

1. The breakthrough of power meters in running

In our book *The Secret of Running* (www.thesecretofrunning.com) we have derived the theory of running power and our running model. Summarized we can state that the power P of your human engine should be equal to the sum of the power required to overcome the running resistance P_r , the air-resistance P_a and the climbing resistance P_c , as shown in the figure.

$$P = P_r + P_a + P_c$$

The Running Model

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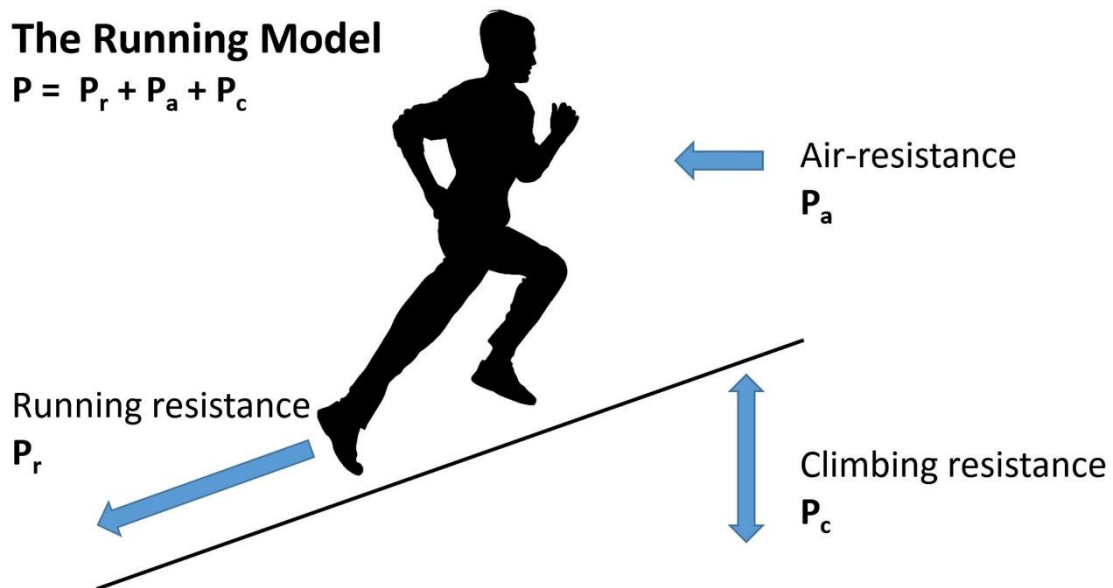


Figure: The Running Model

In a series of papers we will discuss how you can measure your running power in practice. Recently, the first power meters for running were developed. This means that you now have the possibility to measure your running power in real-time, each and every day! Using these data you can start to optimize your daily training and your races. Also, it is now finally possible to quantitatively determine your Running Economy, as we will show in a later paper. So you can now really start to optimize your RE, by changing your running form and evaluating the impact on the energy cost of your running.

We have described our experiences with power meters in 12 papers:

1. The breakthrough of power meters in running
2. How good and reliable are power meters?
3. The running economy (RE) of 14 test runners
4. The energy cost of running (ECR) of 14 test runners
5. The metabolic efficiency (ME) of 14 test runners
6. Measure and improve your Running Economy!
7. How to measure and improve your ECR
8. Determine your Functional Threshold Power (FTP) and your training zones.
9. Why should you train with a power meter?
10. Why should you race with a power meter?
11. Tips and tricks
12. Laboratory testing

The experiences in cycling

Power meters are well-known and used in cycling. A famous example is Chris Froome, who cycles the major climbs of the Tour de France based on the readings of his power meter. He does not try to follow Alberto Contador in his breakaways, but pushes exactly the amount of Watts that he knows he can maintain. The widespread use of power meters is not limited to the professional cyclists. Also performance-oriented national or regional cyclists and even cycling tourists use them nowadays, as it helps them to optimize their training and their races.

In cycling, the measuring principle of the power meter is based on strain gauges to determine the force **F**, delivered to the crank shaft. This force multiplied by the speed **v**, results in the power output **P = F*v**.

Both in theory and in practice, a very strong relation is found between the power output and the performance in cycling. In our book *The Secret of Cycling* (www.thesecretofcycling.com) we have shown that on a flat course the performance is determined by the total power output **P** (in Watt). Contrary, in the mountains the performance is determined by the specific power **SP** (in Watt/kg).

The use of power meters in training and in races offers great advantages. With a power meter you measure your effort exactly, so you can optimize your workout and can find the right pace in the race. Without a power meter you have to rely on your speed or your heart rate (HR). However, these strongly depend on the conditions. Facing a headwind or cycling uphill your speed is much less, while pushing the same Wattage. At the same speed your HR is higher. Your HR is also related to the temperature and your physical fitness.

The breakthrough of power meters in running

Because of the proven value of power meters in cycling, the search for a power meter in running has been going on for years. Obviously, it is difficult - if not impossible - to directly measure the power provided by the legs of a runner. Consequently, another measuring principle has been developed. The breakthrough came with the use of accelerometers. These are small chips, containing crystals that exhibit a piezo-electric effect during an acceleration. This piezo-electric effect produces a voltage, which can be measured. Accelerometers are now very cheap, very accurate and have already been applied in many devices, such as smartphones, tablets, cars, pedometers, and running watches. As a result of accelerometers your smartphone knows if you hold it horizontally or vertically. Accelerometers in your running watch are able to measure your vertical oscillation, cadence and the stride length.

The Stryd: a revolution in running?

Very recently, a practical running power meter has been developed by Stryd of Boulder, Colorado (www.stryd.com). Early in 2016 the Stryd Pioneer became available to the general public. The Stryd Pioneer meter is a simple pod, which is supplied with a chest band, also measuring your heart rate. The sensor includes three accelerometers. These measure the acceleration of your body in three directions: horizontally, vertically and laterally or sideways. Obviously, it is important to restrict the vertical and lateral movements to optimize your Running Economy (RE). With an app you can adjust your body weight. During the training or race you can see the real-time data of your running power (in Watt) on your running watch or smart phone. After the training or race, you can analyze all the data on your PC.



Figure: The Stryd Pioneer power meter on a chest band with the box.

The power P is calculated from your body weight m (kg), the acceleration a (m/s^2) and the speed v (in m/s) with the formulae:

$$P = F \cdot v$$

$$F = m \cdot a$$

The breakthrough of Stryd is obviously their software, which allows the real-time calculation of the running power from all the 3D-acceleration data. The basic formulas are simple, but it requires a complex algorithm to integrate the accelerations in all directions in a correct and stable manner. One of the advantages of the Stryd is that it provides you with accurate and real-time information on the power that you are producing in your workout. This gives a much better representation of your real effort than your pace or your HR alone.

The potential benefits

We have critically reviewed the information on the internet and also tested the Stryd ourselves, as will be discussed in the next papers. Based on all of this, we are very positive of this new tool that offers the potential to optimize your running.

It seems to us that power meters in general and the Stryd in particular may provide a historical and revolutionary breakthrough in running. The use of accelerometers combined with advanced software seems to have paved the way for runners to get realistic and reliable data on their running power.

Many potential benefits have already been identified. We believe the following to be the most promising:

1. **Optimizing your Running Economy.**

A power meter will tell you (each and every day!) how much power you are using and thus how economically you are running. By changing your running form (e.g. cadence, stride length, etcetera) you can measure whether or not your RE improves.

2. **Measuring your fitness and shape.**

You can now measure your FTP and your VO₂-max, without the need to have yourself tested in a Sports Medical Center. This means you can now determine (each and every day!) how your fitness evolves.

3. **Measuring the exact effort of your workout.**

A power meter provides realistic and reliable information, better than pace and HR. This means you can prevent overtraining, adjust your training and optimize your tapering.

4. **Maintaining the optimal pace in a race.**

Obviously, changing conditions such as wind and hills, will affect your pace. Power data will help you to maintain a constant effort, so you do not blow yourself up or have something left in the tank at the finish.

5. **Optimizing the communication with your coach**

Daily exchange of the data on your workout, power, RE, etcetera, will be of great value, not just to yourself but also to your coach.

Obviously, it is early days yet with the application of running power meters. In practice, these potential advantages still have to be proven. Also, perhaps other advantages will materialize in the coming years. We have already started our own experiments and hope that many other runners will join us in this quest to optimize our running!

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