THE POWER METER HANDBOOK

A User's Guide for Cyclists and Triathletes

BY JOE FRIEL

Best-Selling Author of the Training Bibles

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CONTENTS

3

Getting Started with Your Power Meter

THE PURPOSE OF THIS CHAPTER is to help you become acquainted with your power meter so that you can start using it effectively. Of course, your power meter isn't magic. You don't just mount it on your bike and all of a sudden you're training differently and become an overnight podium contender. The power meter doesn't work that way. As with any tool, you'll have to undertake some adjustment and learning to make the best use it. And there's a lot of adjusting and learning to do. Power meters are rather complex devices. You've probably started to get that sense from having read the first two chapters. And so far we've only scratched the surface.

While power meters are new as mobile devices for our bikes, they have been used as big, cumbersome clunkers in exercise physiology labs for decades. Sport scientists have used them to study performance and almost everything imaginable related to aerobic capacity, anaerobic threshold, and economy. Essentially, what you have on your bike is a powerful scientific tool. There's no doubt that it can help you become a much better rider, but you've first got to figure out how to use it.

WHAT'S ON YOUR HANDLEBARS?

Before you get serious about doing power-based workouts, I suggest you take 7 to 10 days to just ride with your new power meter. During that time, train as you normally would. If you've been using heart rate or perceived exertion to regulate the intensity of your workouts, continue to do so. That will give you time to figure out how to navigate through the power meter menu and to see in real-world fashion the relationships among power, heart rate, RPE, and speed. You'll undoubtedly learn a lot about what you are doing in workouts during this time just by observing the power display. (Again, a word of caution: Don't become so focused on the numbers that you disregard traffic and road conditions.)

After every workout, download the data to your computer and take a look at the graphs and charts. There's no need to start doing in-depth analysis now. We'll get into how to do that later. For now just become familiar with the layout, and take a look at what happens to power when you ride hard and fast, cruise along at a slow speed, climb a hill, sprint, race, or ride with a group.

After a week or so, you should be ready to make adjustments to your training based on what you see. At first, that will simply involve using the power readout on your handlebar computer to regulate workout intensity in much the same way as you may have been doing with heart rate. As you read the chapters that follow and become acquainted with the more subtle nuances of training with power, you'll be able to make other changes to how you train and race. The changes will be rather dramatic. You'll be looking at power numbers to determine how hard you are working. At first, that will take some getting used to if you've been watching heart rate or monitoring perceived exertion. Over time, the changes will gradually become smaller and more refined. Eventually, you'll be an old hand at training and racing with power. I'll help you get there one step at a time.

The first step is to understand the figures that are being displayed on your handlebar computer, which is also called a "head unit." What you see displayed there depends on the type of power meter you have. Some head units are specific to the power meters with which they came. If you have such a device, you must use the head unit that came with the meter. If there is a wire running from the power-measuring device to the head unit on your handlebars, then there's no doubt that the one that came with the device is the one you must use.

Most power meters today are wireless, and a wireless system may give you more options for head units. Many wireless systems use what's called "ANT+" technology. This is a type of wireless communication between the handlebar computer and the power-measuring device in the crank, bottom bracket, pedal, or rear hub. It's becoming a common standard. Any ANT+ power head unit can be used with any power meter that is ANT+ compatible, which allows you to choose a handlebar display and user interface without changing system types. You'll need to check the user's manual for your power meter to see what type of communication method it uses.

One of the main differences among head units is the amount of information they can show you at one time. Some have simple displays with only three data fields shown, while others show up to eight data fields all at the same time. Many head units allow you to customize the display. This is a great feature you should consider when purchasing a new head unit. Some head units are touch screens, while others rely on buttons for the interface.

Minidisplay technology has even led to a wristwatch version from Garmin, which is ANT+ compatible and displays power meter data along with run data. It's also waterproof for swimming, which makes it a good choice if you are a triathlete as all bike and run data are captured in one place.

Regardless of all these options, here are the most common items displayed by power meter head units. Not all head units use the same display abbreviations I'll use here, so you may need to consult the user guide that came with yours.

Power

This is the most basic information you need from your head unit. If you can customize the display to put the fields on your head unit wherever you want, be sure to place the current or instantaneous power display (often called "WATTS" or "PWR") in a prominent place, such as upper left, so that you can see it at a glance while riding. You'll be referring to this field more than any other.

Heart Rate

Just because you have a power meter doesn't mean you are going to forget about your heart rate. It's still quite valuable information. In Chapter 6 I'll teach you how to compare power and heart rate to accurately gauge changes in aerobic fitness. Again, if you can customize your screen display on the head unit, I'd suggest putting the "HR" readout next to power so that they can be easily seen and compared.

Duration

In addition to intensity (WATTS and HR), the other critical component of each workout is duration, or how long the ride was. This should also be displayed prominently on your head unit. You may be able to select either "TIME" or "MILES" (or perhaps "KM," for kilometers) for this field. There may even be other options, such as kiloJoules ("KJ"), that I'll explain later in this chapter. I prefer to use the TIME setting as I believe that is more valuable information when compared with power than is distance. For example, as you'll see later, intervals are usually designed based on time, not distance. And the length of time you can hold a specified power output is closely related to a given time, not a given distance. But if you want to set this field for distance and like to think in such terms about your ride duration, I won't argue with you.

Cadence

When I coach athletes who frequently use a gear I consider too high for the situation, such as climbing a hill or sprinting, and I think they could perform better in a lower gear with a higher cadence, then I recommend they set up the head unit with cadence ("RPM" or "CAD") prominently displayed. If this doesn't seem to be an issue for you, then you might want to use the next available field for other data.

Altitude

Climbing a hill is one of the major challenges of riding a bike for all athletes. Most ANT+ head units allow you to monitor climbing by setting a field to display altitude changes in feet or meters ("ALT FT" or "ALT MT"). You may even have the option to set up the grade of the climb ("% GRADE") or how much climbing you've done in a workout ("FT GAIN" or "MTR GAIN").

Some head units use the Global Positioning System (GPS) for this function, while others use barometric pressure. You may notice when standing at a stoplight that the altitude reading seems to bounce around quite a bit. That's common with both systems and reflects "handoffs" between newly arriving overhead satellites (GPS) or changes in temperature and atmospheric pressure (barometer). Which is more accurate for determining altitude, GPS or a barometer? There's a fair amount of disagreement on this matter among experts. For our purposes in riding a bike, it's not important. What we want is reliability. For example, your bathroom scale is probably not absolutely accurate to the ounce, but (you hope) it is reliable—you are confident that if it shows a change of 1 pound, what changed was you and not the scale. That's the same sort of confidence we want in your power meter.

You may even find that when you download the data after a ride, altitude changes such as feet or meters gained and starting and ending altitudes displayed on your head unit don't agree with what the software says. That's also common and has to do with the algorithms being used by each to compute altitude. Some software, such as TrainingPeaks and WKO+, correct your elevation profile based upon known coordinates in the U.S. Geological Survey (USGS) database when GPS is used. Of course, the most important piece of altitude data is feet gained rather than actual altitude at any point in the ride. Regardless, I'd recommend relying on the one shown by your software and always using it for workout analysis.

Speed

I've never met a cyclist who isn't interested in speed, so most riders set up their power meter head units to display speed in "MPH" or "KPH." In fact, however, there is a good reason to monitor speed besides the simple thrill of seeing how fast you went. In Chapter 5, I'll show you how you can use speed in conjunction with power to reliably pace steady-state races such as time trials and triathlons.

Temperature

Some head units give you the option of displaying temperature ("TEMP") in a field, while others measure it but don't display it in real time, instead opting to reveal temperature after the fact in the download to your software. Temperature measurement not only has to do with how warm and comfortable you may be on the ride but also is used to adjust the altimeter on the head unit if it relies on a barometer for altitude display. Older power meters used to be affected by big changes in temperature, but recent self-calibrating models have reduced this inaccuracy.

Other

There are a multitude of other data fields your head unit may be capable of displaying based on how it's set up and the power meter you are using. For example, it may provide such options as watts per kilogram of body weight ("W/KG"), the current power zone you are in ("ZONE"), Normalized Power™ ("NORM PWR"), Training Stress Score ("TSS"), and Intensity Factor™ ("IF"). I'll explain each of these in the following chapters. They are critical bits of data that reflect your performance. You can wait until you know more about them before deciding whether you want to display one or more of them on your head unit.

There are even more options, again depending on the power system you have. Other data fields could be dedicated to vertical ascent in meters per hour ("VAM"), kiloJoules per hour ("KJ/HR"), and left-right pedal balance ("L-R"). GPS-based head units often provide maps and directions much like those you may use when driving your car.

With all of these possibilities, setting up your handlebar display can be a daunting task. For now, you may want to keep the settings on the unit's default, just as it came out of the box. Later on, as you get the hang of what all this means, you can customize the display to better fit your needs and interests.

KILOJOULES, AVERAGE POWER, AND NORMALIZED POWER

There are several less obvious fields on your head unit that are fundamentally important for some of the workouts and analysis you'll be doing. I'll describe in later chapters how these are applied to training and racing on a bike. If you are a bit confused by any of these or other terms when you encounter them in this book, on your head unit, or in software, you can refer to the Glossary for help.

KiloJoules

In Chapter 2, I told you that watts (the unit of measure for power) is an indicator of how much energy you're expending during a ride. That may have seemed a strange way to explain something that deals with how much force you are generating and how fast your cadence is. But they are really one and the same. The greater your power is owing to the combination of force and cadence, the more energy it takes to pedal the bike.

As humans we usually think of energy expended in Calories. A Calorie (with a capital "C") is the same as 1,000 calories, and the scientific term for the Calories we burn is "kiloCalories." The distinction is pointless in general conversation, but it is useful for training. You see, mechanical energy, the kind you create on your bike and that your power device senses, is expressed in "kiloJoules." This is what your power meter is measuring and what shows up on the head unit. And the relationship between kiloCalories and kiloJoules gives you a good picture of how much fuel you burn, which in turn can help you plan your nutrition.

Here's how it works: 1 kiloCalorie equals about 4 kiloJoules (actually, it's 4.184, but we don't need to be nearly that precise here). Humans pedaling a bike are roughly 25 percent efficient—and that's probably a bit high but okay for our purpose. This means that only about one-fourth of the biological energy you generate (kiloCalories) during a ride is converted into the mechanical energy that drives the bike (kiloJoules). The rest is mostly lost to the heat your body gives off, no matter whether it's a hot or a cold day. So if you are 25 percent efficient in terms of mechanical energy generated, and 1 kiloCalorie is about 4 kiloJoules, then only about 1 kiloJoule is actually realized as mechanical energy for every 1 kiloCalorie of biological energy burned. What all of this means is that when your head unit shows 500 kiloJoules at the end of a ride, you have used about 500 kiloCalories. That may be around 10 percent higher than the actual number, but individual riders vary so much that this number is close enough for training purposes. And it's very useful, as we'll see later on.

Average Power

If you've been using a speedometer or heart rate monitor when riding, you're used to dealing with average speed and average heart rate. Average power is a similar metric: It is the total of all the watts generated during a ride divided by the number of time units (for example, minutes) during which the data was collected. This calculation is always going on within the head unit and can be displayed during the ride or afterward in your software download. Average power is quite simple—so simple that it is not always the most useful measurement for our purposes. Instead, as you'll see in a moment, you will want to use Normalized Power (NP) for most of your analysis.

Normalized Power: Why Not Just Average Power?

Even though I will occasionally use average power as a metric in the chapters that follow, I'll frequently refer to Normalized Power as it is better at taking into account what you experience while riding. Normalized Power is simply an expression of average power adjusted for the range of variability during a ride and therefore more closely reflects the effort or metabolic cost of a ride than does average power. So what does "normalized" mean?

One way to normalize data is to divide one set by another. For example, we could normalize the power of several riders for their weights (and, in fact, we will do so in a later chapter). To do this, we divide power by body weight. For example, if rider A weighs 180 pounds and his average power for a given ride was 210 watts, his power normalized for weight would be 1.17 watts per pound ($210 \div 180 = 1.17$). We could compare that with rider B's data on the same course. If B weighs 120 pounds and had an average power of 150 watts, her power normalized for weight would be 1.25 ($150 \div 120 = 1.25$). So we could conclude that even though A puts out far more average power than B, B is actually more powerful pound for pound. That relationship becomes very important under some circumstances, such as climbing a hill, which we'll get to later. But for now, that's what is meant by *normalizing.*

NP compares the range of variability of power during a ride with the average power of the ride. So when you see the word "normalized," you are being tipped off that we have altered the parameters to be examined. Let's see if we can get a better grip on this concept.

If you've had a chance to download and look at one of your power charts from a ride, you certainly will have noticed that there are lots of spikes in the chart. If you compare the power chart with the heart rate chart for the same ride, you'll see that heart rate doesn't spike nearly as much. That's because power generation is quite variable and the power meter is very sensitive to change, whereas heart rate doesn't change much at all. If you were a machine, we could design you to create steady, even power. But you aren't a machine; you're human, and humans expend energy with lots of high and low spikes. Every time there is a rising spike in power, you are expending more energy than if you rode with perfect steadiness and no spike at all. Average power doesn't account for these minute changes in power and therefore in the energy you used to pedal. Normalized Power does.

The concept of Normalized Power is critical for power meter training because it reveals the true effort of a ride by accounting for variability. I will refer to NP frequently throughout the following chapters; to help lock it in, let me give you a real-life example of NP from two of my recent rides.

Not too long ago, I had only 1 hour to work out between other commitments. You know how it is sometimes—you have to shoehorn bike rides in whenever you can by working around other responsibilities. I happen to live at the top of a 1-mile hill that is about a 5 percent grade. What I did for this short workout was repeats on the hill for 1 hour. On the climbs I rode at a hard effort with several short surges thrown in all the way to the top. Once at the crest, I turned around and coasted back down without pedaling. After 1 hour my average power was 141 watts. The next day I was a bit tired from the hard workout the day before, so I went for a moderate-effort, steady ride on a flat course. Interestingly, my average power was once again 141 watts. Now, there was nothing about those two workouts that was even remotely the same except for the average power. I burned a lot more calories per hour climbing and descending the hill than I did riding steadily. In fact, NP reflected this difference. The hill-climbing workout had an NP of 176 watts. For the moderate-effort ride, it was 149 watts. If I had only the average powers to compare, I would assume the effort and the metabolic cost were the same for both rides. They obviously weren't, and NP revealed this.

So what NP is actually telling us is what the workout *felt* like, which is a much more revealing training component than a simple measurement of average power level for the ride. In my example, the hill repeats felt much harder than the steady, moderate-effort ride, and NP reflected a difference that average power would not. Normalized Power also gives us a much better idea of the energy cost of a ride. Doing surges on the hill burned a lot more calories than riding steadily. That's why we will use NP for much of our riding and analysis. (If you are still unsure about what Normalized Power means, please take a few minutes to reread this section.)

POWER'S RELATIONSHIPS WITH TIME AND HEART RATE

Earlier I suggested that in setting up your head unit, you should place duration and heart rate in prominent fields near current or instantaneous power since they are the next most important data fields. After riding with your new power meter for a week or so, you may notice some interesting things happening in the relationships between power and time and power and heart rate. These are critical relationships for training and racing, which we'll explore in much greater detail later in the book. For now, let's look at how they interact.

Power and Time

You're probably already starting to get some thoughts about how to train with power. From the last section, you should now understand that the power data on your handlebars is closely related to your effort and expended energy while riding a bike. Power is also closely related to the duration—time—of the workout or race or a segment of one of those.

As time increases, power decreases if you are working at or near maximal effort. This should be obvious by now if you've gotten in a few rides with your power meter. You've probably done a short sprint of a few seconds at some point in a workout or race and seen the spike in power on your head unit and in the software chart after downloading the session. Do you think you could hold that same sprint power output for an hour? Absolutely not. Would you be able to hold that sprint power for a minute? Again, absolutely not if the sprint was an all-out effort of only a few seconds.

Your personal power levels are specific to the duration of the output. As the time of the workout increases, the normalized and average powers will decrease if you are riding with a high effort. This should be obvious in racing. It is also true of intervals, which we'll examine in much greater detail in later chapters. Power and time are inversely related—when one changes, the other changes in the opposite direction. The "5 Percent Rule" explains this.

The 5 Percent Rule says that when the duration of a session (or a segment) doubles, the power you generate to ride at a maximal effort for the longer duration decreases by about 5 percent. For example, if you do a short time trial race that takes 20 minutes and you will soon do another that is expected to take 40 minutes, you can estimate that the power of the longer one will be about 5 percent less than that of the shorter race. So if your average power was 240 watts in the 20-minute race, the estimated average power for the 40-minute race would be 228 watts (240 × 0.05 = 12; 240 – 12 = 228). The 5 Percent Rule is helpful whenever you try to calculate from a known duration to a new duration so that you can estimate the required power for a maximal effort. (There is an interesting exception to this rule that I'll explain in Chapter 4 in the section that describes how to determine your Functional Threshold Power.)

Power and Heart Rate

You've probably been training with a heart rate monitor for a long time now. They've been around since the late 1970s and can be found on nearly all riders at the start lines of races. To make the best use of your heart rate monitor, you've set up zones. In the next chapter, I'll show you how to set power zones to use in much the same way as you've done with your heart rate zones. But before doing that, I want to make sure you understand the relationship between these two sets of zones as it is confusing for many athletes, especially when they start comparing heart rate zones and power zones during rides.

In your first year or so of serious training, your heart rate zones stabilize as you become more aerobically fit. Once your zones have stabilized, there will be only slight changes found in testing over the course of a season. These changes are more likely the result of how tired or rested you are when testing; they could also be due to factors such as diet, air temperature, and even motivation, rather than how fit you are. Heart rate zones are quite constant. They change very little.

In contrast, power zones may vary a lot during a season. And that's a good thing. As your endurance fitness improves, you are capable of achieving greater power outputs at any given heart rate. (In Chapter 7, I'll show you how to use this change to measure aerobic fitness improvement.) This means your power zones will change significantly as your fitness changes—yet your heart rate zones will remain unchanged. The two sets of zones may be about the same early in the season when fitness is at a low point. In other words, in the early base period when you are riding in heart rate zone 2, you may also be in power zone 2, although they still won't match exactly. But in the build period, shortly before your first targeted race, you may be in heart rate zone 2 but power zone 3. Don't be freaked out by this. It's a good thing and will help you understand why to gauge intensity, we will use power zones, rather than heart rate, in most of your training.

MAKING SENSE OF IT ALL

One of the great benefits of training with power comes from examining the graphs after the workout is over. In doing this, you can see if you are achieving the markers of race readiness you've set for yourself. You will be able to answer the questions "Am I becoming more fit?" and "What should I do next in my training?" This is analysis. It can be a very simple process involving a brief glance at certain graphs, or it can be highly complex activity with nearly as much time spent analyzing the data as it took to create it on a ride. If you do no analysis at all, then there is little reason to have a power meter. In that case, it's just an expensive accessory on your handlebars.

Do You Need Power Software?

The answer to that question is "yes." You definitely need software to make your power meter a complete tool for better athletic performance. In the remainder of this book, I'll show you how to quickly view your workout data so that you can see how you're doing. It's not hard or confusing or complicated. Anyone can do it who knows what to look for and how to use a computer. Viewing your data also doesn't have to take a lot of time. A five-minute look at a few key reports after each ride, or even every few days, will reveal all you need to know.

The greater question has to do with what software you should use. Appendix C lists all the power software available as of this writing. Your power meter probably came with analysis software; you may have already loaded it and taken a look at some of your workouts. I'm sure the data looks confusing. But don't give up. It will all begin to make sense over time. This book will help.

Understand that not all software shows everything I'll explain in later chapters. And some charts on your software won't be covered here. All of the metrics described in this book are found in the TrainingPeaks and WKO+ software (both available at TrainingPeaks.com). If you want to use software that shows exactly what is covered here, then these are good options. TrainingPeaks is an online software service, so all of your data is stored on its servers. You must have Internet access to use the service, but it's available from any computer. WKO+ is a desktop application, and the data is stored on your computer's hard drive. With WKO+ you may also upload it to TrainingPeaks for backup in case something goes wrong with your computer. WKO+ is compatible only with PCs; it can't be used with a Mac unless you have virtualization software that enables Windows software to run on a Mac.

What About a Coach?

Some riders strongly dislike anything to do with analysis. They want to know how they are training and what they can do to get fitter and faster, but they don't want to even glance at software charts and graphs. My wife is one such person—a strong rider who has no interest in analysis. She has me to help (I hope that's not the only reason she keeps me around!). If you'd like help, I highly recommend hiring a coach to do your analysis and planning. I've trained hundreds of cycling, triathlon, and mountain bike coaches to use the methods explained here. You can find them listed at cycleops.com/coaches.

HAVING READ PART I, you now should have a basic understanding of what a power meter is and generally how it can help you become a stronger cyclist. Now it's time to move on to Part II and how you can start training and racing with your power meter to become fitter and faster.

INDEX

ABOUT THE AUTHOR

JOE FRIEL is the cofounder of TrainingPeaks.com and TrainingBible Coaching. With a master of science degree in exercise science, he has an extensive background in coaching, having trained endurance athletes since 1980. His clients have included novices, elite amateurs, and professionals. The list includes an Ironman Triathlon winner, USA and foreign national champions, world championship competitors, and an Olympian.

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IT'S TRUE: A power meter is the best training tool you can put on your bike. Even if you have been racing for years, a power meter can take you from the middle of the pack to the podium in one season.

But having a power meter is one thing; **knowing how to use it** is another. *The Power Meter Handbook* will demystify the numbers, clarify the setup, and show you how to train with power in simple terms. Joe Friel's power meter system will **immediately** improve your fitness, speed, and training.

- Precisely match your training to your race season
- Push your limits step by step
- Pinpoint your fitness changes—reliably and accurately
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JOE FRIEL is the best-selling author of *The Cyclist's Training Bible* and *The Triathlete's Training Bible* and cofounder of TrainingPeaks.com. As one of America's most trusted coaches, he has trained national athletes and represented the United States at world championships.

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