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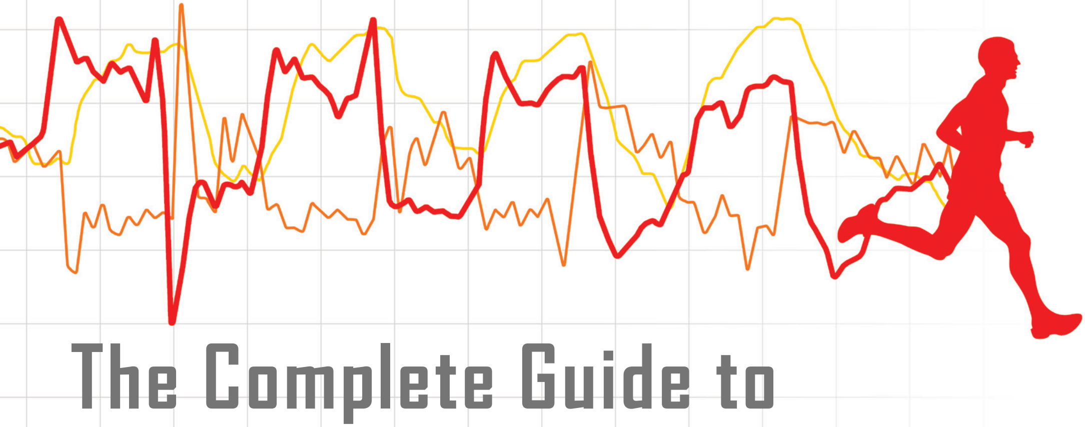

The Complete Guide to Power Meters *for* Running

JIM VANCE

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Introduction: The Future Is Here

We are on the cusp of a performance revolution in the sport of running. The science of training and the art of coaching are entering a new relationship, one much stronger than we've ever seen. With the advent of the power meter for running, we now have a tool to measure athletic performance directly, objectively, and with precise repeatability. We can measure the athlete's power output not only throughout the days and weeks of training, but also during competition. This lets us plan for each event's specific demands and capitalize on the athlete's specific strengths. The power meter is easily the most powerful tool we've ever had to analyze running form, fitness, and potential. When used correctly, it will make you a better, faster runner.

You may think you've heard this story before, and in a way, you have. When heart rate monitors first came on the market, there was a period of time when many people didn't bother learning how to use the technology. Today, however, if you are using *only* a heart rate monitor—or simply a stopwatch—you're considered out of touch with technology, since you're not using GPS. The advent of GPS was a significant step, and it can still be a useful training tool. But once you learn of the full range of the power meter's capabilities, you will see that GPS was just scratching the surface, especially for athletes who have high goals.

What Will Happen?

The sub-2-hour marathon is today's most prominent running barrier, equivalent to the mythical 4-minute-mile barrier broken by Roger Bannister in 1954. Today, we see similar doubt about the 2-hour marathon, with many scoffing at the idea that humans are capable of running that fast. Countless articles, publications, and forums have discussed and debated the feat. Many top runners and experts disagree on whether it is possible, when it might happen (if ever), what it would take from an athlete to accomplish it, and what the course requirements would be for such a spectacular performance.

For years, many thought the sub-1-hour half-marathon was not likely or possible. Yet the sub-1-hour half-marathon was first recorded in 1993, and by 2011 that so-called barrier had been broken more than 150 times.

Look back to the mid-1990s, when a group of young East African men came onto the distance-running scene and rewrote the record books for 5000 and 10,000 meters, month after month, year after year. We went from wondering if anyone other than Saïd Aouita could run sub-13 minutes for the 5000 meters, as he did in 1987, to seeing it done more than 250 times by 2011. As I write this, the record stands at nearly a 4-minute-mile pace: 12:37. Heck, the men's mile is now down to 3:43. That's over 4 seconds faster per lap than Bannister ran! The women's world record for the mile still stands at 4:12. Could a woman break the 4-minute-mile barrier? I believe we are closer than we realize.

Call me overly optimistic, but I believe we'll see a sub-2-hour marathon very soon, probably by the Olympic year 2028 at the latest. And that's just the beginning. Yes, 2028 sounds like the distant future, but many of us remember the blitz of those 1990s performances like they were yesterday.

The problem with a belief that a particular performance is impossible, or that the prospect is too far away for any of us to see in our lifetime, is that this viewpoint looks at the result, not at the process of getting there. As a professional coach, however, I believe that the results come when the process of training improves.

I am a coach who is big on data and technological training tools. In cycling, we have power meters, which have done wonders for training and performance. In swimming, we've profited from important studies with force plates, swim flumes, and video technology for stroke analysis as well as the insights from bold and knowledgeable coaches creating new periodization models and training plans. In many endurance sports, the processes of training and performance have improved as much as the technology, but in the running world, we've been very limited in our use and advancement of technological tools throughout history. That has now changed.

What Can We See?

What we've been missing with running is a way to measure output consistently, throughout an entire season, in races, across different terrains, course profiles, weather conditions, and more. This tool is here now, and it's so simple that it's hard to believe it didn't arrive long ago, but I believe surpassing the sub-2-hour marathon mark will be just the beginning. Every world record will fall, from the marathon to the 100 meters. In fact, as the power meter becomes available for other sports, the records for every field event—from the horizontal jumps to the high jump and pole vault, and all throwing disciplines—will be broken as well.

This will be because of a simple tool, the power meter, and that tool for running is now available to you. With the power meter, we can measure your output directly, in the actual process of performance, not just indirectly through recorded times or other postperformance marks. Using this tool, we will know much more than we have ever known, with metrics and measurements we've never even considered or knew could exist, and this information will open the floodgates to a new level of high performance.

New technology can be intimidating, and there will be some who will reject the very idea of using a power meter. They'll say that they are happy with the way they're doing things. But I guarantee that if you embrace this opportunity to learn how to train with a power meter, you will find yourself a smarter and faster athlete, thanks to a training schedule improved by power data. The initial onslaught of data and feedback for coaches and athletes will be overwhelming, but those who study it and learn to use the information to their competitive advantage will be the ones who set themselves apart. Once the best athletes come into contact with the best coaches, who know and understand how to use this technology and data to design training programs and improve an athlete's weaknesses, the next revolution will begin, with performances that will leave us dropping our jaws. If you don't believe me, take a look at the history of running and training, and you will see that the writing is already on the wall. History tends to repeat itself. The future is here.

1

Why Use a Power Meter for Running?

Do you have high goals? Are you trying to qualify for an event or place high at a certain race? Perhaps you simply want to run a faster time than you've run before. The higher you set your goals and the better you become, the more commitment you'll need to reach your next level, however you define it. And as your goals become more challenging, the margin for error in your training and performance will become ever smaller. Many of your competitors are just as good as you are, and some of them are better. It's crucial that you get your training right.

Training is stressful on the body. It has to be, because fitness is really just the ability of your body to tolerate a level of stress. The faster you go, the more stress you put on your body for a given level of fitness. But for as long as runners have been training, our ability to measure the amount of stress we put into our bodies has been quite limited.

We can track volume easily—we don't need anything more sophisticated than a training diary to record how long and how far we train each day. But volume is not a very accurate way to measure stress.

Workout intensity is the real key to fitness, but the usual ways we measure intensity, such as a scale of perceived exertion, are subjective. Heart rate (HR) is a tool we've used to infer intensity in the past, but it's flawed, too. In addition to the fact that heart rate does not measure intensity directly, it can also be affected by factors unrelated to training, such as diet, temperature, and stress.

With a power meter, you can take control of your training and racing to improve every aspect of your running career.

Pace may seem as straightforward as training volume at first, but in fact it is hard to quantify; varying terrain and elevation can markedly affect pace. Windy, hot, or cold conditions can also affect pace negatively or positively, adding to the challenge of quantifying the intensity.

All of these tools are helpful in creating a snapshot to measure fitness, and yet none of them give us an impartial way to monitor training intensity with repeatable precision. But when we measure stress incorrectly, our training suffers. We become more vulnerable to injury. We may suffer from a lack of recovery. We may get intensity wrong. Any one of those setbacks can derail a training plan.

What we need, clearly, is a better way to measure the stress we are inflicting in our daily training routines. And that's exactly what the power meter provides, and it is why the power meter has the potential to revolutionize your run training.

With a power meter, you can measure your performance and training stress more precisely than ever before, and take control of your training and racing to improve every aspect of your running career. No longer will you wonder whether you are meeting the intensity, recovery, pace, and volume goals of your training plan. Instead, you will erase any doubts about your training, and you will be able to monitor changes and improvements in every aspect of your running fitness.

Why Power?

If you're a triathlete, a bicycle racer, or a fan of either pro sport, you are probably already familiar with the use of power meters in cycling. The power meter transformed training and racing in the cycling world. It has surpassed every other training tool because it delivers an objective and repeatable assessment of overall fitness without any of the drawbacks of previous measurement methods, such as heart rate, speed, and perceived exertion. In fact, the advantages of the cycling power meter are so great—and the margin of error so small in the world of competitive cycling and triathlon—that to ignore the information and the advantage from a power meter would be to concede victory before the race had started.

In the running world, we have recently seen a surge in the popularity of GPS units, and we've seen these units get smaller and smaller as usage has grown. The increased adoption of GPS shows that the running world, like the cycling world, is open to embracing technology and its benefits.

While the GPS unit is a useful tool, its contribution to training pales in comparison with the advantages the power meter can provide. The leap in technology is something like the difference between using a typewriter and a computer. In the history of running technology, a stopwatch is probably equivalent to using a typewriter—pretty good at its job, but severely limited in scope. Running's step up to heart rate monitors was a revelation, but in retrospect, it was like moving from the typewriter to what we would now regard as an old, heavy, slow desktop computer. Today's GPS wrist units are like the first cellphones, much like a flip-phone. The portable power meter for running is the next step, equivalent to the laptop, tablet, and smartphone coming into existence all at once. And while you can still accomplish a lot with a desktop computer, you likely will be much more effective in many ways if you add the laptop, tablet, and smartphone to your arsenal. This is what the power meter brings to the world of training and racing for competitive running.

I am sure you are wondering what makes this technology so great. Here are just some of the ways a power meter for running can positively affect training and performance:

SPECIFICITY

One of the core principles in sports training is the principle of specificity. Simply stated, in order to become better at a specific task, you must practice or train that task. For example, doing cross-country skiing in the off-season can certainly help your running, but you could never expect to become a great runner by doing only cross-country skiing. The reverse is also true, of course: You can't expect to be a great cross-country skier by simply doing run training all the time.

Power meters help us see how well our specific training is improving our fitness. More to the point, the power meter can help you prepare for the specific demands of the target race you're preparing for. If you want to prepare for a hilly course, or a race that requires a lot of spikes in pacing (and thus in your power outputs), you can use your power meter to prepare for that, measuring with great precision the improvement in your surges or hill climbs.

Once you know what you're preparing for, your power meter can help you to better plan and strategize for the event to maximize your performance potential on the day.

TECHNICAL IMPROVEMENTS

Imagine making a small change in your run form and seeing a major change in power (whether good or bad). The power meter can help you understand which aspects of your running technique you need to focus on and which you can improve or even abandon. This understanding becomes especially helpful when learning or trying a new technical change. It also is a huge asset late in a race, when you may be tired and need help to stay focused on going as fast as you can. The power meter can help with that simply by monitoring your pace and power and telling you accurately what you have left in reserve.

OBJECTIVE FITNESS MEASUREMENTS

Fitness may seem pretty simple to measure: Just look at how fast you ran. But not all courses are the same, and conditions vary constantly. What if you ran entirely into a headwind? Or had a constant tailwind? Yes, pace is a good tool for analyzing your training, but power and pace together are an even more powerful way to measure training and fitness. Add in heart rate (HR) and you've got some very objective data to work with.

What these variables can tell you about your fitness includes when you're about to hit a performance plateau and need to consider a change in your training. If you can avoid a plateau in your fitness while continuing to get better and better, your confidence will grow. Of course, your performances are likely to get better too, putting you in a better position to achieve your running goals.

If you get injured, you can use these measurements to understand exactly how much fitness you've lost, or better yet, bolster your confidence by showing you how *little* fitness you have actually lost. In some cases, the data from your power meter can even tell you if you are still suffering from an injury that you thought you had put behind you (or, more likely, that you are pretending to ignore), thus avoiding the chance of further breakdown. Once you measure fitness with power, you have a new perspective on your running technique that you never had before.

QUANTIFICATION OF TRAINING STRESS

With power data, we not only get objective fitness measurements, but based on the intensity of a workout, we can also better assess the actual load of training stress and fatigue that athletes are under relative to their fitness level at that moment. In Chapter 8, we'll define Training Stress Score, or TSS; it's a key calculation to quantify the load you're under as a runner, and it can help you make sure that your training accomplishes the right amount of stress and recovery. It is another area where power data is a better predictor of fatigue and training stress than pace.

BETTER RECOVERY

If you don't recover adequately, you're not actually training; you're just beating yourself down. You are probably familiar with the formula Training = Stress + Rest. But how much stress is enough? How much is too much? How often do you need to take a day off? How many days of recovery do you need after a big training block?

The ability to recover from intense training is an extremely individual trait. If you're taking a day off simply because everyone else in your training group is, or if you are guessing when and how much recovery you need, you might be missing a chance to improve. On the other hand, if you understand the correct amount of recovery you need based on the data from your power meter, your training will be better. And with better training comes better performance.

PRECISION TAPERING

Tapers and their effectiveness can vary greatly among athletes. Some athletes feel that they shouldn't taper at all, some are trying to figure out how long to taper, and others are just trying to find out what type of taper to do. When you have data from your power meter that measures training stress and fatigue, you can use it to better plan and perfect your taper, down to specific target numbers. When you can taper with precision, you'll know you are ready when you toe the start line.

EFFECTIVE WARM-UPS

Few successful runners start a race without a warm-up, but the scope of that exercise varies considerably. There's no use expending more energy before a race than absolutely necessary. With the data from your power meter, we can dial in specific intensities and certain physiological systems to deliver a high-quality warm-up that will prepare you fully for your race.

POWER-TO-WEIGHT RATIOS

With the advent of the power meter in cycling, a key measurement for performance and potential has become a calculation of the rider's power divided by his or her mass. The calculation is expressed as watts per kilogram (w/kg), and once a certain threshold is reached, we know that athlete is capable of some amazing performances. Power meters for running give us the tools to deliver the same calculation. Your ability to convert your watts into speed can be greatly affected by your mass, as we will discuss in Chapter 5. If you're looking to break 3 hours for the marathon, reaching a certain power-to-weight ratio might be a very effective metric on which to base your training and diet.

SPEED PER WATT

Possibly the most important concept in this book, and arguably the biggest advantage of a power meter, is a better understanding of how the watts you produce are converted into speed. This insight into your running is something you could never measure until now.

OBJECTIVE FEEDBACK ON PERIODIZATION

At the end of your season, the data you've accumulated from your power meter can be invaluable in assessing how well your training plan worked and how to move forward with your run training. How did your training go for the year? Was there a particular type of training you responded to especially well? Training you didn't respond well to? Was there a point where things started to go backward and your performance declined? Being able to see this lets you learn a lot about yourself as an athlete, and your power meter data gives you an unparalleled view of your season's ups and downs.

PACING

A strong fitness base gives you a margin of error to race with, even when it comes to your pacing. If you make a mistake in pacing, you can minimize the damage—if you're fit enough. But add in tough competition, challenging courses, and rough conditions, and you might not be able to overcome that pacing mistake. This makes pacing a critical skill for success, especially as you set your goals higher.

A power meter can help you establish and maintain the correct pace, even on courses where establishing the right rhythm is difficult. For example, if you're preparing for a hilly course that requires perfect pacing, your power meter can help you dial in the exact output pace you need to hold throughout the varying terrain.

Here's another way a power meter can help with pacing: Many runners look at pace as a governor; it's their tool for holding back during a race to make sure they don't overdo it in the early going, or get carried away midrace as the field sorts out. But sometimes with a taper, an athlete might be rested enough to run even faster than he or she expected; in this case, holding back to a predetermined pace might prevent the runner from doing as well as he or she could. A power meter gives you an objective assessment of your running condition and can help you determine—even in the middle of a race—when you have the form to open the throttle.

Training with Heart Rate *and* Power

If you already use a heart rate monitor in your training and racing, you might be wondering why you need a power meter. The main reason is that heart rate always lags behind effort. While power is a precise view of your immediate condition and always represents the work you are doing at the moment you are doing it, heart rate is like looking in the rear-view mirror: It tells you what has already happened. If you suddenly up your pace and move into a sprint, for example, your heart will need a few moments to respond to your muscles' request for more oxygen (in the form of increased blood flow). While your power output has increased, and the amount of work you are doing is greater, your heart rate is still ticking along at its previous beat. The same holds true when you back off from a rapid pace: Your speed and power output decrease, but your heart keeps thumping along until your body rebalances its systems.

But that doesn't mean there isn't a lot of value in HR data from a workout or race. It's just that to make heart rate a truly valuable tool for analysis, it needs to be compared with other performance metrics. When we take HR data and compare it with an actual performance output, like pace and power, that changes the game. Now we can begin to measure economy and efficiency, two essential training concepts that will greatly improve your training. Briefly, economy is a measure of oxygen usage—how many meters of distance you are getting from each milliliter of oxygen. Efficiency is a measure of how much speed you are getting for the watts you are producing. All of this will be covered in later chapters; for now, the message is that if you already use heart rate, a power meter will greatly enhance what you get out of it.

Training with Power Versus Training by Feel

There is a misconception I have found among many cyclists and triathletes (and I am sure it will be true of some runners, too) that using a power meter and analyzing its data somehow means they can't train according to feel, or that they must train and race only by the numbers on the power meter. I am not sure where this misconception comes from; it might arise from people assuming that the power meter does all the thinking and does not allow any deviation. But the power meter doesn't think, and it isn't designed to stifle innovation in training. Quite the contrary; the power meter is designed to help stimulate innovation in training.

The best coaches and athletes are the ones who innovate, who devise training sessions and periodization plans that meet the individual needs, strengths, and weaknesses of the athlete on a regular, daily basis. Sometimes athletes feel good and are able to push the pace, and sometimes not, even if they're doing the same thing they did the day before.

The ability to read the signs of fatigue, to listen to the body to squeeze out every possible ounce of training, is something that requires careful observation by both the coach and runner in order to maximize performance potential. A power meter supports this because it's not about pace (time, distance, cadence); it's about power and the work actually accomplished.

If you coach yourself, one of the biggest challenges you face is not having an objective expert at your side who can remove all emotion from the decision making. The power meter can help fill that role, giving you factual data so that you can evaluate your training and make smart decisions for your future training sessions.

To be sure, nothing in the world is perfect, and that includes the running power meter. Some power meters can account for wind, while some can't. Some can account for the type of shoes you use or the terrain you run on, but others can't.

A power meter also cannot tell you how your legs feel, or where your mind is at. It can't tell you when to make a move in a race. But a power meter can help you learn your own strengths and weaknesses, and it can supplement your gut feelings and ability to read your body. It can tell you when you can increase your efforts and when you need to hold back, and it can help tell you how hard to push, both in training and during a race. As much as anything, the power meter can make you faster and fitter than ever before.

This book will give you a great understanding of the current state of power meter technology and how we can use it. It's the first book of its kind, and I will be the first to admit that there is plenty more to learn about power meters in the years ahead. But I am confident that the power meter can help you improve your training and fitness right now, starting today. I am also convinced that this book has the right information to get you started so that you can use your power meter effectively. In the following chapters, we'll define the concept of power, then explore the many ways to use power measurements in your daily training and racing. So let's get going on the path to better running.

GLOSSARY

Acute Training Load (ATL). The recent workload of training, usually the previous seven days, expressed as TSS-per-day average.

Aerobic threshold. Point where the anaerobic energy pathways begin to be used more significantly in energy production than aerobic pathways.

Average power (AP). Total amount of power data collected from a session, divided by the number of time units, such as minutes.

Cadence. The rate at which steps are taken during a run.

Chronic Training Load (CTL). The long-term workload of training, usually the previous 42 days, expressed as TSS-per-day average.

Efficiency Index (EI). The metric to express the speed per watt of the runner. This is meters per minute divided by the average power for the duration.

EI@FT. The metric expressing the Efficiency Index of an athlete at functional threshold, for power and pace.

Force. Energy used to overcome resistance, pushing into the ground with the foot, while running.

Functional Threshold (FT). The best output one can perform for one hour.

Functional Threshold Pace (rFTPa). The best pace one can hold for one hour, on a flat course, with relatively low fatigue and in good conditions.

Functional Threshold Power (rFTPw). The best power one can hold for one hour, on a flat course, with relatively low fatigue.

Head unit. The hardware that collects and displays the data from the power meter to the runner, during or after a session. Can be a watch, tablet, smartphone, or a computer.

Horizontal power. Work rate being accomplished in the forward and back planes of movement.

Intensity Factor (IF). The ratio of a runner's Normalized Power to Functional Threshold Power. This is an indicator of how challenging or intense a workout or segment of a workout was.

Kilocalorie (kcal). The unit of measurement for biological energy expended while running, usually referred to as "calories."

Kilojoule (kJ). The unit of measurement for mechanical energy, or work, expressed as kJ.

Kilojoule per km (kJ/km). The metric to express how much work is required to run the distance of one km.

Lactate threshold. The intensity at which blood lactate levels accumulate faster than they can be reduced.

Lateral power. Work rate accomplished in the side planes of movement.

Normalized Power (NP). The average power of a run, adjusted for the variability of power within the session. A much better indicator of the intensity and metabolic cost of the effort, compared with average power.

Peak power (P). The highest average power a runner can achieve for a given unit of time, such as 2 seconds, 1 minute, 5 minutes, or 60 minutes. This is usually expressed as P followed by time in minutes. Five minutes would be P5, and 30 seconds would be P.5.

Performance Management Chart (PMC). An analysis tool available in many analysis software programs that allows the athlete or coach to monitor and manage CTL, ATL, and TSB.

Power meter. A device that measures or estimates the work rate of a runner, from either two planes of movement (2D) or three (3D).

Revolutions per minute (RPM). Cadence of the runner, isolating the average number of steps for a single foot in a minute.

Steps per minute (SPM). Cadence of the runner, as the average total number of steps for both feet in a minute.

Taper. A training model in which workload is reduced over a period of several days or more in order to eliminate fatigue for a peak event.

Tempo. A workout or effort done in Power Zone 3.

Training Stress Balance (TSB). A value that represents how well rested an athlete is, and the potential to perform well. Calculated by subtracting the ATL value from the CTL.

Training Stress Score (TSS). The workload of a run workout based on its intensity and duration.

Variability Index (VI). A value which helps show how well paced a session was. It is the ratio of Normalized Power to Average Power for that session.

Vertical power. Work rate being accomplished in the up and down planes of movement.

Watt (w). The unit of measure for power.

Watts per kilogram (w/kg). A ratio of a runner's power output and mass.

Work. Movement of a runner through a distance.

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ABOUT THE AUTHOR

Jim Vance is a former professional triathlete who trained under the guidance of the national team coaching staff at the US Olympic Training Center. He recorded two world championship titles as an amateur in XTERRA and International Triathlon Union. His range of performances also stretches to Ironman; he finished third overall at the 2006 Ironman Florida in a time of 8:37:09, running a 2:54 marathon in that race.

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Jim is the author of *Triathlon 2.0: Data Driven Performance Training*, which teaches athletes how to use technological training tools such as power meters, GPS, and heart rate monitors for Ironman triathlon racing based on their age, gender, and goals. In 2013, Jim coedited the book *Triathlon Science* with best-selling endurance training author Joe Friel.

Jim holds a BS in physical and health education, K–12, from the University of Nebraska, where he ran track and cross country and won two academic scholarships. He was a schoolteacher for six years before committing to triathlon full time in 2005. He retired from triathlon competition in 2010.

Jim currently resides in San Diego with his wife, Orlanda, and two young sons, Alistair JT and Alden James. He coaches high school swimming at Coronado High School and coaches a number of beginner and aspiring elite triathletes, runners, and cyclists. His website is CoachVance.com.

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