



TRAINING AND RACING WITH A
Power Meter

2ND EDITION

Hunter Allen and Andrew Coggan, PhD

PRAISE FOR THE FIRST EDITION OF *TRAINING AND RACING WITH A POWER METER*
BY HUNTER ALLEN AND ANDREW COGGAN, PhD

“Training and Racing with a Power Meter is the ultimate guide to training with power. Hunter Allen and Andrew Coggan are, without a doubt, the most knowledgeable people on the planet when it comes to power meters.”

—JOE FRIEL, WORLD-RECOGNIZED ENDURANCE SPORTS COACH
AND AUTHOR OF *THE CYCLIST’S TRAINING BIBLE*

“Training and Racing with a Power Meter is a must-have for every triathlete serious about excelling in this sport. Using the steps outlined here has really helped me not only to just understand what the data means but to apply it on a daily basis. As a result, my functional threshold has raised over 30 watts!”

—TERRA CASTRO, PROFESSIONAL TRIATHLETE, TEAM LUNA CHIX

“When affordable power meters hit the market, I knew they had the potential to revolutionize the way we train. Anyone who could harness the exact demands of elite racing and apply that knowledge to specific training would definitely have a serious advantage. Training and Racing with a Power Meter is, without a doubt, the definitive manual on how to use a power meter to the fullest extent. It’s an unmatched opportunity to have access to cutting-edge training methods developed by the world’s leading experts. Hunter and Andy have given all cyclists an amazing opportunity to take their training to the next level. I certainly have!”

—JEREMIAH BISHOP, PROFESSIONAL MOUNTAIN BIKER

“It’s been exciting to actually see my progress quantitatively for the first time in thirty years of racing.”

—PHIL WHITMAN, ACCOMPLISHED MASTERS RACER

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BOULDER, COLORADO

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Distributed in the United States and Canada by Ingram Publisher Services

Library of Congress Cataloging-in-Publication Data

Allen, Hunter.

Training and racing with a power meter / Hunter Allen and Andrew Coggan, Ph.D.—2nd ed.
p. cm.

Includes bibliographical references and index.

ISBN 978-1-934030-55-4 (alk. paper)

1. Cycling—Training. 2. Triathlon—Training. I. Coggan, Andrew. II. Title.

GV1048.A55 2010

796.6'2—dc22

2010005328

For information on purchasing VeloPress books, please call (800) 811-4210 ext. 169 or visit www.velopress.com.

This book is printed on 100 percent recovered/recycled fiber, 30 percent postconsumer waste, elemental chlorine free, using soy-based inks.



Cover & interior design by Erin Johnson

Cover photo by Tim De Frisco

Illustrations by Tom Feiza

Photographs courtesy of Hunter Allen (p. 255); Garmin® (p. 29); Brad Kaminski (p. 26); Polar (p. 21); Saris Cycling Group (p. 19, top); photographs on pp. 16, 19 (bottom), and 24 by Don Karle

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Foreword

The first edition of *Training and Racing with a Power Meter* has been front and center on my bookshelf since it was first published in 2006. I keep it handy so I can refer to it often. In fact, there are few books I rely on as much as this one. I've learned a lot from it—and I'm not the only one. Whenever I talk with riders who train with a power meter, they nearly always tell me they also have Hunter Allen and Andrew Coggan's book. This makes sense because *Training and Racing with a Power Meter* was the first book for serious cyclists on how to train with power, and it continues as the guide for anyone using a power meter.

If you are new to training with power, you are starting in the right place by reading this book. Begin applying the lessons learned on the following pages to your training, and I'm sure you'll find what many other athletes have discovered—training with power will make you a stronger rider. And this book will show you how to do it.

If you've already read the first edition, the second edition includes some new concepts you'll want to apply to your training. Perhaps most notable is the discussion on how to create form at pivotal times in your season. Using the Performance Manager Chart (found in TrainingPeaks WKO+ Software), Allen and Coggan explain how to quantify and plan form for your best performances. In the past three years, I've come to rely on the information in this chart to help me make decisions about my clients' training.

For steady-state events such as triathlon, pacing is the key to fast racing. You will find guidelines to master this challenging skill in a new chapter dedicated to using power to train for triathlon. Other data within WKO+ that triathletes will find beneficial is running Training Stress Score (rTSS), which is introduced and explained here. When there is more than one sport to master, the Performance Manager Chart will be even more valuable to the triathlete who is attempting to achieve peak fitness in three sports.

Triathletes aren't the only ones to receive much-needed new attention for power-meter training. If you compete in cyclocross, track, ultra-endurance mountain biking, or BMX, you will now find more power-based information on the training and racing demands of your sport.

The world of power meters continues to change as new products and features are introduced. Here you will find up-to-date information on the latest power meters and a comparison guide to help you find the best fit for you.

If you want to train smarter and race faster using power, there is nothing else that even comes close to this book. This is the source for information on training and racing with a power meter.

—*Joe Friel*
Coach, Author, and Co-Founder of TrainingPeaks

Preface to the Second Edition

We wrote this second edition of *Training and Racing with a Power Meter* because we wanted to teach you about the latest tools, techniques, theories, and principles emerging in power-meter technology. In this book you will find some brand-new sections along with updated and revised chapters on the basics. All of this information will enable you to use your power meter to enhance your cycling and achieve optimum performance.

As in the first edition, we will explain how to collect and analyze data from your power meter, how to use your power meter to identify your strengths and weaknesses, how to develop the best possible training plan using your power meter as a training tool, and how to use your power meter effectively in racing. We have updated the information on power-meter features and software to help you make the best possible decisions about what to purchase. We also introduce the concept of Fatigue Profiling in this book, which will allow you to choose the correct tactic in a race or spirited ride. Fatigue Profiling, along with Power Profiling, will help you expose the exact weaknesses that you need to work on in order to become even more successful.

Since the first edition was written, we have learned more about triathlon as well, and we have dedicated an entire chapter to this unique event. You will learn how best to incorporate power training in the bike leg of triathlon (and even how to use GPS devices in your running) to maximize your effort. We have also added new information on BMX, track racing, cyclocross, and ultra-endurance mountain biking. You'll learn key workouts to do on the cyclocross bike in order to be better prepared than your competition, and you'll learn strategies used by the world's best to improve your mountain biking.

Developing a training plan using power can sometimes be challenging, but we have further developed our "16-Week Threshold Improvement" plan and added an "8-Week Peak Performance" plan. These plans illustrate how power will help you become a better cyclist. It's quite possible that one of the two is a good fit for your training goals. To complement these plans, we have supplied a menu of workouts to use on a daily basis, which will guarantee that you are training at the correct level.

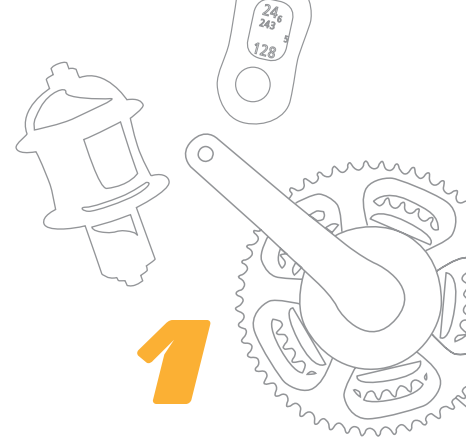
Peaking at the right time has been an elusive "art," understood by a few elite coaches and racers but hard to grasp by others who could hope to achieve it only through trial and error. Power-meter technology takes much of the mystery out of this aspect of training and racing,

and in this edition we will teach you how to create the form that you want on the day that you want it. To that end, we'll explain how Chronic Training Load and Acute Training Load interrelate with a proper taper. Balancing your training stress is key to making sure that you peak on the exact date that you want to, and with the tools we give you in this second edition, you no longer have to just hope that things will work out.

Whatever your specialty in cycling, you will learn exactly how to apply the latest power-training principles to your own situation in order to create the watts when and where you want them. We encourage you to dig deep into this book, and we are confident that it will become your reference guide to training with a power meter. Refer to it again and again as you see your cycling abilities improve.

The power is in your hands now.

—*Hunter Allen and Dr. Andrew R. Coggan*



Why Train with a Power Meter?

At cycling events and triathlons, in bike shops, velodromes, and anywhere else cyclists and multisport athletes gather, the power meter has become the topic that everyone wants to discuss. The consensus is the same: For cyclists, training with power is the next big step in achieving peak performance.

In our work in coaching and exercise physiology, we have seen the benefits of training with a power meter firsthand. Using a power meter can take your training to a new level and allow you to fine-tune your training program. Simply put, the power meter allows you to quantitatively track your fitness changes, more easily define your weaknesses, and then refocus your training based on those weak areas. It can be an impetus for change in your training program.

Even riders who have been racing for many years and think they “know it all” are likely to benefit from a power meter. Hunter has found this to be true again and again, even with masters riders who have been cycling for twenty or thirty years. Phil Whitman, for example, a masters 60+ rider, had seen many advances in cycling over the years and was hesitant to adopt the power meter, thinking it unlikely that it could help him improve further. However, he gave it a try and found that his power meter did help him improve. “I have seen all the little ‘gadgets’ that have promised improvement, and most have come and gone,” he said, “so when Hunter asked me to purchase a power meter, it took some convincing. However, now that I have used it for a full season, I don’t need any more convincing. I know it really helped me this year in focusing my training for specific intervals, pacing in breakaways, and also in time trials, plus it’s been exciting to actually see my progress quantitatively for the first time in thirty years of racing.”

By installing a power meter on your bicycle, you will gain access to more data than you can now imagine. True, the benefits accrue only when you know what to do with all that data and how to interpret it using the power-meter software. This has been a problem for many power-meter users: Seeing the graphs of all the data from your ride may seem daunting at first. That is why we have devoted Chapters 6 and 7 to explaining how to extract the information necessary to focus your training and track improvements. You also will need to understand how to implement new wattage-based workouts in your training regimen and when and how to make changes in your training. Chapters 3, 4, 5, 8, and 9 will teach you how to train effectively with a power meter and use this new technology to achieve your performance goals. By learning some simple steps, you will be well on your way to training with a power meter effectively and expertly. We are going to help you take this “fancy” bike computer and turn it from an expensive toy into a tool to be utilized completely. Truly, this is what a power meter is: a tool to be used to improve performance.

Here, we will survey the benefits that you can look forward to when you take the simple steps to improvement that are presented in this book. The benefits are many, but they generally fall into four main categories. These can be expressed in four brief phrases that sum up what you can do when you know how to use the power-meter technology properly:

- *Know Thyself:* A power meter supplies a great deal of information about your ride, and these data will enable you to identify your strengths and weaknesses.
- *Work Together:* A power meter communicates detailed information to your coach and teammates in a way that will enable everyone to work together more efficiently.
- *Focus Your Training:* With this information at your fingertips, along with good coaching and teamwork, you will identify appropriate training goals and methods.
- *Achieve Peak Performance:* With better information, better communication, and better training, you will be positioned to do your best in cycling.

As you can see, these four areas are interlocked. They build on each other. Without the data that the power meter provides, analysis of your ride, communication with your coach and teammates, and development of a training plan all remain limited to guesswork. With the data as a basis, you can move to a whole new level in all these areas.

However, let the old-timers be warned: If you do not use a cyclocomputer or heart rate monitor now, or if you are unwilling to change the way you train, then training with a power meter might not be for you. It will take some time and effort on your part, using your home computer and adjusting your training paradigm, but in the end, if you are serious about training and going faster, then a power meter will help you reach your peak performance.

Here, in more detail, are some of the reasons why.

KNOW THYSELF

Record Your Effort

Power meters record massive amounts of data that you can download after your ride. By literally creating a second-by-second diary of your ride, you will be able to see exactly how strong you were as you “stomped” up that hill, whether you should have eaten more snacks or rehydrated yourself better along the way, whether you had the right gearing on your bicycle when you hit that “wall” 50 miles into the ride, and so on.

A power meter records your effort from both a cardiovascular viewpoint (heart rate) and a muscular viewpoint (watts). The watts that you are able to produce are what drive the bicycle forward. Your heart rate is your body’s response to the pressure you are exerting on the pedals, and by being able to quantify the exact training “dose,” you will be able to better understand all the other aspects of your training and racing. You will know exactly how much time you’ve spent in your wattage training zone while riding. You will be able to highlight the areas of your ride where you need the most practice, concentrating, for example, on intervals, hills, sprints, or attacks during a race. By reviewing your data after the fact, you will know with certainty whether you completed your training goals or need to revise your training methods.

Add Meaning to Heart Rate Monitoring

Heart rate monitoring alone does not tell you how much you are improving on your bicycle; it just tells you how fast your heart is pumping. Your heart rate may be affected by factors that have little to do with actual performance, however, and using only a heart monitor could easily trick you into believing a false conclusion about your fitness, mislead you about your performance, or even undermine your confidence.

Your heart rate is influenced by your level of hydration, by the air temperature, by your core temperature, by how well you slept the night before, by the level of stress in your life, and other factors. The rate at which your heart can pump depends on so many factors that sometimes you really are better off not knowing your heart rate when training or competing, and going on your “perceived exertion” instead. Although heart rate monitors can be valid and useful tools—athletes have been training with them now for more than twenty years, and certainly this has improved the level of fitness of many athletes—heart rate is just one small piece of the puzzle. How fast your heart is pumping is a response to a stimulus, whether that is you being chased by a bear in the woods, your level of anxiety before that big presentation at work, or the exertion required to push harder on the pedals as you try to latch on to the tail end of that winning breakaway. Think of your heart rate as being similar

to the rpm dial (tachometer) in your car. The more you step on the gas pedal, the higher the rpms go.

How does a power meter add more meaning to heart rate data and thus allow you to improve your performance? A power meter measures your true rate of work (power), that is, how hard you are pushing on the pedals. Power is the amount of horsepower your car engine uses to cruise at 60 mph. You are the engine for your bike, and a power meter tells you how much power you are exerting in the form of watts. By comparing your heart rate response with the power output, you may find there are days when your heart rate is telling you to slow down, but your power meter is telling you to speed up because you are not making those muscles work hard enough to really create a training stimulus. Your heart is a muscle, just like any other muscle in the body, and it gets tired, too. This means that if, for example, you've been training hard for seven days, your heart rate may be lower than normal for a given wattage while you are riding. If your heart rate is normally 165 beats per minute (bpm) when you are riding at 280 watts, then after seven days of hard training it may only be 158 bpm at 280 watts. This does not necessarily mean that you should not train that day, however, because clearly you are still getting training benefits. It's highly probable that you would still be able to do the same amount of watts, or nearly the same amount, as when you were fresh at the beginning of the block. Your wattage will be the key to knowing when you truly need a rest day.

Track Fitness Changes

Gaining the ability to track change in performance is possibly one of the most exciting reasons to train with a power meter: Over time, you will know with certainty whether your fitness is improving and by exactly how much. Is all this hard work really worth it? Are you really getting faster? Will doing all those dad-blame intervals really help you get over that last hill in the Tuesday-night group ride with the leaders?

Since you will be able to download your information directly after your ride, you will easily be able to see the differences between today's effort and the same ride last week, and the week before, and so on. Since your fitness changes continually, and you will have different strengths and weaknesses from one month to the next, it's essential to see on a regular basis exactly where you are in the bigger picture of the season. With power data, you will be able to find out whether your lactate threshold is improving, for example, or whether you are making improvements in your anaerobic capacity, and then make appropriate changes to your training regime. You will be able to look back on previous data and see how long it has taken for you to achieve a new level of fitness, which will enable you to set realistic goals. On the other side of the coin, it is also important to know when to take a rest to avoid overtraining, and this is also one of the great uses of a power meter. By tracking the overall training

stress, using a method such as Training Stress Score (TSS), you will be able to make more accurate decisions about your training load.

Analyze Your Race

Using your power meter during a race and analyzing the data later is a great way to gain an objective view of your race performance. You can use the data to examine the demands of the racecourse and to determine what would have been needed to finish well. In fact, often your best data will come from races, as you always go harder in races than in routine training.

Sometimes the most interesting data you can gather will come from a race in which you got “dropped.” You can review the power-meter file, much in the same way that a football coach would review a videotape of a game, to see what changes are necessary to avoid similar problems in the future. During a very hard stage in the Gila Stage Race, for example, one of the athletes whom Hunter coaches was dropped on a particularly hard part of the climb. In reviewing the post-race data, Hunter was able to pinpoint other races in which he had been dropped from the lead pack and then compare these very critical times with each other. He found that whenever this racer had to pedal at a slower cadence than 70 rpm while producing watts at his threshold for more than five minutes, he was dropped. However, Hunter also found many cases in which the cyclist was able to stay with the same athletes at and above his threshold wattage as long as his cadence was over 95 rpm. As a result, they changed the gearing on his bike so that the largest cog had twenty-seven teeth instead of the standard twenty-three. This allowed him to “spin” at a cadence of over 100 rpm on the steepest climbs, thus maximizing his ability to produce watts based on his body’s physiology. This rider benefited immensely from this change, and for the rest of the year he was able to stay in the front group of riders.

A power meter can also help you determine when you are using too much energy in a race. Could it be that you are pedaling “too much”? From the thousands of power-meter files that Hunter has analyzed, he has found that the racers who consistently win are also the ones who do not pedal as much as the rest of the peloton. How can this be? Well, the best racers just sit in the pack, watch, wait, and hide from the wind, conserving their energy. These aren’t the guys who are sitting out front driving the peloton down the road for hours on end. The winners are the ones who pedal less than the rest, but when they do pedal, watch out, because they pedal harder than the rest of the pack.

In this same vein, a power meter can tell you when you “burned a match”—that is, performed a very hard effort (you have only so many matches in your “matchbook” to burn)—or whether you used too much energy in parts of the race that were not decisive. Maybe you made a tactical error in a race but didn’t realize it. By analyzing the data, you can replay the race in your head while viewing your power-meter file, and understand exactly what it

would have taken to make the winning break or the decisive split. Then you can take this information and use it to better focus your training.

Pinpoint Your Strengths and Weaknesses

Ultimately, armed with this new information, some simple testing protocols, and experience with your power meter in a variety of races and training rides, you will begin to get a clearer picture of your specific strengths and weaknesses. Before the advent of power meters, cyclists had to guess at their strengths and weaknesses, and many times these guesses were wrong. Guessing can hurt your ability to improve. With a power meter, you will be able to find out whether you need to work on changing the gearing for your bike or on building your muscular strength.

Learning what your weaknesses are may not always be pleasant. Finding out that you are a Category I racer in your best 5-minute power, but a Category IV racer in your best 20-minute power, may be exciting for a track racer, but it would be a bit of a disappointment for a road racer desperately trying to improve. However, you cannot improve until you know what your weaknesses are. Each racer is different, and each racer has different goals. Just knowing your strengths and weaknesses will make a big difference in the focus of your training. What will happen if you have to do 105 percent of your threshold power for more than three minutes? Will your lungs feel like they're about to explode, or will this be easy for you? With a power meter, you can analyze your performance and training to find out what your natural talents are and where you need improvement.

WORK TOGETHER

Improve Interaction with Your Coach

Coaches love power meters and the information that they provide. Once a coach starts using a power meter with athletes, he or she will almost never go back to the old way of doing things. The information from the power meter is clear and concise, and it is right there on the computer screen—an objective set of facts that can't be denied. That is why most coaches who have worked with power meters will work hard to persuade all their cyclists to use them. Plain and simple, using a power meter brings you and your coach closer together.

Tim Cusick, coach for the Peaks Coaching Group, explained, “Dose and response is the key communication that goes on between coach and athlete, and power training gives us the ability to be truly analytical about our dose and response communications.” With power training, Tim can “prescribe doses in clear, measurable standards” and “clearly understand the athlete's response to the prescribed dose.” This leads to “greater effectiveness in reviewing daily training schedules, better assessment of progress through more in-depth discussion, improved analysis, and better result tracking over time to ensure we are meeting our goals.”

With the data that you collect with your power meter, your coach will discover things about you and your riding abilities, both positive and negative, that he or she would not otherwise have been able to figure out even by racing with you. Your coach can then use these data to improve your training plan. He or she will be able to react more quickly to changes in your fitness and will be able to make adjustments to your plan accordingly.

One of the primary ways a power meter aids the coach/athlete relationship is that it improves communication between the two parties. With a power meter, there can be no “hemming and hawing” about what is going on with your fitness or whether you are on the right path. Instead, where you are with your training, and whether you are doing the workouts correctly or not, will be fairly clear-cut. Your coach will be able to see instantly what you are doing in races and training rides, and he or she will be able to make more useful suggestions for further improvements.

A power meter also should increase your accountability—that feeling you get of having to be “responsible” to someone for your training. You will know that your coach is going to see that you did only five out of the ten prescribed efforts as soon as you download and e-mail him or her your weekly data. This can also be a reason not to have a power meter: It’s the equivalent of having your coach with you on every ride. A power meter doesn’t lie, and sometimes, the truth can be tough to face!

One cyclist who started using a power meter, Sam Krieg, commented on how much this accountability issue helped him. He started working with a coach in his second season of training with power. Later, he said, “Combining both made my training super-focused and my racing the perfect test to see if what we were training created results. Several times during my pre-season training, I would see my workouts on my e-mail and think, ‘I can’t finish that.’ I would start the workout saying to myself, ‘When I blow up, I’ll just e-mail my coach the power file and let him know I tried but just couldn’t pull it off.’” However, most of the time the opposite would happen: “Minute by minute the intervals would come and go and somehow I would still be turning the pedals,” Sam said. “More times than not I survived all the intervals in complete disbelief of what I had just accomplished.”

One workout in particular stands out. “My coach prescribed doing 50 minutes at my threshold power, with several cadence changes and power spikes,” Sam said. “I didn’t think I could survive 20 minutes of this workout, much less 50. Slowly the seconds on the computer just ticked away. In the back of my mind, I knew I would have to e-mail this power file to my coach, so I figured that as long as I could sustain the prescribed wattage, I would continue. Several times during the interval I didn’t think I could make it another minute, but my power and heart rate were stable so I pedaled on. Fifty minutes later I finished. I had a new 50-minute peak power, and I had mentally grown more in one workout than I had over the past three months.”

This mental and physical strength translated into racing strengths throughout the season. “In one early-season race, I made the selection early on, only to get dropped out the back door of an echelon 20 minutes later. I just wanted to kick myself. Struggling to regain some composure, I was able to regroup mentally and reframe the remainder of the race into a 30-minute time trial with threshold wattage as my goal. As demented as it sounds, I was racing for a great power file, not against the racers who were up the road. I struggled for the next half hour just like I did in my winter workouts, racing my power meter minute to minute.” As it turned out, Sam caught the break and managed to finish at the front of the remaining riders. “Without having to e-mail that file I would have stopped at my car and called it a day,” he said. Sam carried this new level of persistence into the rest of the season: “My placing in races was not half as telling as the power files I had created during those efforts,” he said. “I had won on days when I was actually weak and struggled on my strongest days of the year. It’s pretty cool to have bad days that are actually great days.”

Improve Interaction with Teammates

The use of a power meter can have a profound impact on how well a cycling team works together. Many times in teams, it is not always clear who should be the leader; sometimes, it’s hard to know exactly who is riding the best. When all the team members use a power meter, and with regular testing, coach and riders alike will know exactly who is riding well enough to be a protected leader and who ought to be a worker bee for the race.

While in a race, a very good rider will be able to teach by example exactly where to ride in the peloton to save the most energy. With a power meter, the leader will know just how many watts were needed to make it over the climb in the lead group. In addition, power meters can build confidence in the team when the data show that team members have the physical ability to win. It’s right there on the graph if, say, three out of five riders have the necessary fitness to win the race, and having that level of certainty can really propel a team to success.

FOCUS YOUR TRAINING

Gain Motivation to Work Harder

As a motivator, a power meter can be very effective. For example, if you are doing a five-minute effort, and you see your average watts drop near the end of the effort, you’ll pick it up just another notch in order to achieve your five-minute wattage goal. As long as the goals are set realistically—that is, they are challenging yet achievable—when you are out there training hard and pushing it to the absolute max, seeing those wattage numbers on your power meter can help you eke out just a tiny bit extra. And in the world of a sport that can be won or lost by less than a tire width, that tiny bit extra is significant.

Every athlete strives to eliminate guesswork and wasted time, and in this day and age, it seems that most athletes are too busy to train as much as they'd like. That's why every training minute must be optimized. If you are strapped for time, having a power meter and sticking to the letter of your workout will help you gain a higher fitness level more rapidly, with fewer wasted junk miles and less of your precious time.

Improve Your Position and Aerodynamics

Your body position is the single greatest factor determining your speed while riding at a specific power output. Why risk the disadvantage of riding in a poor position when you can measure your aerodynamics and discover your fastest position? With some simple tests using a power meter, you can figure out how your current position on the bike is impacting your overall speed and exactly how to change it in order to produce the most watts and the least amount of aerodynamic drag. With the most recent wind-tunnel testing of bicycle frames, wheels, rider positioning, and other factors, it has been found that with improvements in positioning and equipment a rider should be able to pedal at approximately 30 watts less to maintain a given speed. In other words, just by optimizing your position and equipment, you may be able to gain 30 watts of power. This is incredibly significant and represents more of a gain than most cyclists see in an entire year of training.

Pace Your Efforts

When you are out training, racing, or just riding around enjoying the countryside, a power meter allows you to pace your effort better in order to achieve your goal for that ride. Whether that's simply to finish the ride or to achieve a particular physiological stimulus, using a power meter as a pacing tool can help you to conserve energy when necessary and also to expend energy when necessary.

You can use a power meter on all of your long rides—on ultra-endurance rides, in interval workouts, on hill climbs and time trials (TTs), and so on—in order to get the most out of your effort and avoid overdoing it. Once you know your functional threshold wattage (which you'll learn how to determine in Chapter 3), you can hold to it like glue in a time trial or hill climb so that you will know that you went as hard as you could possibly go. Using a power meter for pacing in time trials is an especially good use of the technology. It can give you a “ceiling” to stay beneath to prevent you from overexerting yourself in the first five minutes of the race. During a race, knowing your wattage helps you to focus, providing a “carrot” when the going gets tough and you are pushing right on the edge of your ability. In mass-start races, pacing is equally important. You can use it in the field in order to conserve your energy until later in the race, and you can use it to judge whether the pace is right for you to attempt a breakaway or to figure out what it will take to win the race.

Randy Weintraub, a highly competitive triathlete, for example, was concerned about the lack of hills near his home and training grounds. His goal was to complete the Ironman Lake Placid in less than ten hours. The Lake Placid race is one of the toughest of the Ironman-distance races. The bike course is very hilly and includes a substantial 2-mile climb. Randy needed to figure out exactly how many hills he would have to ride up, and how long each one was, and then go back and train for those racecourse demands at home in Long Island, New York.

Randy went up to Lake Placid and rode the entire bike course for the race at very close to his goal wattage and recorded it with his power meter. First, he wanted to assess whether his goal wattage was actually correct. He had never done this triathlon before and was unsure whether he could maintain that wattage for the entire 112 miles and then still have something left for the 26.2-mile run. After his ride, he downloaded the information and found that he indeed had averaged his goal wattage. Based on his level of fatigue at the end of the bike leg, he surmised that he had enough energy left over for his run. Then, using old-fashioned pencil and paper, Randy simply counted the number of hills that took more than two minutes to complete along the course. With this information, he began to seek out new training routes near his home that would mimic that course as closely as possible. When he did not have a long enough hill, he would simply ride into the wind to simulate a longer climb. He also programmed the number of hill repeats, along with the wattages he would need to reach in order to achieve a peak performance, into his indoor trainer.

Create a Mobile Testing Lab

A power meter allows you to test your fitness on a monthly basis so you can quantitatively see where you have made improvements and where you still need work. For serious racers, using a power meter in this way can even eliminate some of the costly testing that formerly was possible only at a lab, since they now have the mobile equipment installed right on their bikes.

A power meter measures changes in your ability to move the bicycle down the road. It tells you how much force you are putting into the pedals, not just how hard your cardiovascular system is working. By testing your skills regularly, you will better understand your potential for improvement, and you can avoid overtraining. We all undergo changes in our fitness in different areas. Some athletes improve more quickly with shorter efforts, whereas others improve more quickly with longer efforts. With proper periodic testing, you can see exactly which physiological systems are improving and then determine whether it is the right time to focus on a particular area of training.

As Andrew often tells the athletes who consult with him: Training is testing; testing is training. Make every training session a peak performance.

Enhance Indoor Training

With a power meter, you can use your indoor trainer to the fullest extent. One of the first things you will learn about using a power meter on the road is that your wattage will have a high degree of variability. Your wattage fluctuates on a moment-by-moment basis depending on the conditions, and sometimes this is not the best way to train. On an indoor trainer, without the outside influences of wind, hills, dogs, and so on, you can focus your intervals in exact wattage zones for optimal improvement.

In addition, indoor training gains new meaning when you can compare your intensity with on-road efforts. Indoor training also becomes more interesting, as now you have a new goal and focus to your workout. With the advent of the latest computerized indoor trainers, a cyclist with a power meter can even go out and ride a particular racecourse, come back, and download these data into the trainer to re-create this exact ride indoors. Power-meter data from indoor training sessions are also “cleaner” than from on-road efforts, as the massive wattage fluctuations caused by changes in terrain, riding with others, and just the variable nature of pedaling frequency are gone from the power file, making it easier to analyze the periods of effort.

Quantify Your Sports Nutrition

The entire time you are riding your bike, you are expending energy based upon how much work you are doing. Knowing how much work (in kilojoules) you are doing while riding is important. If you know your kilojoule expenditure, you can easily estimate your kilocalorie usage (almost a one-to-one ratio), and this can help you determine when you need to consume additional calories or cut back.

Your production of watts will be drastically reduced if you allow your energy stores to become depleted, so making sure that you are eating often enough, and getting the right number of calories, can be a very important factor in the quality of your workout or race. By knowing your energy expenditure on the bike, you can more accurately plan your post-exercise meals to the exact kilocalorie. This especially helps if you are trying to balance your energy intake with your energy expenditure to maintain body weight during heavy training.

By eating to replenish your expended glycogen fuel stores and possibly packing in more, you should be able to recover faster from training sessions and be ready to train harder, sooner. Sami Srour, for example, a highly competitive recreational cyclist, had been planning for many months to ride a local metric century with his club. However, in each of his practice runs, he ran out of energy toward the end of the ride and had to stop at a convenience store to refuel. This routine impacted his energy levels for the next two days, and consequently, the quality of his training for those days suffered. From his two practice runs, however, Hunter figured out his total expenditure of energy in kilojoules for the entire ride.

What Is a Kilojoule?

Almost all current power meters report the amount of work you have performed in joules in addition to measuring and recording your power in watts. Joules (J) and kilojoules (kJ) are therefore a measure of energy expenditure, or work performed. Here in the United States, however, this is usually measured in kilocalories, or Calories (1 kilocalorie, or large Calorie [with a capital “C”], is equal to 1,000 small calories [lowercase]).

By definition, there are 4.184 kJ per Calorie, so at first glance it would seem that to determine your energy expenditure using power-meter data, you would simply divide your total work in kJ by 4.184. However, this is not correct because power meters measure external work production, not the amount of energy needed to perform that work. Most of the energy expended during cycling is actually converted into “waste” heat that must be dissipated to the environment, with only a portion available to actually turn the pedals. The relationship between work performed and energy expended depends upon your thermodynamic efficiency (i.e., your ability to process food and convert it into energy) when cycling, which, for most trained cyclists, is on the order of 20–25 percent.

Thus, to estimate your energy expenditure (in Calories, or kilocalories) from the amount of work performed, using a power meter, you would need to first divide your total work in kilojoules by 4.184, but then multiply this result by either 4 (if efficiency is at 25 percent) or 5 (if efficiency is at 20 percent). These conversion factors tend to simply cancel one another out, such that you can also take the value for the total work performed in kJ as an estimate of your energy expenditure in kilocalories (or Calories). Although the exact relationship between kJ and kcal is not one to one, it probably is not worth worrying about any error this assumption creates, since an individual’s efficiency can only be readily determined in a laboratory setting, and can vary depending upon the intensity and duration of training, environmental conditions, and other factors.

Then he broke the ride into segments and determined the number of kilojoules used in each segment, which allowed us also to set goals for Calorie intake in each segment. Sami was able to determine when to eat, and how much to eat, during each section of the ride, and also how much electrolyte replacement drink to use. With this new information, Hunter was also able to create a post-ride recovery protocol that gave Sami the correct levels of carbohydrates, proteins, and fats to maximize his recovery, so he would be ready and able to complete his next day of training.

ACHIEVE PEAK PERFORMANCE

With all of the benefits that a power meter offers—greater knowledge about your riding, improved communication with your coach and teammates, and better focus for your training efforts—there is no reason why you should not be able to reach your fitness goals and achieve your peak performance at events.

Every top cycling performance in recent years has been aided by the use of power-meter training technology. In everything from the Tour de France to hour records, track records, Human-Powered Vehicle (HPV) records, mountain-bike racing, and even BMX racing, the best cyclists have used power meters to determine not only the exact physiological demands of hard stages but also exactly how powerful they are as cyclists and how they stack up against their peers. Controlling training with the latest in computer-aided scientific training tools used to be achievable only by the top cyclists in the world with the biggest budgets. Now almost any serious cyclist can gain access to the same data that the pros have and execute their workouts to the same exacting precision.

Training with a power meter is about results. Just training with a power meter is not going to bring you success. It's not the power meter that does the work: You must do the work. If you want to go faster on your bike by just throwing money at it, then go get a nicer set of aero wheels, a lighter frame, or the latest carbon-fiber widget. But eventually, you will have to push harder on those pedals if you want to ride faster. Training with a power meter is worth doing only if you are willing to work at it.

If the information you have about your training is limited, then you are limiting your ability to improve, and you are ultimately limiting your success. Using a power meter may seem intimidating at first, and learning the details of testing and training with it may entail some frustration, but give yourself some time, and soon you'll be on the way to training more effectively and efficiently using a power meter. If your training and cycling are to change (that is, improve), then you must be willing to change first. This book is about how to change your thinking about training and racing and how to gain a clear understanding of what needs to be done in order to achieve your goals.

POWER METERS ARE NOT JUST FOR THE PROS. As equipment has improved, cyclists and triathletes at all levels are using power meters to unlock speed and endurance. But in order to get the most from the technology, you need to know how to read the feedback.

Training and Racing with a Power Meter shows you how to identify your strengths and target your weaknesses with unbelievable precision. By explaining the universal concepts behind the power graphs, authors Hunter Allen and Andrew Coggan will revolutionize the way you train.

Begin by determining your power profile, which describes your strengths as a cyclist. Next, assess your fatigue profile to learn how you resist fatigue at 12 different exercise durations. Finally, identify the workouts that will help you build power across the board while eliminating the flat spots that are holding you back.

Allen and Coggan explain how to interpret power, cadence, speed, and heart rate so that you can train optimally for road racing, mountain biking, cyclocross, triathlon, track, or BMX. Knowing how to analyze your power-meter data will enable you to create a season-long race schedule that plays to your strengths. Understanding your numbers will also allow you to monitor changes in fitness and precisely time your peak performance.

With more than 65 power-based workouts; case studies of professional, masters, and amateur athletes; and hundreds of charts and graphs, *Training and Racing with a Power Meter* is the definitive guide you need to get up to speed on cycling's most important technology.

Hunter Allen is an elite-level cycling coach, former professional cyclist, and owner of the Peaks Coaching Group. **Andrew Coggan, PhD**, is an exercise physiologist and author of countless articles on effective application of power-meter data.

\$24.95

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978-1-934030-55-4

