While Carmichael acknowledges the dichotomy of weight lifting and cycling, he feels that the time spent in the gym lifting in the early season is essential to build the cyclist's strength for the demands of the competitive season. But what about the recreational or amateur cyclist; why should they be concerned with weight lifting?

## Why lift weights for cycling?

In the book *Science of Cycling*, edited by Dr. Edmund R. Burke, Harvey Newton outlines several benefits of resistance training.

- 1 First and foremost is obviously increasing strength. The ultimate goal of increasing your cycling performance is to ride faster. In order to ride faster, the cyclist has three choices: exert more force into the pedals, pedal faster or both. Resistance training builds strength in musculature needed to exert more force into the pedals.
- 2 Second, resistance training improves local muscular endurance. If the primary muscle groups involved in turning the pedals have increased endurance, the rider will be able to sustain a faster speed for a longer time, hence a better performance.
- 3 Third, resistance training plays an important role in injury prevention. Cycling is inherently a highly repetitive activity. Consider a cyclist out for a two-hour training ride. With a cadence of 94 revolutions per minute (rpm), he or

she will perform 11,280 repetitions! If the musculoskeletal system is not prepared to handle this quantity of repetition, overuse injuries can easily result. Resistance training strengthens connective tissue found in muscle, tendon, and at their attachment sites onto bones. The benefit of this “pre-hab” is important for the athlete who wants to stay on the road.

- 4 Finally, resistance training is an important component of a post-injury rehabilitation program to get the athlete back on the bike.

## Cycling Biomechanics

In the power phase, as one leg pushes down on the pedal from a starting point at the 12 o'clock position, the following actions are occurring. The hip flexors contract to flex the hip to prepare for the push phase. Knee extensors (muscles that straighten the knee) contract as the rider pushes down, coordinating with the powerful hip extensors contracting to straighten the hip. Plantar flexors (muscles that point the foot down) contract to further assist with the push on the pedals. As the pedal stroke continues, the antagonist (opposing) muscle groups to those mentioned, contract to prepare the leg for the upcoming pedal revolution.

Anecdotally, it was thought that the use of toe clips, and more recently clipless pedal systems that fix the rider's foot to the pedal, allow the rider to pull up on the pedal opposite to the side that is pushing down. However, laboratory research has more accurately shown that the non-pushing leg is really being prepared to get out of the way and to unload resistance off the pushing side pedal. A skilled cyclist is more efficient at both phases: applying more force to the pushing side pedal, while concurrently unloading the opposite side pedal.

A final point on muscle function—riding a bike is a concentric muscle activation activity. Concentric muscle activation is defined as a muscle generating force through shortening. Eccentric muscle activation is defined as a muscle generating force as it is elongating. Activities that include both eccentric and concentric activation patterns include walking, running, jumping, throwing, and catching. The bicycle as a machine is unique in that it allows the rider to activate the necessary muscle groups concentrically.

**Table 1: Sample Periodization Scheme for Cyclists**  
Based on a competitive season from May through August

Phase	Timing/ Duration	Sets	Reps	Intensity (% 1RM*)	Training Days/week	Recovery Time
<b>Transitional</b>	6 weeks: Oct. to mid-Nov.	1 - 3/exercise	12 - 15/set	low: 30 - 50% for each exercise	2 - 3 on alternate days	60 - 90 seconds between sets
<b>Hypertrophy</b>	6 weeks: mid-Nov. to end Dec.	3/upper body exercise; 5/lower body exercise	8 - 12/set	Moderate to high: 70 - 85% for each exercise	3 on alternate days	60 - 120 seconds between sets
<b>Basic Strength</b>	4 weeks: Jan. to Feb.	5/exercise	4 - 6/set	High: 80 - 100% for each exercise	2 (with 1 on-bike workout)	60 - 120 seconds between sets
<b>Power</b>	4 weeks: Feb. to March	4 - 6/exercise	8 - 15/set	Moderate to high: 70 - 100% for each exercise	2 - 3 on alternate days	60 - 120 seconds between sets
<b>Muscular Endurance</b>	4 weeks: March to April	4 - 6/exercise	20 - 30/set	Low to moderate: 50 - 80% for each exercise	2 days	30 - 60 seconds between sets

\*1 RM: 1 repetition maximum. Maximum amount of weight the athlete can lift 1 time with proper form.  
Adapted from Stone, O'Brien, Garhammer, McMullan, and Rozenek.

## It's not just legs . . .

Cycling is primarily a sagittal plane sport. Anatomically, the sagittal plane cuts the body into right and left halves with the axis of rotation oriented at 90° from the plane or from medial to lateral. Simplifying things further, in the sagittal plane, joints predominantly flex (bend) and extend (straighten). From a strength perspective, a cyclist will want to target those muscle groups mentioned previously that work at the hip, knee, and ankle to flex and extend, but what about the rest of the body?

The two other anatomical planes that exist are the frontal plane, which divides the body into front and back halves, and the transverse plane, which divides the body into top and bottom halves. Muscles of the trunk, spine, and upper extremity that function in these two planes have the chief role of stabilizing movements of the hips, legs, and arms. This stabilization allows the rider to impart more force into the pedals because the hips, legs, and arms now have a stable base to push and pull against while pedaling.

## The plan: Keep first things first

The goal of resistance training for the cyclist is to enhance cycling performance. Resistance training must be viewed as an adjunct to riding; a means to a better end. A comprehensive resistance training program for a cyclist must be specific, dynamic, and adaptable. In order to meet these criteria, the concept of periodization should be used when creating a training plan.

Periodization as a framework for structuring a weight training program for cyclists was outlined by Stone, O'Brien, Garhammer, McMullan and Rozenek in a 1982 article published in the *National Strength and Conditioning Association Journal*. (Table 1 is adapted from this article.) The basic premise of a periodization training scheme is that the training should be cyclical and progressive in nature, allow for rest and regeneration, and manipulate training variables to better prepare the athlete for competition.

## Weight room exercises

Cycling-specific movement patterns involve the major muscle groups used while riding a bicycle. The goal of these exercises is to train cycling movement patterns and not merely muscle groups in isolation. For this reason, emphasis is placed on the use of free weights to further challenge and train your balance reactions. The final, very important point is that every exercise can be used to train the trunk or core musculature. Core musculature includes the abdominals, obliques, transversus abdominus and intrinsic and extrinsic spinal stabilizers. Training cycling-specific movement patterns inherently calls for activation of these stabilizing muscle groups for functional, efficient and safe exercise performance.

### Split squat

Using a barbell held in the traditional squat position, stand with one foot slightly in front of the other with a hip-width stance. Maintain a neutral lumbar spine/pelvis relationship during the entire exercise performance. (In the neutral lumbar spine posture, the low back is held in a mid/neutral position via strong contraction of the core musculature. A neutral lumbar spine is achieved by actively “bracing” the trunk musculature, or drawing the belly button in towards the spine to make a rigid wall through the entire trunk.)

Place 75 - 90% of your weight on the front foot and then squat down to approximately a 90° angle at the lead knee. The lead knee should not move in front of the toes on the lead leg. As you ascend to an upright posture, the lead leg provides the majority of propulsion on the ascent, and the back leg stays on the ground to provide balance and stabilization. The exercise is completed with each leg performing sets in the lead position. (photos 1, 2)



**Photo 1 (above): Split squat mid point**

**Photo 2 (right): Split squat start and end position**



### Single leg squat

The single leg squat is performed in a similar position to the split squat, however place the back leg on a bench or stability ball behind you. The same guidelines apply for the positioning and depth of bend for the lead leg. The nature of this exercise places more demands on your balance and trunk stability for proper exercise performance (photo 8). You can use dumbbells or a barbell for resistance with this exercise. The barbell is more challenging because the weight is moved further away from your center of gravity.



**Photo 3: Single leg squat**

### High step-ups

Using a barbell or dumbbells, perform a step-up onto a flat weight bench. Most gym weight benches are 14 - 17 inches high. The key to proper performance of this exercise is to make sure you use the lead leg to propel the ascent and lower yourself under control on the descent. Don't use the back leg to assist in the push phase on the ascent of the step-up. Again, balance is maintained with a strong contraction and "bracing" of the core musculature throughout the performance of the exercise. (Photos 4, 5)



**Photo 4 (above): High step-up, starting position**

**Photo 5 (right): High step-up, descending position**



### Single arm rowing

While holding a dumbbell in the right hand only and with the feet positioned in a stride stance slightly wider than the split squat, lower the dumbbell to the height of the left shin as you squat down onto the left leg. Maintain a neutral lumbar spine and ensure that the hip and knee of the lead leg are flexing evenly to allow the low back to be protected. Ninety percent of your weight is now on the lead leg and the ball of the lead foot (photo 6). As you begin the ascent from the squat position, concurrently pull (or row) the dumbbell to the lower border of right rib cage to complete the exercise (photo 7). Sets are completed alternating feet in the lead position and switching the dumbbell to the opposite hand. This movement simulates pulling on the handlebars while riding uphill or sprinting on the bike.



**Photo 6 (below): Single arm rowing, descending position**

**Photo 7 (left): Single arm rowing, ascending position**



## On-the-bike strength and skill exercises

The following drills allow you to effectively transfer the strength gains made in the gym to specific, on-the-bike application.

### Single leg pedaling

After a thorough warm-up, alternate pedaling with one foot for bouts of 30 seconds. Pedal against a light to moderate resistance with one leg while the other leg is held off the pedal and to your side. Pedal cadence will drop but the pedal stroke should be made as smooth as possible as your skill level increases. Complete 30 seconds of single leg pedaling followed by 2 - 4 minutes of regular pedaling at a faster cadence (95 - 110 rpm). Alternate legs with each set. Progress to single leg pedaling intervals up to 1 minute.



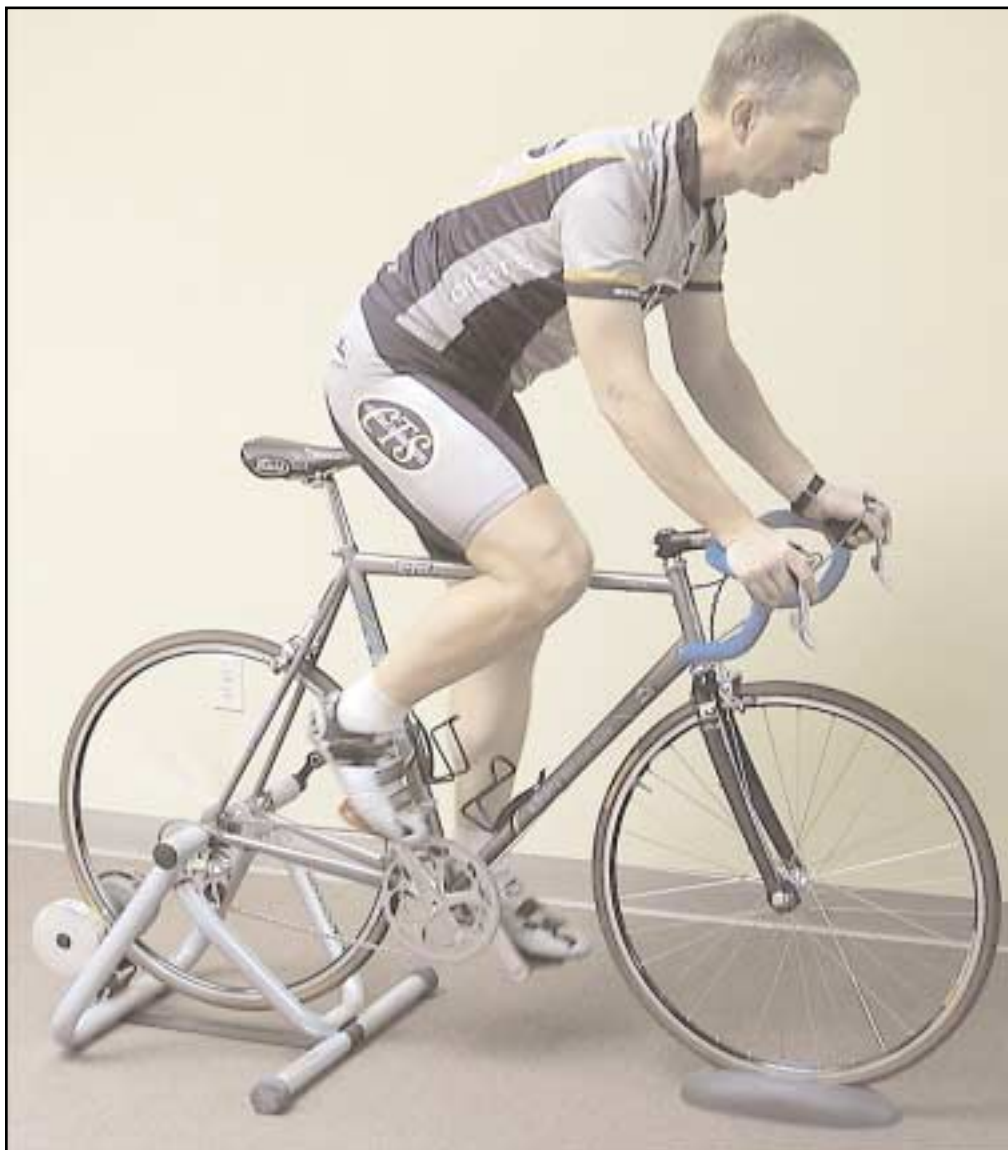
**Photo 8: High resistance pedaling—seated (described on next page)**

### High resistance pedaling seated and standing

After a thorough warm-up, set a high amount of resistance using the gearing on the bicycle and resistance settings on the stationary trainer. Pedal cadence with this drill will be slower; 70 - 80 rpm when seated, and 60 - 70 rpm when standing. When performing this drill seated, your hands should be placed on the top, flat section of the handlebars and you should concentrate on a smooth pedal stroke with the upper body remaining very stable (photo 8, previous page). Rocking of the pelvis or shoulders should be controlled by bracing the core musculature to maintain a solid base for the legs to push against when pedaling under load. In the standing position, you will typically grasp the brake levers on the handlebars (photo 9). Spend 2 minutes initially pedaling against higher resistance. With training and practice, these intervals can progress up to 10 minutes.

**CAUTION:** This drill places a higher compressive load on the knees. Do not attempt this drill until you have completed the Basic Strength Phase of weight training outlined in Table 1. Athletes with known knee injuries or chronic knee pain should not perform this drill.

A comprehensive training program that includes both endurance and resistance training will maximize cycling performance.



**Photo 9: High resistance pedaling—standing**

## References

1. Burke, E.R. *Science of Cycling*, Human Kinetics Publishers, Inc. Champaign, Il; 1986.
2. Timmer, C.A.W. Cycling Biomechanics: A Literature Review. *Journal of Orthopaedic and Sport Physical Therapy* (14) 3: 106 - 114; September 1991.

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