

YAROSLAV POPOVYCH: WHY I'M HAPPIER BEING BACK WITH BRUYNEEL

Cyclingnews.com > ISSUE 121 > FEBRUARY 2009

Pro Cycling

INSIDE THE WORLD'S TOUGHEST SPORT

FACE TO FACE INTERVIEW

LANCE ARMSTRONG

ANSWERS YOUR QUESTIONS

- > "I don't need an eighth Tour"
- > "I've got no problem riding for Contador"
- > "I'd love to have my own \$15m team"

MARCO PANTANI

The week that could have changed it all

CARLOS SASTRE

"RIIS DIDN'T THINK I COULD WIN THE TOUR"

LARS BOOM

DOWN & DIRTY WITH THE CYCLO-CROSS WORLD CHAMP

BETTER THAN A NEW BIKE?

WHY POWER METERS ARE THE MUST-HAVE GADGET

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Printed in UK

\$9.95

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POWERING UP

Ever wished you could see how hard you're working on a bike? Then a power meter could be the answer. **Jason Sumner** investigates the tool that helps pros understand and develop their potential

Photography by **Tim De Waele** unless stated

Question: What piece of equipment can help bike racers conduct baseline fitness tests, plays an integral role in training, serves as a valuable coaching and time trial pacing tool, provides strategic diagnostics both during and after races, is useful in aerodynamic testing and bike fit calculation *and* can maybe even help in professional cycling's anti-doping fight?

If you don't know the answer, you've missed the boat on an innovation that is arguably one of the most valuable cycling components on the market. And if you had your hand raised? Well, the chances are pretty good that you already own a power meter.

"I honestly believe that if you're not using a power meter, you are giving up a huge chunk of information," says Jonathan Vaughters, directeur sportif of the Garmin-Slipstream team, himself a former pro who was among the first wave of riders to embrace the technology. "There are always going to be riders who can compete at the ProTour level without using a power meter, but to my mind those riders are under-utilising their talent."

Such staunch approval is not universal within the pro peloton. There are plenty of coaches and riders who still prefer more traditional methods of training and racing. But Vaughters is certainly not alone in his glowing recommendation. Among cycling's elite ranks, the use of power meters has become increasingly commonplace, by riders including the likes of Lance Armstrong, Levi Leipheimer, David Millar, Chris Horner, Christian Vande Velde, Paolo Bettini, Cadel Evans, Tom Boonen and countless others.

"They have become a very normal part of the pro peloton scenery – just like radios," contends Allen Lim, head sports physiologist for Garmin-Slipstream, and the director of cycling science for Wisconsin-based Saris Cycling, manufacturer of PowerTap, one of the most popular power meters on the market. "I think the initial shift happened in 2006 and 2007. Now, power meters are embedded at the top level of the sport."

Admittedly, Lim's position at Saris makes him biased. But the Garmin squad is by no

means the only professional team to fully embrace power meters. Saxo Bank, Columbia, Astana and Quick Step are just some of the other teams regularly using the technology.

"Using a power meter is a big part of my day-to-day routine," says Chris Baldwin, a two-time US national time trial champion who will ride for Rock Racing in 2009. "It helps me quantify how and what I'm doing in training and races, by giving me an idea of when I need to rest and when I

"If you're not using a power meter, you are giving up a huge chunk of information"

need to continue to push myself. Obviously, it's important to listen to your body. But at the same time it's good to have objective measurements to look at."

SO WHAT EXACTLY do these devices measure? And how can the average weekend warrior put one to use in their training plan? Well, to understand how to use a power meter, it's best to first understand what

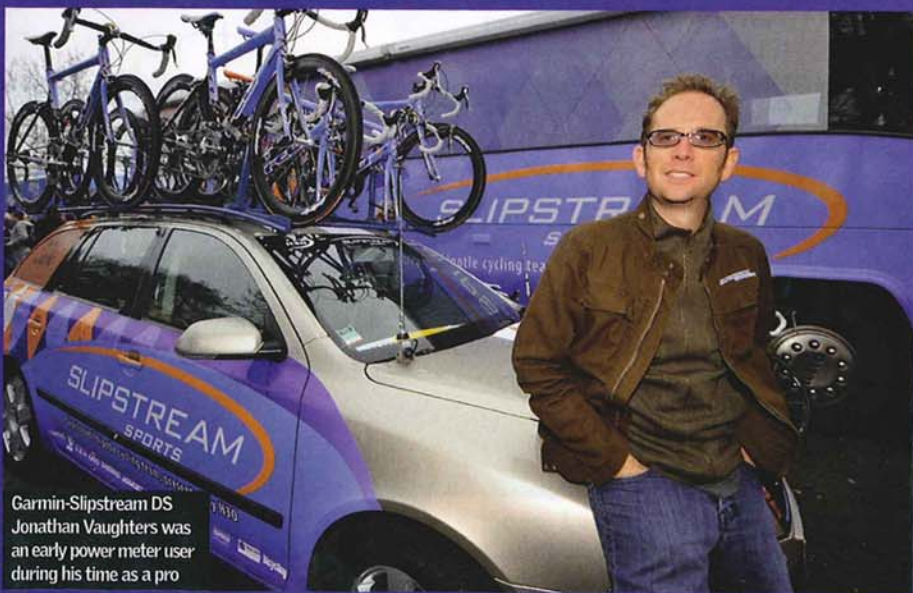
power is. Cycling-related definitions vary slightly from source to source, but the basic gist is that power is work divided by time, a measure that's represented in watts.

A standard household light bulb consumes electricity at a rate of about 80 watts. A person climbing a flight of stairs is producing about 200 watts. A typical automobile engine running at cruising speed churns out roughly 25,000 watts. And the recently un-retired Lance Armstrong could average upwards of 400 watts during his legendary charges up the Alps and Pyrenees.

"Basically, power is a measurement of intensity," explains Garmin's Lim, who has a master's degree in exercise physiology and a PhD in integrative physiology.

And the reason the measurement matters is that if you spend too much time above your optimum intensity level, you'll likely end up over-trained and not perform as well. Conversely, if you ride at a low intensity all the time, your training won't yield the fitness boost you're looking for. The power meter helps riders find the covered happy medium.

"Unlike heart rate, which is affected by outside variables such as how much sleep you got the night before, or if you're dehydrated



Garmin-Slipstream DS
Jonathan Vaughters was an early power meter user during his time as a pro

Tim De Waele

POWER METERS COMPARED

The biggest factors to consider before buying a power meter are your budget – and whether or not you'll actually use it. Top-end meters cost \$1,000 or more, and require some technical aptitude. If you're the sort of person who has trouble saving numbers in your mobile phone, you might be better spending your money elsewhere. But if you embrace technology and you're looking to take your training to a new level, it's time to start shopping.

	 SRM	 Ergomo	 PowerTap	 Quarq	 Polar	 iBike
Cost	\$2,000-\$5,000	\$1,600	\$1,000-\$2,000	\$1,195	\$715	\$399
Meter location	Built into crankset	Bottom bracket	Rear hub	Attached to crankset	Chainstay and rear derailleur	Uses Newton's Third Law, measuring rider's opposing forces
Pros	Can be used with multiple wheelsets, highly accurate	Can be used with multiple wheelsets, easy to set up	Lower price, very accurate. Can be used with different bikes	Can be used with multiple wheelsets, transferable between bikes	Less expensive, can be used with multiple wheelsets	Inexpensive, easy to install, can be used with multiple bikes or wheelsets
Cons	Expensive, not easily switched between bikes	Difficult to transfer between bikes	Lack of wheel choice, vulnerable in crashes	Not compatible with Shimano or Campagnolo cranks, computer sold separately	Requires multiple sensors, difficult to set up or move from bike to bike	Requires calibration, can't be used indoors

you can tailor your training to target and improve specific areas.”

The first step is to establish your various “training zones”, which are typically broken down into seven categories: recovery, over distance, endurance, tempo, lactate threshold, VO2 Max and anaerobic capacity. If you have the time and means, many sports science labs still offer a full battery of baseline testing to help establish these zones. But if you'd rather not spend the extra cash, or subject yourself to the litany of blood-drawing finger pricks that accompany a lab-based lactate threshold test, you can use a power meter to come up with fairly accurate estimates of your training zones instead.

Henderson suggests self-administering four timed maximum effort tests: five seconds, one minute, five minutes and 20 minutes. Do them in that order during the same training session, and give everything you've got for each test. The end result will be a general idea of what your measures are for peak power (five seconds), anaerobic capacity (one minute), power at VO2 Max (five minutes) and lactate threshold (20 minutes). Next you

can take those results and slot them into the aforementioned training zones.

For example, a rider who produces a 20-minute average of 250 watts, a five-minute VO2 max effort of 350, and a one-minute anaerobic capacity of 400 would end up with a training zone profile that looked something like this:

Recovery: Less than 125 watts
Over distance: 125–200
Endurance: 200–230
Tempo: 230–250
Lactate threshold: 250–275
VO2 Max: 275–400
Anaerobic capacity: Greater than 400

“Being able to establish the different intensities for different workouts is really important,” explains Henderson. “This is the best way to make sure that you're not doing too much training, or too little. If the day's goal is a long, steady ride, you probably want to be doing 60–70 per cent of your established lactate threshold power. So in this case, about 175 watts. But if you're doing 10-minute threshold intervals, you want to go right up to that threshold number of 250 to 275.”

Right about now, a lot of cyclists' eyes will be glazing over. Riding bikes is supposed to be fun, and all these training zones, test numbers

and interval sessions can bleed the enjoyment out of your ride. But before you write off power meters as the province of professionals or the scientifically inclined, ask yourself a simple question: do you like seeing a tangible improvement in your performance? If the answer is yes, you may want to reconsider.

“It's a pretty powerful motivator when someone sees that their threshold power has gone up 10–15 watts,” says Henderson, adding that nearly all the riders he works with have made at least modest fitness gains when they started training with power. “By using a power meter, you can look at the progress of established levels over time, and see that progress in real, absolute terms.”

Put another way, instead of getting back from a ride and thinking, “Damn, I'm fit right now because I dropped the guy who usually drops me,” you can download your power data and see that your maximum 20-minute average during the local group ride climb was 10 watts higher than last time you did it.

NEAL HENDERSON IS part of a growing segment of the coaching population who prefer to work with cyclists who use power meters. “I'll even loan them one of mine if I have to,” Henderson says. “To my mind, I can't be as effective a coach without getting that information. I usually require that they use it in training and suggest that they use them while racing as well.”

For training purposes, power meters offer a multitude of benefits. They make it much easier to complete specific workouts. Say

POWER METERS: A GLOSSARY

THE VOCABULARY YOU'LL
NEED TO KNOW WHEN
TRAINING WITH POWER

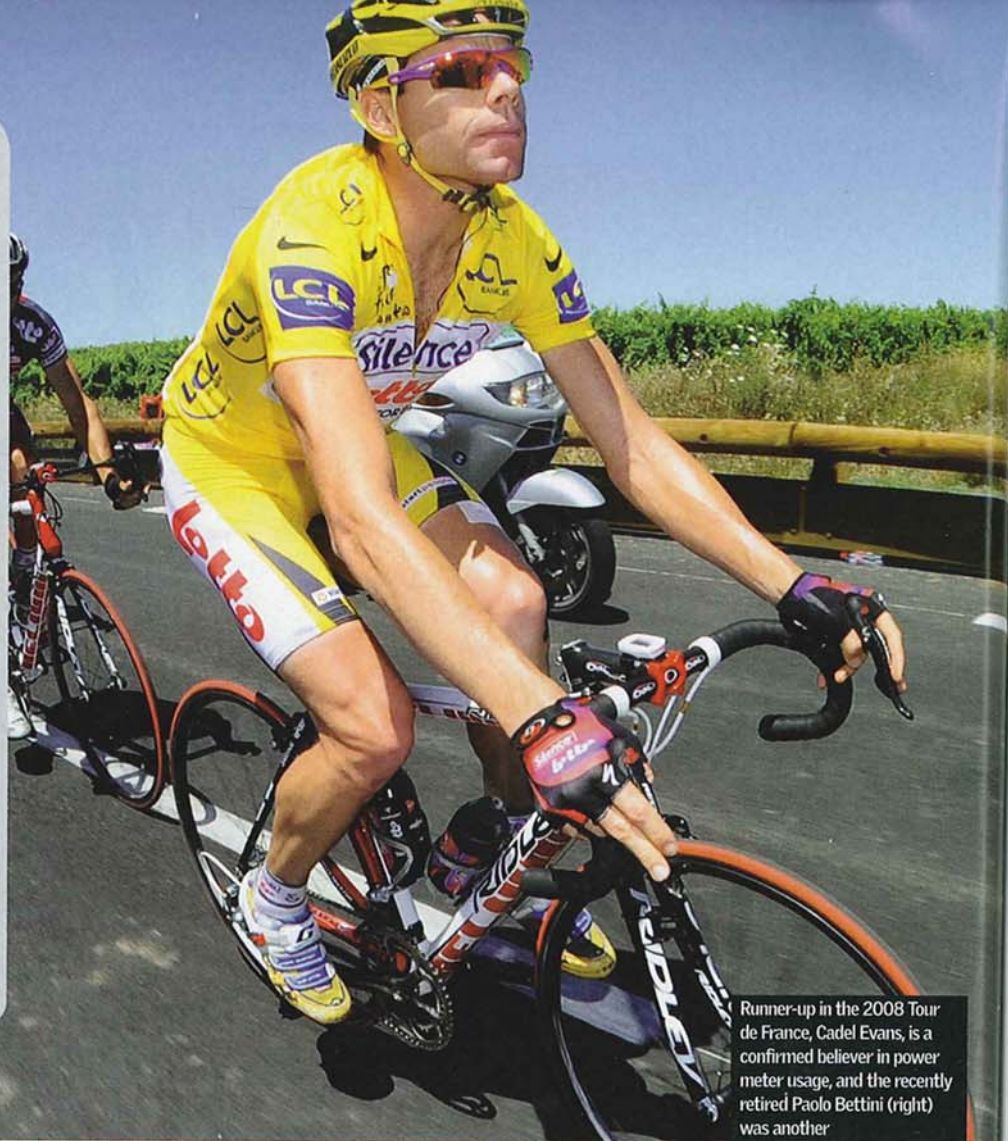
VO2 Max: Maximum capacity of a person's body to transport and utilise oxygen. Modest improvements in this figure are possible, but it's generally limited by genetic potential.

Lactate threshold: Power output that can be maintained for a sustained period of time (often called the "hour of power"). Good predictor of endurance performance that can be improved with proper training.

Watts per kilogram: Critical ratio of lactate threshold power to body weight that allows comparison between different riders. Pros can typically maintain a minimum of five watts per kilogram, while grand tour GC contenders are closer to 6.5. A moderately trained cyclist is usually around three.

Normalised power: Measure of average power that ignores zero values recorded when rider is not pedalling.

Tim De Waele



Runner-up in the 2008 Tour de France, Cadel Evans, is a confirmed believer in power meter usage, and the recently retired Paolo Bettini (right) was another

“Or how hot it is outside, power is a completely objective number,” says Neal Henderson, sport science manager at the Boulder Center for Sports Medicine. Henderson is an elite-level coach who’s been working with power for more than a decade. “It’s a great tool for identifying current ability, and then seeing how your training is affecting that ability as you move forward,” Henderson explains.

To calculate a rider’s power output, most power meters use strain gauges mounted in the bottom bracket, rear free hub or crankset. These gauges measure torque and then transmit that data, along with speed, time, distance, cadence, heart rate and calories burned, to a handlebar-mounted display device, providing riders with real-time information and feedback. At the end of your ride, all this collected data can be downloaded into a computer, allowing for deeper, longer-term analysis by rider or coach.

A new generation of handlebar-mounted devices now utilise the principles of Newton’s Third Law, measuring a rider’s opposing forces – gravity, wind resistance, inertia and rolling resistance – and then combining them with velocity to determine power output.

Power meters came along in 1986 when German engineer Ulrich Schoberer invented the SRM or “Schoberer Rad Messtechnik” (literally, “Schoberer’s technical bike measurement”). With the advent of the SRM, riders could measure their power output in real-world conditions, rather than going back and forth between the outside world and ergometer-equipped sports science testing labs.

“With a power meter, you can figure out how much output you are capable of for different time periods”

Three-time Tour de France champion Greg LeMond was one of the first pros to incorporate the new device into his training, and it wasn’t long before the expensive but revolutionary gadgets gained a foothold in the pro peloton.

“When I heard LeMond was using one, and thought about what it was – a true measure of what you were actually doing on the bicycle – it just made sense to me,” says Garmin’s Vaughters, who turned pro with the Santa Clara team in 1994 and subsequently spent

time with the US Postal Service and Crédit Agricole squads before retiring in 2002. “I think they cost about \$4,000 back then, so it was roughly a third of my salary. But it really helped me in those early years. As we now know, the racing was pretty fast back then. But even though I wasn’t winning many races, using the power meter helped me see measurable improvements. Without it, I might not have stayed in sport – instead, it gave me a benchmark to keep shooting for.”

THE AVERAGE WEEKEND warrior doesn’t need to worry about how fast professionals in the peloton are riding – but establishing and monitoring benchmarks for their own performance is still the cornerstone of any rider’s power meter usage.

“When you’re putting together a training plan, the first thing you need to do is figure out your current fitness levels,” explains Henderson, who counts US Olympian Taylor Phinney among his select stable of clients. “With a power meter, you can figure out how much output you are capable of for different time periods. It also helps you to identify strengths and weaknesses so that

«The day's assignment is three 10-minute lactate threshold intervals, it's far easier to get the proper intensity of effort right using a power meter than it is if you do it by feel, or with the aid of a heart-rate monitor. And assuming you download your data post-ride, you or your coach will be able to assess the effectiveness of your current training regime, and figure out where a rider is in terms of fitness and fatigue.

“If you use a power meter consistently, there are analytical models that you can plug the data into that take into account what each training session yields in the form of an estimated training load,” Henderson explains. “They can then predict your current and future fatigue levels, when you can turn up the training intensity, when you need more rest – and, most importantly, when you'll achieve peak fitness. That's good information to have if you're trying to target a certain race or event.”

Come race day, power meters continue to be a useful tool, especially now that weight isn't as much of a concern as it used to be. In the past, pro riders were not willing to use the devices because of the additional weight they added – but as overall bike weights have come down, more and more pros are now competing with power meters. Some even view it as a common-sense way to obey the UCI rule that stipulates bikes must weigh no less than 6.8kg.

“Many bikes are too light now, so you might as well add something,” says Astana's Leipheimer, who's won back-to-back Tour of California titles and finished third overall at the 2007 Tour de France. “I've used one in training for a long time, but now I'm using it in most races, too. It's mostly just a reference.

I guide myself on how I feel and don't look at it much during the race. But afterwards it can yield some pretty valuable information.”

Indeed, power meters can serve as a powerful race diagnostic tool. Say, for example, there's a 20-minute climb in an upcoming race, and you know

CAN POWER METERS HELP BEAT DOPING? PUTTING AN ELECTRONIC POLICEMAN ON EVERY BIKE

Somewhat lost in the awkwardness of Greg LeMond's (right) now-famous Interbike inquisition of Lance Armstrong was LeMond's call for riders' bikes to be fitted with sealed power meters, controlled and calibrated by the anti-doping police. That way, if a rider did something beyond the realm of ordinary human capability, the evidence would be clear for all to see.

“I don't think it's a bad idea, but it couldn't be used on its own,” says Garmin-Slipstream directeur sportif Jonathan Vaughters. “If you were able to correlate power numbers with blood values, and remain conscious of factors like heat and humidity, it could be useful. Say a rider has a consistent haematocrit reading of 42 and they suddenly jump to 48. That's still within the legal limit and maybe the rider will say it's due to dehydration. But if that's the case, his power should go down. If he goes up to 48 and has a 10 per cent jump in power, the red flags would start going up.”

Still, we can't just assume a leap in ability is evidence of doping. As yet, anti-doping authorities have no plans to require blind power meter usage.



that in the last race with a similar climb you were able to stay with the group for 15 minutes before getting dropped. By looking at the previous race's power data, you'll be able to assess what level of power output you need to maintain to make it over the top with the group. You can then take that information and incorporate it

“During a race a power meter can serve as a strategic pacing tool, not unlike a car's rev counter”

into your pre-race training programme.

“You want to replicate the expected output demands and give the rider confidence going into the race,” says Henderson, who used this philosophy to prepare several riders for the Tour de Georgia's gruelling Brasstown Bald climb in the spring of 2008. “We used one of the local climbs in Boulder that had a similar pitch. I had them train on it at a certain output level, and that gave us a pretty good forecast of what was going to happen in the race.”

In time trials, the application of the power meter is even more direct. During a race it can serve as a strategic pacing tool, not unlike a motor car's rev counter. Coming into a TT, a racer will have a general idea of what their body is capable of for a given duration of time. By watching their output levels as they ride they'll be able to ensure they remain within that acceptable range, and not fall into the common trap of starting too fast and blowing up in the second half of the race.

“I think it's really cool during a race,” says Tom Danielson, a power meter user who has an overall Tour de Georgia title and Vuelta a España stage win on his résumé. “You can see how much energy you expend and how much power you're producing relative to what you've done in training. You just have to remember to use it wisely and not let it get inside your head.”

Riders who become obsessed with power numbers can do more harm than good. Danny Van Haute, director of the US-based Jelly Belly squad, doesn't allow his riders to use the devices in races, in part because one of his riders started placing too much emphasis on his power numbers. “It really messed him up,” recalled Van Haute. “I told him to get rid of it, and when he did he started riding better.”

Even Henderson, a devout power meter user, believes the device has its limits. “Training should give you confidence that can be translated into good race performances,” he says. “Power meters can definitely help facilitate that, but they are just a tool. At the end of the day you still have to be able to ride your bike.”



Power meters enable time trial specialists such as David Millar to stay within an acceptable output range when racing

Tim De Waele x2