
THE FASTEST WAY TO YOUR NEXT PERSONAL BEST:

RUNNING POWER

CURRENT POWER:

284 WATT.

EXPECTED FINISH TIME
HALF MARATHON:

1:42:32



Hans van Dijk • Ron van Megen • Koen de Jong

THE FASTEST WAY TO YOUR NEXT PERSONAL BEST: **RUNNING POWER**

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THE FASTEST WAY TO YOUR NEXT PERSONAL BEST:

RUNNING POWER

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Foreword

by Koen de Jong

Years ago, coach and sports physician Guido Vroemen spoke enthusiastically about power measurement for runners. I wasn't very interested. I preferred to train mostly without equipment and, whenever I did want to use some sort of measuring device, I just used a basic heart rate monitor.

With a heart rate monitor, I gained insight about *my body* (heart rate) instead of *my output* (power). For that matter, I didn't believe that you could accurately measure power in running. As a cyclist, I could somewhat imagine measuring power output, but as a runner, it seemed unreliable and pointless. Until, that is, I bumped into data geeks Hans van Dijk and Ron van Megen -- engineers who love running and measuring running. The duo were very enthusiastic about Stryd's running power meter and it caught my attention. I tried to read their book *Running with Power!*, but it proved to be a challenge. As it turned out, the book is full of formulas like $t = E / P = mgh / P = m * 9.81 * 100 / P = 981 / (P / m)$.

Halfway through the first chapter, I set the book aside. Too complicated. I just wanted to run and to find out how to improve my 10K PR. Or, how to run a full marathon and set a realistic time goal. I emailed Hans and Ron asking if they would like to get a cup of coffee. Partially because their contagious enthusiasm for running by power made me curious about this new phenomenon, but I also wondered whether it was a good idea for me, historically a "run-by-feel" athlete, to run by power. Hans and Ron laughed when I "complained" about their book. "Yes, we love formulas and calculations," admitted Hans.

"But you don't have to make it that complicated," Ron added. "Running power is very simple. Easier than running with a heart rate monitor."

At first I didn't believe them. But after two coffees, an orange juice, and a lengthy discussion of power, I wanted to try it. I followed the instructions Ron and Hans gave me and started training by power. And to my surprise, it brought a lot of peace to my training. Running by power does indeed appear to give more peace than running on heart rate. Peace?

I didn't expect that. I thought that adding something else on top of heart rate, Strava, and GPS, would be overwhelming. But it turns out that I now only have to pay attention to one thing: my power. My power fluctuates much less than my heart rate and, to my surprise, it turns out to work really well: I've been consistently getting faster ever since I started to run with a power meter. In this book Hans van Dijk, Ron van Megen, and I write about the pros and cons of running by power. Users who've been training by power for some time share their experiences. And we'll discuss in detail the differences between training by heart rate, speed, or power.

Initially, our goal was to write a book about running power in the general sense. We didn't want to write a refined brochure about Stryd, the best-known power meter on the market. But gradually, we ended up with Stryd. When it comes to running power, Stryd is simply more reliable than anything offered by Polar, Garmin, or COROS. In the future, power meters that can compete with Stryd will certainly enter the market. When that time comes, we'll add to our book. This edition is mainly about Stryd because they represent the current market leader, and by a significant margin. With this book and a power meter, training will be easier than ever. You don't need an expensive personal trainer and you don't have to do an exercise test every quarter. With your Stryd, you can easily go full throttle once a month on your favorite (short) distance and your data will automatically remain up-to-date and reliable.

If you're running with Stryd, you have your coach on your shoe, and every session is automatically included in your training analysis.

All you have to do: train with variety, and enjoy your new PRs.

In this book I regularly draw on my own experiences. The knowledge and background about running by power comes mainly from Hans van Dijk and Ron van Megen. We tried to write a book for runners who want to improve themselves. Regardless of whether you want to run a 20 or 30 minute 5K, whether you train to race 10K, or you run for general health. Running power is a valuable tool from the moment you decide to pursue greater fitness.

I even suspect that within five years, running power will be more common than heart rate training is today.

Not sure if running power is right for you? This book will help you find the answer to that. Do you have any questions, thoughts, or comments we didn't address in the book? Feel free to visit prorun.nl. Have fun reading and running.

Koen de Jong

Preface

Running by power is not yet commonplace among runners. In October 2019, I ran the Amsterdam marathon with a Stryd power meter, and it was the first time that I ever measured my power while running. I had no idea what to do with it! I had done my training with a heart rate monitor, so I had reliable heart rate targets that I knew could lead me to a PR. Still, I clicked a power meter on my shoe to measure my power.

During the marathon I did nothing with the values, but after my conversations with Ron van Megen and Hans van Dijk I became curious, and the measurements of an entire marathon seemed like a valuable starting point. After the race, I checked the Stryd app and learned that I had averaged 229 watts.

Neat.

But I still didn't do anything with it yet. I enjoyed my shiny new PR (2:59:02) and took a month of rest.

At the end of my month off I started to experiment with training by power. I learned what my power values were for a 5K, a 10K, a half marathon, and a full marathon. I learned which Power Zone I should target for my interval training and what power target I could maintain for my endurance runs. It turns out to be amazingly simple. I didn't need the formulas used by Ron van Megen and Hans van Dijk in *The Secret of Running* unless I wanted more background information. All I really need to know is: what is my power target for today? And my power meter gives me a simple answer to that.

I regularly speak to other runners who also train by power. Two comments keep coming back for all runners: "It gives me peace of mind" and "I've made enormous progress."

Everyone I speak to who has trained with power for a few months is enthusiastic.

But the runners who don't train with power have many questions. And doubts. These are all questions and doubts that I have had myself. Some I've heard include "Isn't training by heart rate more reliable?," "How do you measure progress and recovery?," "Isn't it complicated?," and "How do you determine the right power target to train with?"

With this book, we want to explain the pros and cons of running with power. Armed with this knowledge, you can decide for yourself whether running with power is right for you.

Note. We write in this book about power and how you can train smarter by running with power. If you want to train with power after reading this book, you'll need a power meter. At the moment, only Stryd's power meter is reliable. Nowadays, well-known brands such as Polar, Garmin and Coros, and apps for Apple Watch and iPhone, all do something with power. But as mentioned, the capabilities from these alternatives are not yet accurate enough, and are less suitable for real training. Ron, Hans, and I, therefore, are in close contact with Stryd. The openness with which they provide answers to our questions is always stimulating. We're very enthusiastic about their meter and the possibilities. We also expect more good power meters to appear on the market in the coming years. Ron and Hans test all new meters and write about their findings on their website <https://hetgeheimvanhardlopen.nl>. So, should a power meter come onto the market that is just as reliable as Stryd, you'll read it there first.

What is power exactly, and why should you measure it?

What are watts?

After many poor grades and frustrating struggles, I was happy to be able to drop physics in the ninth grade of high school. I'll take languages over the hard sciences any day!

What I am interested in (in addition to languages) is running, making how to progress transparent, and finding ways to improve my sports performance.

To train with power, you don't even need to know what a watt is. Even without knowing, you can improve personal records and make progress. For example, you don't need to know how the Internet works to use it. If you know to enter the URL for your favorite news website, you'll automatically see the news of the day, even without knowing how it's possible that you can access the Internet from nearly any place in the world. It's exactly the same with wattage from your running power. You can work with it, without knowledge of power itself and without knowledge of how said power is measured. As long as you know at what level of power you have to run in a training session, or at what level of power you can run during a 5K, 10K, or half or full marathon, you will make progress.

If you're not interested in the background of watts and power, but just want to do targeted training for your PR, you can skip Part I of this book and scroll straight to Part II. There, we explain how you can use your power to improve your running performance.

If you're not yet convinced of the usefulness of power training, it's instructive to know what power meters actually measure, how they do it, and what the differences are with heart rate measurement.

A watt is a physical unit of measurement used to indicate power, which is the amount of energy consumed per second. Energy is represented by the unit, Joule. Calories may be something you are familiar with from food. Joules are simply an alternative way to represent energy. Let's take a look at some energy and power values that we may be familiar with. A kcal is equal to 4.184 kilojoules. Nutritionists tell us that we consume (roughly) 2500 kcal per day, which corresponds to 10,460 kJ. In addition to kcal and kJ, we also recall energy consumption as kilowatt hours (kWh) when tracking use of electricity. 1 kWh equals 3600 kJ. So, we can say

that the energy value of our daily food corresponds to $10,460 / 3,600 = 2.9$ kWh. That's not much. Especially when we consider that 1 kWh costs approximately \$0.12. If we were to eat electricity, we would only need to pay $2.9 * 0.12 = \$0.35$ to cover our needs each day.

How do we make use of this knowledge?

In his article appearing in *Outside*, author Alex Hutchinson nicely describes why we're all interested in calories, even if we just don't know it yet. Why should you care? It's a matter of terminology, says Hutchinson. If you do a sports performance test having your VO_2 max determined with advanced equipment, you're actually also measuring calories. Oxygen uptake is measured, as it's a good measure of energy consumption. And if you use this data to determine your heart rate zones and where your anaerobic threshold is, then you use your heart rate as a proxy for energy use; in other words, calories. And even for runners who run by feel (without a heart rate monitor), you could argue that they rely on their perception of how quickly they burn calories and how long they last. In short: knowing your use of calories plays a big role in your preparation for a new PR.

When we run, a chain reaction of physical activity takes place. Our heart rate increases, our lung capacity is used to a greater extent, our muscles are switched on, and blood flow accelerates. You can think of the human body as a complex miracle where 100,000 billion cells intelligently work together. But you can also represent the function of the human motor, the muscles and the heart-lung function, which can deliver a certain power, in a number expressed in watts.

We all know that running takes energy. And it makes sense that it takes more energy to run a marathon as fast as possible, than it does to run 5 kilometers at your leisure. You can express the energy you use in kilojoules, or kJ.

Watts are the number in which your energy consumption per second is expressed. You can imagine a runner as a machine that extracts energy from food and converts it into valuable fuels for running. There is one problem: no machine is perfectly efficient, and neither is your body. You never get as much energy from your body as you put into it. For example, a car is only 25% efficient. If your car has used 100 joules of gasoline energy, only 25 of these joules have been used to propel the car forward, while the remaining 75 joules have been converted to useless heat.

Your muscles are also around 25% efficient, under normal circumstances. But that depends, among other things, on training, stride length, ground contact time, temperature, and more. Together with your weight, your energy consumption and your power are therefore a golden combination to predict how fast you can run at certain distances. Because if you know how

much power your body can deliver, you also know what your body can do to push your weight in a given direction at a certain speed.

“Power is the amount of energy per second it takes to propel your body in a particular direction”

Ron and Hans have created a clear model to describe running power:

THE RUNNING MODEL

Power of the human engine equals the sum of:

Effort required to run on a flat surface P_r

Air Resistance P_a

Overcoming Gravity P_c

$$P = P_r + P_a + P_c$$

Effort required to run on
a flat surface P_r

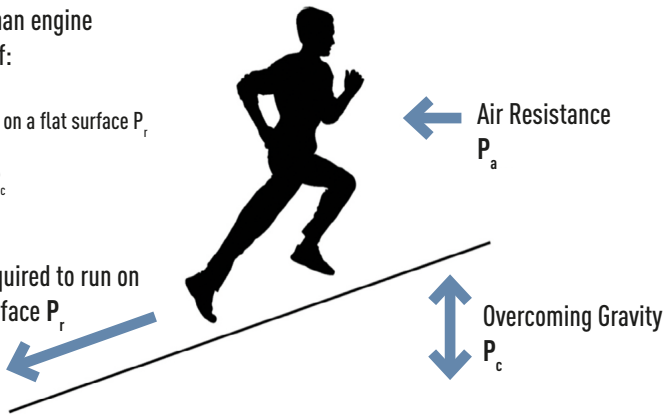


Figure 1: The Running Model

This model looks simple, but is based on complicated formulas. For example, the air resistance depends on, among other things, wind speed, temperature, air pressure, height above sea level, and your body size. You'll also notice that the air resistance is different when you walk alone or in a group, where you're (partially) sheltered from air flows.

The Amsterdam Beach Marathon is the most famous half marathon in the Netherlands. You start on the beach near Amsterdam, and halfway, you turn off the beach, back through the dunes. A very tough section, where the runners on the beach were facing strong winds, however was an excellent opportunity for Hans and Ron to test the Stryd power meter in strong winds. A running friend of theirs - Niels - ran this section of De Halve van Egmond with Stryd, and the results were interesting.

What happened?

On the beach and running against strong wind, it turned out that Niels had to deliver an average of 40 watts to overcome the wind while running, delivering power peaks of more than 70 watts. Running with a constant power, you can imagine that your speed will be quite a lot slower if the wind alone requires an extra 40 watts to overcome. Niels ran consistently at 270 watts, a wattage that he knew he could sustain for a half marathon. His pace was 8:05 min/mile in the strong headwind and (with the same power!) as compared to the pace he ran with a tailwind, that being 7:00 min/mile. His run time: 1:36:28. By running with constant power, he knew exactly what to do in the strong wind. If he was measuring heart rate, this wouldn't have worked out nearly as well, because heart rate always needs a little time to climb to a steady and reliable number. Running with pace would not have been possible at all, because he could never have known how much slower he'd have to run against the headwind. This example clearly shows how running with power works well in strong winds (and also on hilly terrain).

This model looks simple, but is based on complicated formulas. For example, the air resistance depends on, among other things, wind speed, temperature, air pressure, height above sea level, and your body size. You'll also notice that the air resistance is different when you walk alone or in a group, where you're (partially) sheltered from air flows.

The great thing about power is this: all these conditions can be captured in only one single number: your power. And if you know at what level of power you need to run to get better, you will improve quickly.

Altitude, wind, temperature, speed, heart rate, and air pressure: all of these variables affect the total time of an event. Of course, you can't constantly keep an eye on all of these variables. When the weather gets warmer or when you walk up a hill or a bridge, it affects your heart rate and your pace. Should you mainly pay attention to your heart rate or your pace? And in warmer weather, is it better to run with a higher heart rate, a lower heart rate, or the same heart rate you run with in cold weather? These questions are difficult to answer. And, during an event, it's too complicated to attempt to take all of these variables into account. The big advantage of running with power is that you only have to keep an eye on this one simple to understand number that takes everything into account: altitude, temperature, speed, wind, humidity, and air pressure. The following graph clearly shows the benefits of running with power. While all variables can freely change, you can simply keep your power level at a constant number.

And the best part is: this predictor is accurate across all distances. So if you run 3 kilometers as fast as possible once, you get a very accurate picture of what's possible for a 10 kilometer race, half marathon, or full marathon.

For example, if you look at your wattage instead of your speed, you'll also know exactly how much slower you would have to run against a wind or on an uphill. Better yet, even

RUNNING WITH POWER

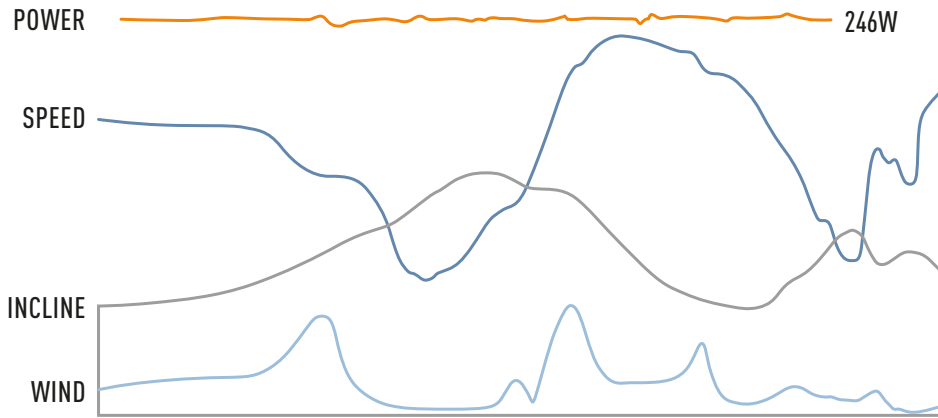


Figure 2: Running with Power: one number

downhill, you can see exactly at what level of power you should run to keep your wattage at the right intensity.

Power allows you to clearly see your progress, regardless of whether you primarily run on a running track or in a forest or on a hill.

Sure, this all sounds good. But doesn't heart rate measure your progression and the capability of your body too?

What works for you: training by power, heart rate or pace?

Many runners who take their sport seriously have a heart rate monitor. They know their heart rate zones, and they know where they perform best. This allows them to train and measure their progression in a targeted manner.

Why is heart rate monitoring so popular with runners?

In 1982, Polar was the first company to come up with a watch for a wide audience that could measure heart rate. With smartphones, Fitbits, heart rate monitors, pedometers, and the Apple Watch, we now have endless brands and devices with which we can measure heart rate, steps, speed, sleep, activity, and stress. But in the early eighties, Polar was actually the first to launch a watch with which you could collect data from your own body. And the data you could collect was heart rate. With a strap around your chest and a watch connected to it, you could see what your heart rate was while you were running.

Many researchers and exercise physiologists used these devices to conduct research on topics such as the relationship between heart rate and fuel consumption. We learned that at a low heart rate you use your fats relatively more, and that at higher heart rates you use your glycogen stores more (for an explanation of glycogen, see box). The relationship between heart rate and lactic acid was extensively explored, and the tipping point became a value that, as an avid runner, you simply had to know. The tipping point (or anaerobic threshold, AT point) is the heart rate at which you produce more lactic acid than you break down. Lactic acid is sometimes mistakenly seen only as a waste product. What not everyone knows, is that you also produce lactic acid with light exertion, and that in low doses, lactic acid is used by the heart as fuel. It's only when you produce more lactic acid than you can use, that it starts to become an issue. As lactic acid accumulates, you start to lose performance capability, and you use your glycogen stores to the fullest. You can maintain this intensity for about an hour.

ANAEROBIC THRESHOLD AND FUEL

Is the anaerobic threshold a new concept for you? We'll briefly explain what it is and why it's so valuable for a runner to know about it. If you exercise more intensively, your muscles need more oxygen because energy must be released faster. That's why your heart rate goes up with physical exertion: your heart pumps more oxygen to your muscles. If you accelerate after a gentle warm up, your heart rate will increase, as will your breathing frequency and tidal volume. In the beginning you will breathe deeper, but not faster. There will automatically come a point (if you keep increasing intensity) at which you can no longer breathe deeper, but your thighs do require more oxygen. That's when you start to breathe faster. This is the moment when the training stimulus starts. At your aerobic threshold, and above this effort, you will build up fitness. It's called the aerobic threshold because when you're taking in a lot of oxygen, you can mainly use your fats as fuel. You can maintain this intensity for between four to six hours. If you keep increasing intensity beyond the aerobic threshold, you will reach your anaerobic threshold. You breathe less deeply and exponentially faster, lactic acid accumulates, and you can maintain this effort for about an hour while mainly burning glycogen.

You have four fuels to draw from: ATP, Creatine Phosphate, Glycogen, and Fat. Glycogen and fat are particularly important for endurance athletes. You can run quite a few marathons with your fats as fuel. The big advantage of fat is that you can take a lot of energy with you, even if you have a relatively low weight. Even if you have a fat percentage of 8% (which is very low) and you weigh 70 kilos (154 lbs), you still have 5.6 kilos (12.3 lbs) of fat, good for more than six marathons. A disadvantage of fat is that it does provide energy, but the energy is released slowly. A lot of oxygen is needed, and you don't get the energy directly. So if you run slowly, you can use your fats, but if you increase intensity, you also need another fuel: your glycogen. You have about 500 grams (1.1 lbs) of your glycogen stored in your muscles and in your liver. These 500 grams equal approximately 2000 kCal.

Every runner has enough fat to live on for weeks. We sometimes joke that you can easily find out exactly for how long you can persist with fuel stored in your fat stores: stop eating, and then wait until you die. That's how long. You can go without food for more than 40 days, which shows that you have fuel that you can really use for a long time. A property of fats is that they are energy efficient and last a long time. When you sit in a chair and you're relaxed, you mainly use your energy-efficient fats. When you go for a run, you also use your energy-fast sugars.

You should not confuse these sugars with the sugars in sweets or sports drinks. It's a general term that includes slower carbohydrates. In exercise physiology, these sugars are called glycogen stores. This glycogen is stored in your liver and around your muscles. A well-trained runner can run on maximum glycogen use for about one and a half to two hours. However, it's not true that the combustion of one fuel stops before the other continues. In other words, you're never running on only fat or only glycogen. And, fat always contributes. As you keep adding intensity, more muscle fibers are involved that "eat" something else.

So the idea that one system is switched on (glycogen) and that your other system (fats) no longer participates, is not the case. The fact that oxygen uptake increases proportionally with increasing load provides evidence that both systems remain active. If the “fat burners in your muscles” (which use the most oxygen) stop, the oxygen uptake would no longer increase linearly. Oxygen uptake does increase linearly, showing that fat burning does indeed continue throughout.

Okay. But how is this knowledge useful?

Because you always have more fat than glycogen, as a runner, you want to achieve two things with training:

1. Run as fast as possible on your energy-efficient fats
2. Store as much glycogen as possible in your liver and muscles.

FUN FACT: a kilo (2.2 lbs) of fat is good for 9000 kcal. So, if you weigh 70 kg (154 lbs) and you have a body fat percentage of 20%, you have 14 kilos of fat x 9000 kcal = 126,000 kcal fat. You can store about 500 grams of glycogen, which is about 2000 kcal.

With this knowledge, you immediately know why many training schedules emphasize that variation is important. You want to train your muscles to run efficiently on fats, and you want to stimulate your muscles to store glycogen.

Many heart rate monitors therefore work with zones based on this tipping point.

There are three main zones:

- I. Very easy, little training effect. It's about recovery. For your body, fuel consumption is comparable to sitting on the couch: not much happens. In terms of training, however, it's a part of your schedule that should not be underestimated. In this zone, you run, but you don't build up fatigue or damage your muscles, tendons, ligaments, and joints.
- II. If you exercise more intensively, you will reach the aerobic threshold. This is where the training effect begins.
- III. If you keep increasing intensity, you will arrive at your lactate acid turning point, and you will no longer be able to maintain your power. This is the anaerobic threshold.

Though we describe 3 zones here, you will often see 5 zones in heart rate training because 3 zones are distinguished between the aerobic threshold and the anaerobic threshold (low, medium, high) and there is also a separate zone above your turning point.

Pay attention

You can enter your own heart rate zones when training by heart rate. This way, you'll have (reliable) values that you already know. Even if you don't enter zones, you'll still see different zones from your heart rate monitor. Note: this is unreliable. If you take your new heart rate monitor out of the box and you turn it on, you'll have to answer some questions. What language do you speak? What time is it? Do you want a 12h or 24h time format? Are you male or female? Do you wear your watch on the left or right? How much do you weigh? What's your year of birth? And that's where it goes wrong. Your watch determines your maximum heart rate based on your age. There's a standard formula that determines your maximum heart rate as follows: 220 minus your age. Based on this invented maximum heart rate, the monitor will determine your zones. This is a shame. Because, for many runners, this standard formula does not apply at all. Suppose, you're 45 years old and you have an actual maximum heart rate of 195 (which is not surprising at all). Your watch says 220 minus your age (45) = a maximum heart rate of 175. If you then train in your zones in a targeted manner, you'll become quite annoyed. Because, every time you run smoothly, your heart rate monitor starts to beep that you should slow down. In this way, you structurally train too carefully, and at a certain point you'll no longer make progress.

That's a shame.

You can do better.

Heart rate measurement has taught us a lot in the last 40 years. And with a reliable heart rate monitor and sufficient knowledge, you can train on flat terrain as long as you don't do short intervals. In some cases, however, a heart rate monitor is not suitable. For example, with your interval training of 200 or 400 meters. By the time your heart rate is high, you're already at the end. Running uphill is another issue when training by heart rate. Your pace drops, your heart rate shoots up, and your results are hard to compare to your flat training laps. But the biggest "danger" of heart rate training is an inaccurately measured heart rate. Many major brands have switched from measurements via a strap around the chest to a wrist monitor, and those are still far from accurate for everyone. Runners who often suffer from cold hands generally get inaccurately low heart rate values from a wrist monitor. Ron himself has a different experience. His wrist monitor indicates values that are too high.

If you look at the physiology of a person, it actually makes much more sense to measure breaths, instead of heart rate.

The three stages we mentioned earlier can be registered faster and more clearly by looking at your breathing. When you get up from the couch and go outside to run, you start to breathe deeper. So, the first zone is that you take deeper breaths, without breathing faster. At the aerobic threshold, your thighs ask for more oxygen and you breathe faster, as we described in the box about aerobic threshold. You keep increasing intensity, so you'll breathe faster and faster, with the same tidal volume until you reach your tipping point, the anaerobic threshold. At this point, you can no longer deepen your breathing. Because you still need more oxygen, you'll breathe faster, but more shallowly.

Physiologically, your breathing responds faster than your heart rate, which makes it ideal for targeted training. It's just that, back in 1982, it was easier for the company Polar to measure heart rate via a belt than to measure respiratory frequency and tidal volume, so they decided to go with the heart rate monitor.

Well before heart rate monitors emerged, enthusiastic runners trained by pace.

Funnily enough, training by pace in the 1970s and 1980s was very reliable, but nowadays that's no longer the case. How is that possible? Fifty years ago there were no watches that determined your speed via GPS. So, if you started training focused on pace, you were forced to train with a stopwatch and to know your distance very precisely. On a running track you could calculate exactly how fast you had to run your 200, 400 or 1000 meters to train at a certain pace. That way of tempo training is of course still reliable and still popular with track training. With your fastest time at a certain distance (3, 5 or 10 kilometers,) you can calculate what your possible times are at other distances, and you can also determine what your intensive interval paces or your leisurely endurance runs are.

So, what's the problem?

Many runners have a Garmin, Polar, or Coros and train by pace using their watch as a compass. Unfortunately, this way of measuring is not always reliable because the watch bases your speed on GPS data. Your watch is connected to satellites and uses the distance between the different position measuring points to know how fast you took to go from point A to point B. Tall buildings, trees with wet leaves, winding roads, or not enough connected satellites can all contribute to GPS measurement errors. Pace based on GPS varies from moment to moment and is not very useful. Of course, the measurements are more stable over longer distances because deviations average out.

Therefore, if you run a marathon, your distance will always be around 42.195 km (26.2 miles),

although you're not always running the ideal line and your watch is always slightly off. We all know that when training on a track and using Strava it sometimes seems as if you have cut straight across the middle area. That's simply because your watch combined two "satellite" points and missed the curve in between.

Another disadvantage of running with a heart rate monitor is that your heart rate responds slowly. When you run up a hill, your muscles immediately use more energy, but your heart rate takes time to notice that your muscles need more oxygen and it needs to pump faster. So, if you walk up a hill with a constant heart rate, you have to work hard for the first part and you have to walk very slowly for the second part.

That is one of the great advantages of training with Stryd. You train by power and Stryd does not depend on GPS or heart rate, but measures your power with accelerometers on your foot. And that turns out to be extremely reliable.

The breakthrough in power running came with the use of inertial measurement units (IMUs). We prefer to call them accelerometers. These are small instruments in a chip that can be used to measure accelerations. The measuring principle is based on the fact that the crystals in the chip produce a piezoelectric effect under the influence of an acceleration. This piezoelectric effect results in a voltage that can be measured. The Stryd chip accurately measures this voltage more than 100 times per second, which makes the device ingenious and reliable.

"Ehhhh, Ron and Hans, I really don't know what you're saying now. Plain human language please."

* Laughter * "Okay, we have a great every day example."

Thanks to an accelerometer, your mobile phone knows whether you are holding it horizontally or vertically. If you watch a video on YouTube and you tilt your phone, the image on your screen will tilt. With the same type of technology, your running watch knows your cadence and the number of steps. Accelerometers today are very cheap, very accurate, and they are found in all kinds of devices, such as smartphones, cars, tablets, pedometers and running watches. A smart power meter uses this technology to determine your speed and stride cadence. And that turns out to be much more reliable than GPS. The Stryd power meter is currently leading the way in converting this technology into reliable speed (and power) measurements for runners.

The sensor includes 6 accelerometers. These measure the acceleration of your body while running in 3 directions: horizontal, vertical, and lateral/sideways. Obviously, in running, it's important to limit vertical and lateral movements, as this consumes energy that doesn't

contribute to forward displacement. Everyone has a certain optimal economic step frequency and technique. With Stryd you can determine which running technique suits you best. As mentioned, Stryd takes measurements many times per second, which makes the accuracy of the device very precise. And Stryd doesn't just measure your movement from side to side, top to bottom, and your speed forward, but also air pressure, temperature, and humidity.

These measurements, combined with your weight and height, together with Stryd's well thought-out algorithms, accurately reflect your power. When you run, you can see your power (in watts) via your smartphone, your Apple Watch or your running watch. Power (P) is calculated from your weight (m) (in kg), the measured acceleration (a) (in m / s², in 3 directions), the speed (v) (in m / s), and the air resistance with the basic formulas:

$$F = m * a$$

$$P = F * v$$

Stryd's breakthrough is the software it has developed to calculate the power by using all data from the accelerometers continuously and in real time. As we saw, the basic formulas are simple but a complicated algorithm is needed to accurately calculate the power based on the accelerations in all directions.

The advantage of the Stryd footpod is that it gives you a pure and exact measurement of power in real time. This gives a much better and objective picture of your effort than your feeling, your speed, or your heart rate alone.

And the biggest advantage for runners who prefer simplicity, rather than to read complicated books about training: you only need to train with 1 number in mind. As long as you know which level of power you need for which training, that's enough.

Why the wattages from Polar and Garmin are wrong

One of Koen's running friends wanted to know what his expected time was on the half marathon. To calculate, he used the power of a fast 10 K.

"I may not have gone all the way because I was running on my own, but I did my best anyway," said Joost.

His time on the 10 kilometer was 44:15 and his power was 357 watts. So, Koen and Joost used 357 watts as his Critical Power and started calculating.

According to the formulas, after some calculations, Joost would end up with a half marathon of 1:16:34 ". That can't be true, said Koen.

"Did you enter your correct weight in Stryd?"

"I don't have Stryd," said Joost. "I measured it with my Polar."

What did we find out? The power measured by Polar (and Garmin) is far too high.

Hans and Ron have done several studies that showed that the wattages of Polar and Garmin were 25% to 35% higher than those of Stryd. The differences can be explained by the fact that Polar and Garmin derive their power readings from measurements with force plates in the lab. However, this doesn't take into account the energy recovery in the muscles during the landing phase. Stryd bases calculations on the actual power required to move around while running, resulting in this difference of 25-35%. In addition, Polar and Garmin use GPS, which is much less accurate. Incidentally, the relatively new brand Coros does make use of the necessary power to move around while running. Coros has fully integrated the information from the Stryd Footpod. This makes the Coros watch a strong duo with Stryd. Coros can also measure power based on GPS, but this is less accurate, especially with changes in speed and course. Coros also doesn't take into account the resistance from the wind. So for now, Stryd works best.

What is Critical Power and what can you do with it?

In the previous chapter, we wrote about the tipping point (anaerobic threshold) and different heart rate zones. When running by power, your Critical Power (CP) is a valuable number to know. You can use it to determine your different training zones.

Your Critical Power is the power that you can maintain for a certain duration. Because of this definition, it can sometimes be confusing. In sports literature, this could be the power that you can sustain for 20 minutes (CP20), 45 minutes (CP45), or 60 minutes (CP60). CP60 is lower in wattage than CP45. And CP45 is lower than CP20. After all, you can last for a shorter time with a higher power.

Stryd uses one Critical Power, calculated based on your power curve. Without knowing your Critical Power you can't properly use your power for training and competitions. A power of, for example, 260 watts says nothing, just like a heart rate of, for example, 173 doesn't say anything. For the information you gather to be useful, you need to know what capacity you can maintain for a certain period of time.

Until recently, you had to do an exercise test with a sports doctor to accurately determine your heart rate zones. On a bicycle or a treadmill you would go through increasing levels of cycling harder and faster. A sports doctor would take a small sample of your blood at each level to measure your lactic acid values, or you would have to wear a mask for a breath analysis. A major disadvantage of these expensive tests was that athletes regularly got anxious from wearing the mask or doing the blood test, and that the measurements were therefore not completely true to reality in comparison with outdoor sports. For example, it was possible that (due to rapid breathing) the anaerobic threshold was set too low and athletes started exercising with heart rate levels that were lower than they should be. Result: frustration due to slow pace and little progression because of overly cautious training.

A power meter has the great advantage that you can determine your Critical Power outside on the street or in nature.

You can take a test to determine your Critical Power, but Stryd also has a feature to automatically adjust your Critical Power based on your workouts: auto-calculated Critical Power. Basically, Stryd itself determines your Critical Power based on a series of training sessions and competitions. The auto-calculated Critical Power is accurate to 1 - 2% for most runners, and adjusts automatically as runners get fitter or out of shape.

To get a good indication of your Critical Power when you first start, 3 training sessions with sufficient variation are required.

For example:

1. Short distance, sprints or accelerations with a duration of 10 to 30 seconds;
2. Medium distance, a 10 to 20 minute pace run, or a 5 km or 10 km at your race pace.
3. Long distance, a gentle endurance run of at least 50 minutes.

After that, the workouts are tracked for the last 90 days and your Critical Power becomes increasingly more accurate.

Every workout counts.

The fact that every run is automatically included in your Critical Power is a luxury that will give you enormous benefits in the long term. In the past you probably went to a sports doctor once a year to determine your VO2 max and your heart rate zones. With Stryd, every training is analyzed and compared with your values from the past. As with any new device, it takes a little thought and dedication to download Stryd's app and pair your Stryd with your phone and watch. But once you've done that, you'll have the smartest and most loyal trainer in the world, sitting right on top of your shoe. In the app you will see various data under Summary: Stress, Running Stress Balance, Upcoming Events, Power Duration Curve, and Critical Power at the bottom. First, you'll see your power (in orange), and then your power per kilogram of body weight.

You'll only want one thing: that your capacity per kilogram of body weight is as high as possible.

It can be very addictive (in a good way!) to work to increase your Critical Power. We see regular sessions on Strava with the subject: Critical Power boost workout. After your workout you'll have to wait anxiously to see if you've earned the notification: 'Your Critical Power has increased!'

Warning: make sure you always train with Stryd. Koen was once notified that his Critical Power had increased to 5.26 watts / kg. That would allow Koen to run a marathon within 2.5 hours and that's not correct. What had happened? Koen was running with different running

shoes and had forgotten to put his Stryd on his new shoes. So the readings were coming from his Polar Vantage V, not Stryd, and were inaccurately high. Due to the link between Stryd, Strava, and Polar, the training was stored in Stryd's PowerCenter and included in Koen's calculations.

You can easily ensure that Stryd doesn't include one of your sessions in your results. Go to the app and click on Calendar. Click on your training and at the top right you see three horizontal dots. Click on view details and voilà: your training. Include Run in Analysis is normally green. Slide the ball to gray and your training will not be counted.

You see: it's not complicated, but it is more convenient to just train with your Stryd, then you won't have this problem at all.

If your Critical Power suddenly drops a number of points, it means that your Critical Power was determined more than 90 days ago and that you haven't trained at the level of your Critical Power for 90 days. In short, did your Critical Power drop? Then it's time to get to work! Sounds good, but what exactly does your Critical Power do for you?

If you're stuck at the same level at the moment but would like to improve your PR on the 5K, 10K, half marathon or full marathon, then your Critical Power is priceless.

Variation in training is important, especially if you train specifically for a PR. Five zones emerge from your personal Critical Power:

Easy

Moderate

Threshold (upper limit of Threshold is your Critical Power)

Interval

Repetition

In the chapters focusing on the different distances (5K, 10K, half marathon, and full marathon), we'll discuss these zones in more detail.

What distinguishes running by power from running by heart rate, is the possibility to do more targeted interval training. The great thing about running by power is that you can work with two zones above your tipping point. You can, of course, run an interval of 200 meters at higher power than intervals of 400 or 600 meters. That distinction can't be made with a heart rate monitor. Above your anaerobic threshold you have only one zone: from your anaerobic threshold to your maximum heart rate. It wouldn't make any sense to have other zones above your anaerobic threshold for short intervals. Just think about it. If you really run 200 meters intensively, it's not hard to overshoot your target. But by the time your heart rate is too high, you've already finished your 200 meters. If you train by power, you can do targeted intervals at 200 meters. For example, if you want to run 320 watts for 200 meters, you can check after 80 meters (or earlier) whether you're running fast enough (or too fast) and then you can speed up or slow down.

Another advantage of power training is that you can go full out any time you want. Of course this is always possible, but normally you don't know exactly how fast you can run at any given distance or time. If you know that you can run 10 kilometers in 50 minutes, it's easy to figure out how fast you would be on a 5 K, half marathon, or full marathon. But if your favorite run has a nice segment of (for example) 1380 meters, calculations become a lot more complicated. Doing the math for one segment of a run is manageable, but if you have different segments on different laps where you'd like to go full throttle, you obviously don't want to calculate the ideal time for all those odd distances. For example, for 2130 meters, the ideal run time is slightly different from (for example) 1380 meters. With power and Stryd, all these distances become easy to work with.

What does this have to do with Critical Power?

Based on your Critical Power, you get a beautiful curve showing all wattages between 10 seconds and roughly 3 or more hours. So every distance (and time) is included. And the best part is: you don't have to do any complicated calculations, it's all automatic. So, if you accelerate during (for example) 1380 meters, that's a reliable test run to see whether you're progressing or not.

POWER DURATION CURVE



Image 3: Power Duration Curve

In the Power Duration Curve you see a white line (your potential) and blue segments (your actual results from the past thirty days).

Power Duration Curve

This power curve is very interesting for several reasons.

The power curve is based on your best running performance over the past 90 days.

The power curve can be found in your PowerCenter at Stryd. To our knowledge, there are currently no other parties that work with a power curve for running, although it has long been commonplace in the cycling world. That's why triathletes are so excited about running with power. They're already familiar with the many benefits of the power curve.

What's the benefit of the power curve?

1. You can go full throttle on your favorite part of your run and you will always get valuable information from it. So even if it's a hill of 272 meters or a lap with a distance that you don't normally run in a competition, like (for example) 5752 meters.

2. You can see at what level of power you have to run for a PR at your favorite distance, and you can quickly see whether that's already feasible or if you still need more training.

We dare to say that your power curve alone is already enough to make meaningful use of a power meter and to train for your PR in a targeted way.

Achievements older than 90 days are not included in the curve. It's about what you can do now, not what you were able to do in the past. If you performed well today, the corresponding point in the curve (duration and average power) will improve immediately. If a 90-day performance falls outside the curve, that affects the curve. The best performance of the past 90 days will take its place.

You can also use the curve the other way around. For example, if you think that 45 minutes on a 10K is feasible, you can check the curve to see which power is associated with that time. Whether or not a certain time is achievable with your current level, can easily be determined using the Race Power Calculator. More on this later.

The Race Power Calculator will give you a good indication of the minimum power level that you must maintain for optimal performance.

Disadvantages of training by power

We've discussed some of the great benefits of running by power: you don't need a relatively unreliable GPS, and your power responds much faster than heart rate. And even with headwind and uphill terrain you can continue to run by power. Power training provides peace of mind and you can train specifically for a PR.

Are there any disadvantages to training by power?

We often hear from runners who are used to training with a heart rate monitor that the monitor can be a necessary break for people with a lot of stress. After all, stress at work or after an illness makes your heart rate go up, so if you train on heart rate, you should naturally run more slowly in times of stress. Also, for avid runners who overtrain, the heart rate monitor can be a remedy if the heart rate no longer rises during intensive training.

Does this happen with running by power?

No. Stryd's power meter determines your Critical Power based on your workouts. Training older than 90 days doesn't count towards your Critical Power. That is to say: progress is directly included in your new values, but illness or overtraining is only compensated after 90 days.

Example.

Imagine you run a very fast 10 kilometers in March. You participate in an event and you give it everything you've got. You cross the line exhausted. Red faced. Heavy legs. Nice PR. The following week is rough. Your partner wants to leave you and a colleague is sick, so you're working twice as hard. You just had a hernia surgery. Life is full of heartbreak and stress. If you keep running and only train with Stryd, things can go wrong. Running is a welcome distraction, but your body does not recover as well as you're used to during this difficult period. If you continue to train on your abilities and you train just as often as before all the setbacks, then things are bound to go wrong. After all, your Stryd will take your top time from March into your Critical Power and your zones for another 90 days. The fact that you are gradually performing less is only taken into account in June (90 days after March).

Incidentally, Stryd does monitor your training sessions to check whether you are training constructively, or whether you may be doing unnoticed damage. Stryd indicates this by means of the Running Stress Balance.

What's your Running Stress Balance?

A handy trick from Stryd that we will discuss here is your Running Stress Balance (RSB). Your RSB indicates the difference between your activities of the last 7 days versus the 42 days before. This way, you can see in 1 number whether you're improving, or whether you could use some rest. If your RSB is -40 or lower, it's good to take a few rest days. If you're between -25 and -40, you should be careful. Extra rest works better than an intensive workout. You're training constructively when you're between -10 and -25. It's good to be in between these two points during training periods, and to take some rest days in the run-up to a match. Between -10 and 5 you'll maintain the condition you have, so if you're training and want to get better, you should put on your running shoes more often (or run more intensively). If you have consciously taken some rest because an important event is coming up, this is fine. Because between 5 and 25 is the perfect RSB to be at, at the start of your event where you want to run a PR (after a training period between -10 and -25). If you're between 25 and 45, then you need a push to get off the couch and start running again. However, this Running Stress Balance is only related to your training, and doesn't know when you're feeling ill or stressed. So, that remains a pitfall of running by power.

This disadvantage of running by power is easy to fix. You can train by power and heart rate. Power controls your training. When training, you only have to pay attention to your power, but in Stryd's PowerCenter or on Strava (or another app where you analyze your workouts) you can check whether your heart rate is keeping up. When you are in good shape, your heart rate will drop over time at a certain wattage. Your body has become stronger (and your Critical Power improved). You deliver more power at fewer revs (heart beats). Hans and Ron go so far as to keep a graph of all training sessions for themselves in Excel. Such a graph is very educational and will help you avoid unpleasant surprises.

Resting heart rate

Another way to check whether you are recovering sufficiently from your workouts is your resting heart rate. Your resting heart rate is a value that you can measure on a daily basis. It's the heartbeat you have when you sit quietly on the couch. Whether you measure resting heart rate in the morning or in the evening doesn't matter, as long as you do it at the same time. Make sure that you sit for at least 5 minutes, because your heart rate increases just from standing. In any case, it's very educational to measure your resting heart rate for a period

of time. You'll gain insight into your recovery in relation to work, sleep, alcohol, jet lag, and training. Is your heart rate five beats higher than you're used to? Then it's time to rest (even if you actually had an intensive interval in mind).

HEART RATE VARIABILITY

More and more heart rate monitors are also showing heart rate variability. That's even more reliable than your resting heart rate. Your heart rate variability is the time difference between two consecutive heartbeats. Are you training in a constructive way and are you recovering well? Then your heart rate variability increases. Contrary to popular belief, it's unhealthy if your heart beats evenly. During your inhalation, your heart rate increases a little and, when you exhale, your heart rate decreases. This is related to two different systems in your autonomic nervous system: your orthosympathetic system and your parasympathetic system. Your orthosympathetic system is your so-called accelerator and stands for action, high heart rate, the upper number of your blood pressure, and rapid breathing. Your parasympathetic system is the recovery, the brake pedal of your body. Your parasympathetic system stands for rest, recovery, low heart rate, the lower number of your blood pressure, and calm relaxed breathing. In times of stress and a lot of work or training, your orthosympathetic system can take the upper hand and even remain active in your sleep. By measuring your heart rate variability, you can keep an eye on this and you can build in rest and take more time for relaxation exercises when needed.

Feeling

We love measuring and making progress transparent. But of course, there are also ways of knowing if you're making progress without using measurements. If you feel fit and full of energy, you're fine. Do you dread your running workouts and feel tired and lethargic? Then it is time to rest and listen to your body. Tip: do run, even if you are tired and lethargic. After fifteen minutes of running you'll know whether it's okay to go back home, or whether it's better to keep running to get more energy. Do you still feel tired after running for 15 minutes? Then it's time to rest. But it may well be that you're surprisingly more ready after fifteen minutes of running than when you just stepped out of the door. Then it's fine to finish your workout.

Summarizing, the disadvantage of running by power is that you can't measure fatigue in your body with a power meter.

But, power meters are great for measuring progress. That's why we'll now go to Part II: How can you run faster?

In summary

Power is the amount of energy per second that is required to propel your body in a certain direction at a certain speed.

GPS is not reliable over short distances.

Air resistance is also included in your performance. Air resistance depends on, among other things, temperature, wind speed, air pressure, and height above sea level.

Your Critical Power can be used as a surrogate near your tipping point, or anaerobic threshold.

Every training is included, so your Critical Power automatically remains accurate.

With the Power Duration Curve you have insight into what you can do at specific distances.

How can
you run
faster?

Weight (mass) and speed: what you need to know

If you want to make progress and sharpen your PR at your favorite distance, introducing variation in your training is important. Are you a runner who often runs the same distance at the same pace? Introducing variation in your training will make a big difference. More on that later.

First, we want to talk about weight. If you're starting a few pounds overweight, losing that extra weight is the fastest way to progress. If you are (for example) twenty pounds heavier than is healthy for your height, you can, of course, train for a PR focused on power. That works, but it's a bit like buying a new house because your windows are dirty. It works, but there's an easier way. Note that we will use mass extensively in the next section rather than weight, but, assuming you are running on earth and not with some other planet's gravity, which one we use does not matter much.

In *The Secret of Running* Hans and Ron write extensively about the relationship between weight and speed. They've devoted an entire chapter to it: *How Much Faster Will You Go When You Lose Weight?*

How big is the effect of your mass?

The mathematics of mass influence can be explained simply, according to Hans and Ron. Your body basically has a fixed power, P , in watts. If you run on a flat course, you use that ability to overcome running resistance and air resistance. If you lose a few pounds, your power remains constant (because your strength is unchanged), but your running resistance decreases. Result: you can run faster. There is, however, a limit. Things go wrong at the point where you no longer lose excess fat, but muscle mass. We want to prevent runners from going overboard in their drive to lose weight. The moment your sweat starts to smell like ammonia, it's important to start eating more. But again, knowing you can lose some of your extra pounds is an easy way to boost your speed. Overall, you can say that for every excess percent that you become lighter, you also become one percent faster. This makes sense, because you use less energy when you are lighter, while your heart-lung system is unchanged. Note: this is

ACHIEVABLE TIMES BY DISTANCE BASED ON CP60 AND VO₂ MAX

CP60		ACHIEVABLE RESULT					VO ₂ MAX
watt/kg	3000 m	5000 m	10.000 m	21,1 km	42,195 km	Distance for one hour	ml/kg/min
2.00	0:23:16	0:40:12	1:24:24	3:07:38	6:33:51	7.27	28.0
2.25	0:20:36	0:35:34	1:14:41	2:46:02	5:48:32	8.15	31.5
2.50	0:18:27	0:31:53	1:06:55	2:28:47	5:12:19	9.03	35.0
2.75	0:16:43	0:28:53	1:00:39	2:14:50	4:43:03	9.90	38.5
3.00	0:15:14	0:26:19	0:55:15	2:02:51	4:17:53	10.80	42.0
3.25	0:14:05	0:24:20	0:51:06	1:53:36	3:58:27	11.62	45.5
3.50	0:13:04	0:22:34	0:47:23	1:45:20	3:41:06	12.47	49.0
3.75	0:12:12	0:21:04	0:44:13	1:38:19	3:26:23	13.30	52.4
4.00	0:11:26	0:19:45	0:41:27	1:32:09	3:13:26	14.13	55.9
4.25	0:10:46	0:18:35	0:39:01	1:26:45	3:02:06	14.95	59.4
4.50	0:10:10	0:17:34	0:36:53	1:21:59	2:52:06	15.76	62.9
4.75	0:09:39	0:16:40	0:34:58	1:17:45	2:43:13	16.56	66.4
5.00	0:09:11	0:15:52	0:33:18	1:14:01	2:35:23	17.34	69.9
5.25	0:08:46	0:15:08	0:31:46	1:10:37	2:28:14	18.12	73.4
5.50	0:08:23	0:14:29	0:30:24	1:07:35	2:21:52	18.88	76.9
5.75	0:08:02	0:13:53	0:29:08	1:04:47	2:16:00	19.64	80.4
6.00	0:07:43	0:13:20	0:28:01	1:02:16	2:10:43	20.38	83.9
6.25	0:07:26	0:12:51	0:26:58	0:59:56	2:05:49	21.12	87.4
6.50	0:07:10	0:12:23	0:26:01	0:57:50	2:02:23	21.84	90.9

Image 4: What times are achievable?

a simplified explanation. It does not take into account certain physiological complexities, but generally applies to situations where excess weight is being lost.

For this reason, your Critical Power (just like your tipping point) only becomes interesting when you start looking at your capacity per kilogram of body mass. So, a Critical Power of 250 Watts doesn't say anything about your possible run times. If your mass is 60 kilos (a weight of 132 lbs), your power per kilogram of body mass is 4.1, but at a mass of 80 kilos (a weight of 178 lbs), your power per kilogram body mass is 3.1. For example, a 10 kilometer run with a Critical Power of 4.1 per kilogram of body mass takes around 41 minutes. The same run with a power of 3.1 per kilogram of body weight takes around 54 minutes. So, your power per kilogram of body weight is what matters, not your absolute power.

In the table in figure 4 you can see your favorite distance and your potential times at your current watt / kg.

If the numbers start to make you dizzy, don't panic. For runners who already run with Stryd, the Critical Power per kg isn't rocket science. After all, you can easily go to your settings in the app and look at your Critical Power. You will then automatically see your

PERFORMANCE COMPARISON FOR MALES

Klass	CP60 watt/kg 30 years	CP60 watt/kg 40 years	CP60 watt/kg 50 years	CP60 watt/kg 60 years	CP60 watt/kg 70 years	CP60 watt/kg 80 years
Absolute top	6.4	6.0	5.6	5.2	4.7	4.0
International	5.7	5.4	5.1	4.7	4.2	3.6
Nationaal	5.1	4.8	4.5	4.2	3.8	3.2
Regional	4.5	4.2	3.9	3.6	3.3	2.8
Running Enthusiast	3.8	3.6	3.4	3.1	2.8	2.4
Fitness Runner	3.2	3.0	2.8	2.6	2.4	2.0
Untrained	2.5	2.4	2.2	2.1	1.9	1.6
Poor	1.9	1.8	1.7	1.6	1.4	1.2
Very Poor	1.3	1.2	1.1	1.0	0.9	0.8

Figure 4A: Performance Comparison for Males by Age

PERFORMANCE COMPARISON FOR FEMALE

Klass	CP60 watt/kg 30 years	CP60 watt/kg 40 years	CP60 watt/kg 50 years	CP60 watt/kg 60 years	CP60 watt/kg 70 years	CP60 watt/kg 80 years
Absolute top	5.7	5.4	5.0	4.6	4.2	3.6
International	5.1	4.8	4.5	4.2	3.7	3.2
Nationaal	4.6	4.3	4.0	3.7	3.3	2.9
Regional	4.0	3.8	3.5	3.2	2.9	2.5
Running Enthusiast	3.4	3.2	3.0	2.8	2.5	2.2
Fitness Runner	2.9	2.7	2.5	2.3	2.1	1.8
Untrained	2.3	2.1	2.0	1.8	1.7	1.4
Poor	1.7	1.6	1.5	1.4	1.2	1.1
Very Poor	1.1	1.1	1.0	0.9	0.8	0.7

Figure 4A: Performance Comparison for Females by Age

capacity in W / kg . If this book is your first introduction to running with power, then you should remember: if you lose 1% excess weight, you will run 1% faster.

Not just theory

The above statements and figures have not only been studied theoretically, but have also been proven in practice in people who have lost excess weight. For example, Hans weighed 127 pounds in 1980 (with a height of 5'7"). More than thirty years later, he'd gained twenty pounds. With a targeted diet, Hans returned to his old weight of 57.5 kg (127 pound) in six months, a decrease of 15% in weight. His performance at all distances increased spectacularly during that period. In the end - you guessed it - Hans became 15% (!) faster on all distances. Note: This is a personal anecdote; the effort to lose weight and the cost of losing too much weight vary across sex and age - please consult your doctor if you are not sure about your personal case!

Important: All of these situations only apply when someone has extra weight to lose. It can be dangerous to restrict your eating too much to hit a given weight. In this chapter, we're referring to runners who have a few pounds more than they should - not runners who are already at a healthy weight.

In addition to weight/mass, age also influences your running times. For example, if your Critical Power is 3.8 watts / kg, it makes a big difference in competitions whether you are 32 years old or 72 years old. As a 32-year-old, a Critical Power of 3.8 watts / kg is an excellent value, but you won't find yourself at the top of performers for your age. However, if you're 72 years old and are still running at 3.8 watts / kg, you will find yourself alongside the very best in your age.

Hans and Ron made a nice overview of the levels per age category for women and men.

Train in your zones

Where are you?

Earlier, we wrote about 5 different zones. We'll discuss this in more detail in this chapter. Some watches work with D0, D1, D2, D3 and AT+, with AT+ corresponding to your Critical Power or tipping point. Other watches keep zones Z1, Z2, Z3, Z4 and Z5. Stryd also works with 5 zones: Easy, Moderate, Threshold, Interval, and Repetition..

The zones are similar, but not completely interchangeable. For example, Stryd works with two zones above Critical Power, while heart rate watches only have one zone after the tipping point.

How do you use the zones in your training?

Variation is the magic word if you want to make progress. The main reason why you want to know your different zones is because of the two fuels you carry with you: fats and sugars. We've already described the different fuels in detail earlier. As you know, as an endurance athlete, you mainly use fats and glycogen. You use your fat stores when you run slowly, and glycogen becomes your main fuel when you run faster. Variation in training between your fuels makes you faster and provides a good basis to work from.

Variation is needed to use your fats efficiently as fuel and to maximize your glycogen stores. You need a good mix between gentle training and intensive stimuli, combined with good recovery.

After all, you don't get better during training, but during the recovery afterwards.

You can teach your body to run faster on your fats, partly by running slow and long. Note: this is your Zone 1 (or D0) on a heart rate monitor, and the Easy zone in Stryd.

This zone is variable in running intensity. If you make progress, you can run faster on your fats and thus your pace will increase. You see this when you train with heart rate: you run faster at the same heart rate. This is fully reflected when you run by power: your capabilities in this lowest zone go up.

Gentle workouts are good for the basics. If you train more intensively, you will enter an important zone where your body can choose which fuel to use: fats or glycogen. This zone lasts from Easy to Critical Power.

Which fuel your body prefers in this zone depends, among other things, on stress and nutrition. Do you have a lot of stress and do you eat a lot of sugar and carbohydrates? Then your body prefers glycogen combustion. In addition to stress and nutrition, your running training is of course also a trigger for fat or glycogen burning.

Above Critical Power, you mainly burn your glycogen while your fat burning plays a smaller part. With Stryd, the two zones between Easy and Critical Power are called Moderate and Threshold. The slower you run, the more your body can rely on your fat stores. There's a lot to be gained there with targeted training in the various zones. You get to know your body and you learn which zones you've barely trained at the moment. Especially in the beginning, runners often notice that they have a strong preference for one zone over others.

So either fast or very calm.

Are you a runner who sees a training session (or would you rather call it a run?) as a good moment to catch up with a friend? Then there is a good chance that you have a great base in the low zones, but that you have to get used to more intensive training.

Or do you think that training doesn't make sense if you don't sweat a lot and have muscle pain? There's a good chance that you'll improve a lot if you also include slow training ses-

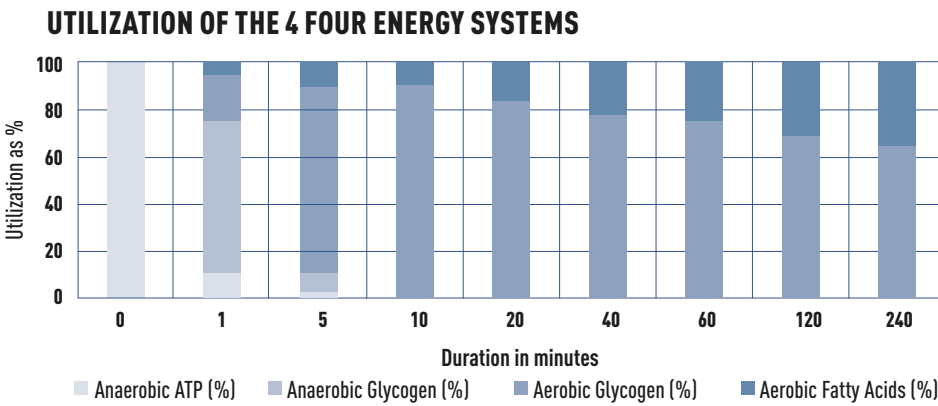


Figure 5: 4 Energy Systems

sions. Training at a slow pace is not a waste of time.

Actually, it's meaningful training which helps build a solid foundation.

Figure 5 shows which fuel is most useful to you in percentage terms at maximum effort. You can see that, starting from 5 minutes, your glycogen and your fatty acids are the main fuels used. In this figure, we make the assumption that you run as fast as possible. If you run slower, you will use more fatty acids, proportionally. Smart variation in intensity and duration of your workouts ensures that all energy systems are trained. Note: through smart training and healthy nutrition you can train your body to run more efficiently on your fatty acids.

In the chapter What is Critical Power and what can you do with it?, we discussed the Power Duration Curve.

This curve is a great way to check whether you train with enough variation, and whether you're engaging all energy systems during your training sessions.

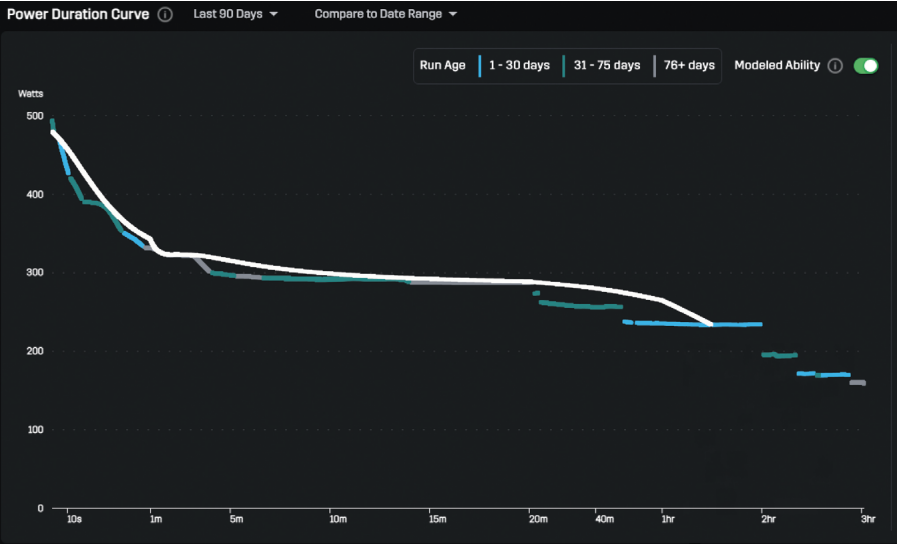
In the curve in your Stryd app, you can see your maximum power from 10 seconds to roughly 3 hours (depending on how long you run) from the past ninety days. To get a nice, personal graph, it's good to sprint at least once for 10 seconds, preferably also uphill or against the wind. And to run a long endurance run at a good pace. The curve also shows whether you've run this wattage in the past 30 days, whether it was between 31 days and 75 days, or more than 76 days. Anything older than 90 days is not taken into consideration.

How does the curve help to check if you have enough variation in your training?

If the Power Duration Curve is a smooth line for the past ninety days, then you know that you've trained with plenty of variation. However, if you see that your line is discontinuous and drops at certain times, then there is an opportunity for improvement.

In this example you can compare your true power duration curve with the modeled curve (white), which is an estimate for the power you are capable of at all durations, even if you have not produced power data at all durations. Based on this curve, the runner can target specific areas of their curve to improve. For example, they could perform a max effort 3 minute activity and a max effort 10 minute activity, two durations which will help improve the overall accuracy of your Critical Power.

POWER DURATION CURVE



(Image 3 again: Power Duration Curve)

The power of intervals

A solid foundation of base training helps you achieve a higher base speed. If your base is good and you've already trained a lot in your different zones, then intervals are a good way to become even faster. Targeted interval training is simpler and more precise with power, compared to heart rate interval training.

By training with intervals you can train at a high intensity. This improves your base speed and your body gets used to excess lactic acid. Because of the rest in between the intervals, these types of workouts are not as stressful as a race, and you can do this kind of training more often. Depending on the goal, the length of the intervals and the intermediate rest varies from one training plan to another. The intensity with which you run intervals also varies. Some intervals are almost full speed, other intervals you go fast, but still somewhat with the brakes on.

How do you know which pace and which distance is most suitable for your intervals?

Books have been written about the ideal distances and paces for intervals. It's a delicate job to determine exactly which pace is most suitable for your 200 meters, your 400 meters, your 600 meters, etc. If you've already calculated at what pace (your heart rate monitor will not help you on short distances anyway) you have to run a 200 meter distance, it will still take you several weeks (or months) before you know exactly what is the best

pace for you. As described earlier, your GPS is also not very useful during targeted, short intervals.

INTERVAL DISTANCE	PERCENTAGE OF CP60
[m]	[%]
2000	100%
1600	102%
1200	104%
1000	107%
800	109%
600	114%
400	120%
200	126%
100	133%

Figure 6: Power Target for Interval Training

However, with Stryd it becomes really easy to do your intervals. Because Stryd immediately measures what you're doing, you can check after 10 meters on a 200 meter sprint whether you are on track or not. Because - we repeat - power is the amount of energy per second that your body needs to push

your mass in the given direction. This applies to a marathon, a half marathon, but also for a 400 meter or 200 meter interval.

And now it gets interesting for runners who want to run faster and are willing to train hard in a targeted manner.

In the table you can see at what percentage of your Critical Power you should target for specific intervals.

So, for example, if your Critical Power is 257 watts, then your ideal power for an interval of 400 meters is 308 watts ($257 * 120\%$).

The fact that you see the percentages increase considerably at short interval distances is because your anaerobic energy systems supply extra energy there. Your anaerobic fuel supply is limited. You will benefit from a 100 meter or a 200 meter interval, but this benefit is lost at 1000 meters.

Experience. In 2019 I (KdJ) trained for the Amsterdam marathon. Since I really wanted to run the marathon in under 3 hours, I left nothing to chance. So, I started to pay attention to my technique, I lost some weight, and I started training my intervals more specifically. After some calculations and consultation, I had determined my ideal pace for 400 meters. After that, it took a few weeks before I could run my 400 meters in 87 seconds. I was used to running by heart rate and had never done interval training before. It took some getting used to. When I started running with Stryd, one of the first things I tested was interval training. According to Stryd, I was able to run 308 watts during my 400 meter intervals. After a warm up, I walked to the starting line of the athletics track and started at a brisk pace. Still in the first bend, I couldn't resist checking my watch to see what power I was running: 308 watts?! For the entire 400 meters my power fluctuated between 305 and 311 watts and I was flabbergasted when I saw that I had run exactly 87 seconds. Then I started training using 200 meter (323 watts) and 1000 meter (274 watts) intervals (because I hadn't done those distances before). It was a revelation. The quality of my training improved immensely and it was all very simple. Much easier than figuring out with what pace or heart rate to run.

Do you know if you're already close to your maximum potential, or if there's still a lot of progress to be made at your favorite distance? In the next chapter, we'll look at how Stryd can help you estimate your potential personal bests at the 5K, 10K, Half Marathon, and Full Marathon.

Know your capabilities

As a runner, it's interesting to know what your potential PR is for a certain distance. Even if a personal best isn't your main reason for running, it's still nice to make progress and know what time you can run for a certain distance. Based on your PR for one distance, 5 kilometers for example, you can find calculation models on the Internet where your potential times are calculated for other distances. There are reliable calculation models to determine your potential for the 10K, half marathon, and marathon based on your PR for the 5K. However, this is only true if you ran the 5K under ideal conditions (8 degrees Celsius (46 degrees Fahrenheit), hardly any wind, no elevation, and your lowest healthy weight).

ACHIEVABLE TIMES BY DISTANCE BASED ON CP60 AND VO₂ MAX

CP60		ACHIEVABLE RESULT					VO ₂ MAX
watt/kg	3000 m	5000 m	10.000 m	21,1 km	42,195 km	Distance for one hour	ml/kg/min
2.00	0:23:16	0:40:12	1:24:24	3:07:38	6:33:51	7.27	28.0
2.25	0:20:36	0:35:34	1:14:41	2:46:02	5:48:32	8.15	31.5
2.50	0:18:27	0:31:53	1:06:55	2:28:47	5:12:19	9.03	35.0
2.75	0:16:43	0:28:53	1:00:39	2:14:50	4:43:03	9.90	38.5
3.00	0:15:14	0:26:19	0:55:15	2:02:51	4:17:53	10.80	42.0
3.25	0:14:05	0:24:20	0:51:06	1:53:36	3:58:27	11.62	45.5
3.50	0:13:04	0:22:34	0:47:23	1:45:20	3:41:06	12.47	49.0
3.75	0:12:12	0:21:04	0:44:13	1:38:19	3:26:23	13.30	52.4
4.00	0:11:26	0:19:45	0:41:27	1:32:09	3:13:26	14.13	55.9
4.25	0:10:46	0:18:35	0:39:01	1:26:45	3:02:06	14.95	59.4
4.50	0:10:10	0:17:34	0:36:53	1:21:59	2:52:06	15.76	62.9
4.75	0:09:39	0:16:40	0:34:58	1:17:45	2:43:13	16.56	66.4
5.00	0:09:11	0:15:52	0:33:18	1:14:01	2:35:23	17.34	69.9
5.25	0:08:46	0:15:08	0:31:46	1:10:37	2:28:14	18.12	73.4
5.50	0:08:23	0:14:29	0:30:24	1:07:35	2:21:52	18.88	76.9
5.75	0:08:02	0:13:53	0:29:08	1:04:47	2:16:00	19.64	80.4
6.00	0:07:43	0:13:20	0:28:01	1:02:16	2:10:43	20.38	83.9
6.25	0:07:26	0:12:51	0:26:58	0:59:56	2:05:49	21.12	87.4
6.50	0:07:10	0:12:23	0:26:01	0:57:50	2:02:23	21.84	90.9

Image 4 (second time): What times are achievable?

Then the comparison is only valid while these variables remain the same. In practice, this is almost never the case. Temperature and wind, for example, are highly variable, which makes it difficult to compare one event with another.

Good news for runners with a Stryd power meter: determining your potential time at different distances is more accurate and easier than ever. Even temperature, elevation, and wind are included.

First, we go back to your Critical Power.

With an accurate Critical Power you can determine which times you can run at different distances. Below, we first take a look at the schedule from Ron and Hans, as we saw earlier in the chapter about weight (mass) and times. In the overview, you can see your possible times at 3K, 5K, 10K, 15K, half marathon, and full marathon per watt / kg. The times naturally take into account a decline at longer distances. You may be relatively better at 5 kilometers, or on longer distances, such as a half or full marathon. Some people notice that the times aren't quite right for them, but the predicted finish times based on your watts / kg can be a good target time, and for most runners the formula works well.

Although these times are a nice guideline, Ron and Hans can't include everything in this overview. For example: temperature. 8 degrees Celsius (49 F) is an ideal temperature for top runners in a marathon, but what should you do if it's not 8 degrees Celsius (46 F) during your event, but 21 degrees Celsius (70 F), for example? We all know someone who, even after a good preparation, didn't reach their desired finish time due to the heat. Their training went well, their nutrition was tested, their recovery was fine, there were plenty of drinking stations on the way, but the weather threw a wrench into the works. Because, if you train at different temperatures than your event, you will have some issues during the race. You run the planned pace for the first half of your half or full marathon, and it feels fine. But once you've passed halfway, it turns out that you've started too fast, because the higher temperature makes it harder than expected.

Stryd has found a solution for that.

Once, I sat at the kitchen table with three running friends and showed them how Stryd's race calculator adjusts your race power to temperature, altitude, and humidity. They were flabbergasted. A week later everyone had bought a Stryd. Below you'll see an example.

I let my Stryd know that I want to run a half marathon. Based on my Critical Power, Stryd calculates my race power and my expected finish time:

So, I can run a half marathon with 265 watts and my expected finish time will be 1:22:23. Stryd says that it can turn out 2 minutes faster or slower. For people who already run by power, the fact that I can walk so fast with “only” 265 watts is because I weigh “only” 59 kg (130 lbs).

Please note: it’s of course not about the distance or the time, those are interchangeable.

Now for the interesting part.

Because, if I indicate that during my half marathon it’s 21 degrees Celsius (70 F), and not 8 degrees Celsius (46 F), I get a different value. I should not run at 265 watts, but at 259 watts.

Of course, my expected finish time becomes a bit slower. Instead of 1:22:23, the predicted time is now 1:24:32.

Additionally, if it’s only 21 degrees Celsius (70 F) instead of the ideal 8 degrees Celsius (46 F), and if there are also some hills and an elevation of 230 meters, I have to adjust my power a little more. I won’t run 259 watts, but 257 watts on my half marathon.

The race course altitude also ensures that my expected end time drops from 1:24:32 to 1:25:20.

This knowledge could have prevented many breakdowns for many people at events. If you know in advance, based on your training: the distance, the surface, the temperature, the height difference, and the humidity, then you’ll know what performance you can reasonably expect on race day. And that is, of course, extremely valuable (and fun).

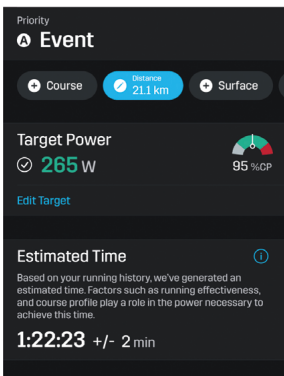


Figure 7

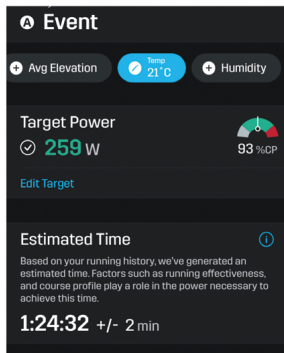


Figure 8

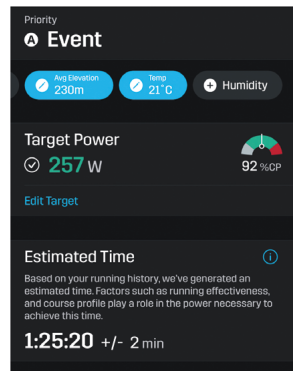


Figure 9

Summary Part II

To improve your personal record, if you have extra weight to lose and you do so healthily, 1% healthy weight loss makes your times 1% faster. Note: If you suffer from eating disorders, or other health complications, it's not a good idea to emphasize weight loss. Always consult with your doctor first.

Variation is the keyword in your training sessions: train in different zones.

Exercising slowly makes you faster.

Your fat stores are your largest energy source: learn to use it optimally.

Training intervals by power works better than training intervals by heart rate.

To predict what's possible for your 5K, 10K, half and full marathon, Stryd helps by analyzing the temperature and altitude difference for the specific course on race day.

On your way to your PR

You can translate any training training plan from pace or heart rate to power.

What's not a good idea, however, is to combine training plans without consultation. Each plan has a balance between intensive training and easy training. Periods of long runs and periods of fast runs. Without a long term view and without knowing the philosophy behind a plan, it's not wise to combine two training plans on your own.

In the last part of this book we give tips per goal distance for how to train in a targeted manner. If you've picked a training plan from the Internet, or if you have training plans from a coach, it's always good to consult with your coach, when in doubt. Normally, you can fit the tips in this chapter into your own training schedule. Of course, you can also use Stryd's own training plans.

There are many different schemes and streams in training theory. To check whether a training plan works well for you, it's good to set a concrete goal and check whether you're making progress. We recommend accelerating once a month at a distance of 3 to 5 kilometers, if your body allows it. Does your Critical Power increase? Then you're doing well. Or, if you find that your workouts feel better on your half or full marathon wattage, that's a good sign, too.

If you're a relatively novice runner (you've been running for less than 3 years), you'll notice that progression affects all your distances. Are you training for a half marathon? Then it may well be that you also improve your times on the 5K and 10K. But if you've been running for a bit longer, then targeted training for one distance is important. Because your basic speed is probably already so high that specific training is needed.

Your paces for a half or full marathon are very different from your paces for a 5K or 10K distance.

In your training plan, a good mix of tempo workouts on your race pace, alternated with intervals and gentle workouts, is a good starting point.

The training plans in Stryd's app have been developed based on plans from professional, respectable coaches. You'll immediately notice that the plans are not expressed in kilometers, but in time. The reason for this is simple: the duration of your training is decisive for your muscles, tendons, ligaments, and joints. If a training schedule is expressed in kilometers, then a workout of, for example, 10 kilometers is only 45 minutes for a fast runner, but for a novice runner with less aptitude, a workout of 10 kilometers requires more than one hour. To get someone with less experience to run longer than someone with a lot of experience - that

would be strange. This “problem” can easily be solved by not giving runners a distance to train, but a duration. This way, 45 minutes is 45 minutes for everyone.

It’s good to regularly train at your race pace during your training sessions, so you can get a feel for this pace for your race day.

How do you determine your race pace?

One of the things that makes Stryd so special, is the race power we wrote about earlier.

In the app, you can enter the distance, and even the course you want to run, under the tab upcoming events. Once you’ve entered this, you immediately see the level of power at which you can run during the race. This is priceless. Headwind, uphill, temperature changes - with Stryd it doesn’t matter. Your plan remains intact, because you know exactly what power level you can run at and that’s always correct. An additional advantage is that you can train at race pace during your training. So whether you train for a PR at 5K, 10K, a half marathon or a full marathon, you know exactly what your competitive ability is and you can train these capabilities in your sessions, get used to them, and experience progression. Your race power will automatically increase as your Critical Power increases. You don’t have to do anything special for that. No complicated formulas or calculations, Stryd calculates it for you and you can start training again. It’s very exciting to see so clearly that your training is paying off.

Don’t have Critical Power yet?

Go to Event in your Summary in the Stryd app. There, you can choose Intro to power instead of a distance. If you click on that, you’ll get a workout that you can do to quickly and reliably determine your Critical Power.

In the next chapter, we’ll describe the experiences of runners who’ve improved their personal bests by training with power in a targeted manner. You can’t activate the training plans in Stryd itself, until you have your Critical Power.

Training for your 5K PR

The 5K is a beautiful distance.

Portrait: Anna P. (42) works for a major shoe brand and is the mother of two children. After her second baby, she didn't exercise much for three years. Little sleep, little time, no energy. Because Anna continued to eat chocolate and desserts, she never lost her pregnancy kilos. Three years after her second baby, she weighed 6 kilos (13 lbs) more than before her pregnancies. One day she decided: I want to lose some weight and I want to get fit again. She got herself a good pair of running shoes and ran 2 or 3 times a week. Her motivation was great, and her discipline did the rest: she quickly lost three kilos (6.5 lbs) and built up her distances from 1 kilometer to 5 kilometers. She'll never forget the day she ran her first 5K race. Her children, her husband, and her mother were at the finish line, and the medal - in the shape of a gold 5 - hangs in the hall among the photos of her family. The local newspaper posted the results and times of all runners. She was proud that at 31:37 she left four more participants behind her. Her new goal: to run 5 kilometers in under half an hour. Then, running became a struggle. She used to get better almost weekly and noticed that the improvement was easy to achieve. But now, she's been stuck on the same level. Her weight remained the same, and so did her pace. A friend recommended trying Stryd.

"Are you crazy, that's for you, because you run marathons. That's nothing for a snail like me," she said.

"The device just looks at your current level and then gives you tips to get better. It doesn't matter whether you train for a 5K within half an hour or whether you want to qualify for the Olympics."

Her frustration that she was no longer improving outweighed her hesitation to run with a power meter, so she tried it. Her power meter quickly taught her two things: she never ran slower than her favorite pace, and she never ran faster than her comfortable speed. Because of Stryd, she started combining easy workouts (which she did in the dark because she was embarrassed of her snail pace) with more intensive intervals. She had to run wattages she didn't think she could, but encouraged by Stryd's personal training plan, she gave it a try anyway. And it worked. She still ran 2 or 3 times a week, but due to the variation in pace,

she was now improving rapidly. She ran her second 5 kilometer race in 27:38: an improvement of 4 minutes!

Want to try for yourself?

With Stryd you can go to Events in the main menu. There, you can enter 5 kilometers. Next, enter the date of your event and how many training sessions you want to do per week. Stryd also asks which day you have the most time, on that day you will get your longest training in the plan.

Choose high volume or low volume, and your workouts are automatically added to your training calendar.

Two workouts are always a lot fun to do:

1. Do a monthly “Critical Power boost training.” That is, a 3,000-meter training session. This way, you’ll test whether your critical power has increased.
2. Run a block of at least 12 minutes every week on the wattage of your 5 kilometers. This way, you get used to this ability and you can check whether it feels good.

Training for your 10K PR

10 kilometers is the distance most often run in competition. Setting a PR for 10K is a delicate task. It's a complex balance between starting fast enough and conserving your energy. Many runners tend to start a 10K too slowly, but it's safe to say that if you can still accelerate after 6 kilometers, you've gone out too easy.

Running by power offers a solution. With your power meter, you won't start too fast or too slow. Using Stryd for the first time, Koen set a new 10 kilometer PR. That's when he realized: Running by power is fascinating, more people should know about this!

Koen: My heart rate threshold is 192. Normally, I based my training by heart rate, and in competitions, I ran at the heart rate that matched that distance. I can run 10 kilometers at my heart rate threshold, so normally, I would start strong, go to my threshold and check occasionally to be sure it was below 192. This time, however, I didn't run by heart rate, but by power. My Critical Power is 270 watts. So, I have to run the whole 10K at or slightly above 270 watts. At 7 kilometers, Stryd began to make the difference for a new PR. Running at my Critical Power, I started to struggle and checked my watch. On my watch (which was paired with Stryd), I saw my power: 262 watts. And I thought: I have to stay above 270 watts. It was tough to do, but it worked. At that moment, if I had not run with power, and had only seen my heart rate, I certainly would not have been motivated to go a little faster. My heart rate was 193 at a pace of 3:58 min / km (5:45 min / mi). Normally, I would never accelerate. I would have thought: ouch, I'm going too fast. But Stryd knew exactly how fast I could really go. That surprised me. The first kilometers also offered Stryd an advantage over my heart rate. After 2 kilometers, I checked my watch, and I was running at 295 watts: 25 watts above Critical Power. I knew that this was a bit too enthusiastic. In the overview on Strava, however, I could see that my heart rate was still at 178, which was 14 beats below my threshold. So, the advantage of running by power is especially valuable on race days: heart rate responds a bit slower, and it matters. The day after my PR, I spoke with an enthusiastic running coach.

"Aren't you over 40?" he asks a bit suspiciously.

"Yes, I'm turning 41 this month, why?" I ask.

"How can you still run PRs?" He sounds a little jealous.

But yes, that's the advantage for many runners who start running later in life. I've only been running seriously for five years, and with the accumulated running history and the knowledge of my body, I can improve for years to come.

Want to try for yourself?

In the Stryd app, you can go to Events in the main menu. In the PowerCenter on Stryd's website, you will find Events under Tools. There, you can enter 10 kilometers. Next, enter the date of your event and how many training sessions you want to do per week. Stryd also asks which day you would like to do your longest run in the scheduled plan.

Choose high volume or low volume, and your workouts are automatically added to your training calendar.

These two workouts are always a lot of fun to do:

1. Monthly Critical Power Maintenance Workout

This workout targets a 3 to 5 kilometer all out effort to help calibrate your Stryd Auto-Calculated Critical Power. This way, you can test if your Critical Power is improving.

2. Interval Training Workout

This workout starts with a 15 minute warm up, then is 5 x 4:00 starting below your Stryd Auto-Calculated Critical Power and progressing to or slightly above your Stryd Auto-Calculated Critical Power (95%-102% of your CP). Your recovery in between each repeat is 2:00 at an easy effort (50-70% of your CP). After your last repeat, run an easy cool down.

Training for your half-marathon PR

A half marathon is a popular distance among avid runners. It's the distance where you can really push your limits, and you still feel good for days after your intensive performance.

Jane S. (48) has been running since she was 12. From her 12th to her 41st birthday, she ran continuously. If she didn't run for a week, she would get cranky. At that point, her husband would suggest that she might go for a quick run. However, at the age of 41, her world fell apart. She had been diagnosed with breast cancer. She overcame the disease with heavy operations, a lot of chemotherapy, and a good dose of willpower. At the age of 44, she set a goal: a half marathon. In her mind, finishing a half marathon was a definitive statement of health. She started training, but it was hard. She was used to fatigue, but not the kind of fatigue she felt after interval training. And she often had odd aches and pains. The fatigue and aches sparked fear and had her question herself. Am I still sick? Am I sick again?

After each check-up, her doctors assured her that she was healthy and that her condition was superb, given her circumstances.

She did an exercise test and started training with a heart rate monitor. That helped. Her pace went steadily from 5:30 min / km (8:30 min / mi) to under 5:00 min / km (8:00 min / mi). It wasn't quite the level she had hoped to achieve, but there was still progression. Then, she injured her knee and had to rest for a month. Jane had hoped to complete her half marathon after six months, but she'd been training for more than six months now, and she felt she hadn't made much headway. Then, one day her old coach asked to go for a run on the track with her. After a month of rest, her coach noticed that Jane was running at a lower step frequency than before. She ran 400 meters with a step frequency of 165 steps per minute. According to her coach, this should be at least 180 steps per minute. It felt awkward for Jane, and the coach suggested testing it with a Stryd meter. At which step frequency does she run the most economically? That was the question. It soon became clear that Jane benefited from a higher step frequency, and she started to learn more about

her Critical Power. As it turned out, Jane had lost her natural technique after surgery and a long break. Tension from her neck and back radiated downward, and her left groin and left calf were also under high tension. Unconsciously, her body tried to correct that, and one of its “solutions” was a lower step frequency. Her new (mediocre) technique, however, combined with her old pace caused a serious injury. After rest and treatment of her back and groin, she could train freely again. She trained in a variety of ways and didn’t pick up her pace until her Critical Power had increased. 14 months after her resolve to run a half marathon, she went for it. With a time of 1:42:46 she declared herself fit and healthy.

Want to try for yourself?

With Stryd you can go to Events in the main menu of the app. There, you can enter a half marathon. Next, enter the date of your event and the number of training sessions you want to do each week. Stryd also asks which day you would like to perform your longest run in the training plan.

Choose high volume or low volume and your workouts are automatically added to your training calendar.

Examples of power-based workouts that make training enjoyable:

1. Monthly Critical Power Maintenance Workout

This workout targets a 3 to 5 kilometer all out effort to help calibrate your Stryd Auto-Calculated Critical Power. This way, you can test if your Critical Power is improving.

2. Monthly Critical Power Maintenance Workout

This workout is an easy warm up with two sections of quality running. Your first quality section will be 20:00 at 88-95% of your Stryd Auto-Calculated Critical Power. You should aim to start the 20:00 between 88-90% and progress up to 95% by the end of the duration. After an easy 3:00 recovery you’ll have a 10:00 section at the same power target, 88-95% of your Stryd Auto-Calculated Critical Power. The aim of this workout is to practice running at a steady submaximal effort for an extended duration. After the 10:00 section, run an easy cool down.

Training for your marathon PR

Covering 26.2 miles is the holy grail for many runners. A common question that marathon runners are asked is, what is your best time? And moments after crossing the line of your first marathon, you find yourself signing up for another one with the goal of running even faster. This was where 52 year-old Rick S. found himself.

After an injury at the age of 35, Rick retired from soccer and picked up running. He expanded his training and became more and more enthusiastic about what he was capable of. As a soccer player, he didn't like long distance running, but slowly, he became a fanatic. On Strava, he tracked all of his workouts and joined a running group. He started gaining mileage and getting faster. His trainer suggested running a marathon the year he turned 50. The age where the decline tends to become noticeable motivated Rick to prove otherwise. I'm still young and in the prime of my life. With a heart rate monitor and a focused plan, he ran the marathon in 4:08. Soon, Rick began to crunch the numbers. A marathon on flat terrain in October would give the opportunity to run under four hours. Moreover, Rick was able to lose 3 kilos, so a new project was born: a sub 4 marathon. Ignited by an enthusiastic user of Stryd in his running group, Rick also started running by power. He trained and lost weight and he set his eyes on his new running goal.

Rick decided to go for his second marathon in Amsterdam. The day before the marathon, he headed to the expo to pick up his racing bib. While there, he saw Ron and Robijn at the Stryd exhibit. Rick talked passionately about his first marathon and the preparation he was taking for his second. His plan was to start out at 5:40 min / km (9:07 min / mi), which would lead him to running just under four hours. He was confident that his training set him up for the race day he had been dreaming of. Robijn asked why Rick wasn't planning to race by power. He was already training with power, so why not incorporate it into his race day plan? That was when Robijn showed Rick Stryd's Race Power Calculator. This tool calculated his ideal power target to aim for over the course of his marathon. Rick decided to give it a go and stuck with it throughout the race.

After the marathon, Rick had exciting news to share. Not only did he break the four hour barrier,

but Rick ended up running 3:48! That is twelve minutes faster than his goal heading into the race. This is a common success story of runners racing by power. Runners often vision their dream finishing time and train just enough to reach them. But, what if the goals that runners set for themselves are just at the cusp of their true capabilities? Running by power helps you reach your peak fitness and then go beyond what you thought you were capable of. At the age of 52, Rick is setting new personal bests in his half and full marathons and his PR journey has just begun!

What if you wake up on race morning and the wind is howling? You will need to adapt your race plan. But how do you adapt your plan at a moment's notice? The answer is Stryd. Stryd reports the extra power required to overcome air resistance. You will know how much power you need to run into a headwind, the power saved when running with a tailwind, and the power saved when drafting off a pack of runners. Stryd gives runners the ability to turn the wind into a measurable and performance enhancing force. All you have to do is stick to your power target. If you ignore power and solely focus on pace, you'll end up hitting the wall, and from that moment on, you'll lose a minute per kilometer.

Ready to get started?

When you are ready, head to the Stryd Mobile app and pick your goal race distance, the date of your race, and enter how much time you have per week to commit to your training. Stryd will also ask which day works best for you to get your longest run in for the week. Continue to the next screen and you will be presented many training plans personalized to fit your training and racing needs.

Choose one of our high volume or low volume plans and your workouts will automatically be added to your Stryd calendar.

Examples of power-based workouts that make training enjoyable:

1. Monthly Critical Power Maintenance Workout

-20 minutes comfortably hard + 30 seconds very hard

This workout targets a 20 minute tempo and a 30 second all out effort to help calibrate your Stryd Auto-Calculated Critical Power and keep your power training zones up to date.

2. Endurance-boosting Workouts

-3 miles 85% of CP, 2 miles at 90% of CP, 1 mile at 95% of CP

This progression workout is designed to build your aerobic capacity to power through to the end of your next race.

Are you currently following your own training plan, but interested in running by power? Any training plan can easily be converted into a plan backed by running power. Hans and Ron explain how.

Let's say, for example, your training plan schedules a 10 kilometer run at your race pace. You weigh 70 kg and run 10 km in 50:00. Your training prescribes you to run at a pace of 5:00 min / km (8:02 min / mi). Over 1000 meters (1 km), that is 300 seconds (5:00), so $1000/300 = 3.33$ meters / second.

The wattage (power) with which you have to run is $3.33 \text{ m / s} * 1.04 * 70 \text{ kg} = 242 \text{ Watt}$.

Another example workout could be that your plan schedules you to run 400 meters in 28 seconds per 100 meters.

You then run $100/28 = 3.57 \text{ m / s}$. Your corresponding wattage is $3.57 \text{ m / s} * 1.04 * 70 \text{ kg} = 260 \text{ Watt}$.

As you can see, any training session can be easily converted into a plan based on running power. Whether you have an endurance run, blocks, or intervals over a certain distance or duration, you can calculate the wattage you need to aim for in all training scenarios.

You can import each of these training sessions directly on your watch for real-time guidance.

DO YOU TRAIN BY THE STANS VAN DER POEL 14 KILOMETER PLAN?

You can convert Stans van der Poel's famous 14 kilometer training schedule into a plan based on running power within seconds.

A few years back, one of us (KdJ) wrote a book together with Stans van der Poel - The Running Revolution - in which you train no more than 10 kilometers for a half marathon and no more than 14 kilometers for a full marathon. At first, the training plan was received with skepticism, and experienced runners thought it was ridiculous. But after testing by a Runner's World and De Volkskrant journalist, the prevailing feeling about the plan shifted. Running a marathon with a maximum training distance of only 14 kilometers is possible. Originally, runners believed that running a marathon off of this type of training was possible but that a fast finishing time was out of reach. This all changed when Koen ran the Amsterdam marathon in under three hours while training by Stans van der Poel's plan. Now, the 14 kilometer training plan of Stans van der Poel has become a household name in the Netherlands. Runners who followed the plan found that while you train fewer kilometers, it's not an easy schedule or a quick fix for bucket list runners. Because, the big secret of the scheme is marathon heart rate. You train fewer kilometers, but you train more in your marathon heart rate zone. Stans van der Poel explains how you can determine your goal marathon heart rate and schedules your training accordingly. Half of your training is done at race pace. The plan is therefore milder for slow runners than for fast runners.

While Stryd's training is quite different from Stas van der Poel's training approach, you can still incorporate running power into these plans. Running power compliments Stans van der Poel plans perfectly to help you reach peak fitness come race day. Instead of doing your training at your marathon heart rate, you can easily do the training by your marathon power. You can find your goal marathon power by heading to the Stryd Mobile app and adding an upcoming event. Stryd will calculate your marathon race power which you can then supplement into your current training plan.

Afterword

We've worked on the book *Running Power: The Fastest Way to Your Next Personal Best* with great pleasure and dedication. Normally, a book goes to the printer after completion, and as a writer you can no longer do anything about it. This book is different. It's readily available online to millions of readers, and at the same time, it's been sent to the printer for a limited edition. In the coming months and years, hundreds of thousands of experiences will be added from runners who train based on power. Of course, new experiences will raise new questions and provide new insights. We'll do everything we can to continue to monitor these developments and continue to test and write about the new developments. Stryd will undoubtedly also provide updates that are worth investigating. And when a new power meter comes onto the market, Hans and Ron will be the first to test and compare it.

This afterword is not a word of thanks or a conclusion. It's the continuation of a great adventure that will last for years to come. An adventure where running through the woods with mud on your calves and your head in the wind meets scientific analysis and smart equipment to analyze your workouts.

And if, after reading this book, you want to know more about power and the secrets of running, you can continue by reading the other books by Hans and Ron. The book *The Secret of Running* is available in print and as an e-book in the Netherlands and is for sale in several languages. We look forward to great events, fast times, and a lot of satisfaction.

To be continued.

Hans van Dijk
Ron van Megen
Koen de Jong

Good luck
with your
training and
we wish you
many personal
bests to come!



Hans van Dijk (1954) is emeritus professor and (together with Ron van Megen) author of *The Secret of Running*. He has been running since 1980 and has impressive PRs: for example, 31:55 on the 10 km and 2:34:15 on the marathon. Hans is a walking encyclopedia and loves complicated formulas. Yet he can simplify complex concepts so that all can easily understand.



Ron van Megen (1957) studied Civil Engineering at the Technical University of Delft, just like Hans. Ron runs a bit slower than Hans with 39:30 on the 10 km and 3:24:54 on the marathon but when it comes to organizing, looking for partnerships and forging new plans, Ron is in the lead.



Koen de Jong (1979) is co-owner of sportrusten.nl and prorun.nl. He has written several books about running and respiration. His work has been translated into more than 8 languages and his marathon PR is in between that of Hans and Ron.



THE FASTEST WAY TO YOUR NEXT PERSONAL BEST:

RUNNING POWER

Hans van Dijk and Ron van Megen have been fans of running by power for years. They're internationally known for their books on this subject. Originally, Koen de Jong thought running by power and the books by Hans and Ron were too complicated, and didn't want to know anything about it. Now Koen is the biggest fan.

Running by power has taken off in recent years as more and more runners are opting for training plans based on power instead of training plans based on heart rate or pace. In this book, Hans, Ron, and Koen explain the benefits of running by power. And most importantly: they explain that running by power is very simple and how it incorporates into any training plan.

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