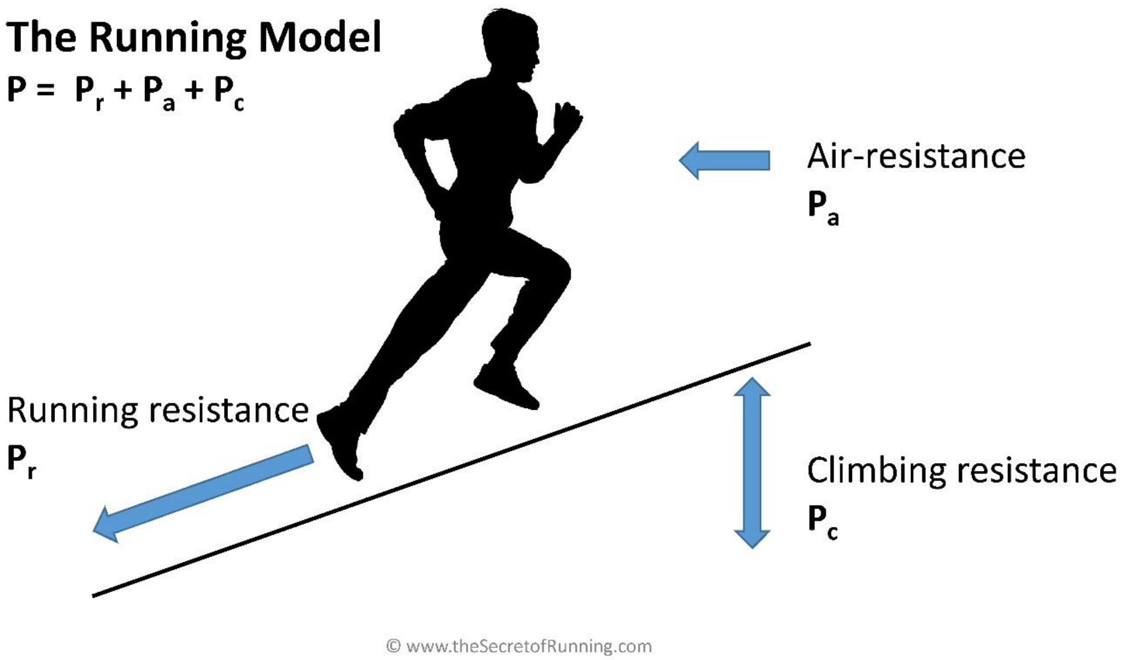
22. Why (and when) is running with power superior to running at pace?

Traditionally, runners use pace as a surrogate for their effort during training and racing. Theoretically, the effort during running is defined by the power of the 'human engine'. In our book "The Secret of Running" (www.thesecretofrunning.com) and in a previous paper on TP (https://www.trainingpeaks.com/blog/running-with-power-how-it-works-and-what-it-means/), we have shown that in running the total required power P is 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 indicated in the figure below.



In this paper, we will analyze the impact of the 3 resistances on the correct pace. We will show that in order to maintain a constant effort/power, it may be required to adapt the pace significantly (by 15% or even more). Consequently, running with power is superior to running at pace, particularly when the 3 resistances are not constant during a workout or race.

The impact of hills (climbing resistance)

In a recent paper (http://hetgeheimvanhardlopen.nl/wp-content/uploads/2017/02/17.-The-Energy-Cost-of-Running-on-hills.pdf), we analyzed the impact of the climbing resistance. Uphill the required power increases and downhill it decreases as a result of gravity. As it is always best to run at constant power, this means that uphill you should reduce your pace to maintain constant power. Uphill the reverse is the case. The table below shows the impact of a hill with a gradient of 3.5% on the correct pace of the author (FTP 250 Watt, body weight 58 kg, P= 4.31 Watt/kg). Obviously, the impact will be even bigger at steeper gradients, as the energy cost of hills is proportional to the gradient!

Impact of hills	Pace/km min:sec
Standard	3:58
Uphill 3.5%	4:37
Downhill 3.5%	3:26

The impact of the wind (air-resistance)

In another recent paper (http://hetgeheimvanhardlopen.nl/wp-content/uploads/2017/03/19.-The-impact-of-wind-on-ECOR-1.pdf) we analyzed the impact of the wind on the air-resistance. Facing a head wind, the required power increases, while it decreases in a tail-wind. As it is always best to run at constant power, this means that in a head wind you should reduce your pace to maintain constant power. In a tail wind the reverse is the case. The table below shows the impact at a wind speed of 15 km/h (at breast height) on the correct pace of the author (FTP 250 Watt, body weight 58 kg, P= 4.31 Watt/kg). Obviously, the impact will be even bigger at higher wind speeds, as the energy cost of the air-resistance is proportional to the square of the wind speed!

Impact of the wind	Pace/km min:sec
Standard	3:58
Head wind 15 km/h	4:24
Tail wind 15 km/h	3:48

We note that state-of-the-art running power meters, such as the Stryd (www.stryd.com) do not reflect the air-resistance by the wind correctly. Stryd is currently working on two possible solutions to handle this and they may come up with a product later this year. At the moment, the best thing we can do is to use the theoretical calculations from our book to predict the required pace as a function of the wind speed and direction.

The impact of the energy cost of running (running resistance)

In our book, we analyzed the energy cost of running (ECOR), which is defined as the power required to overcome the running resistance, divided by the running speed. Obviously, the ECOR of a trail or cross will be higher than the ECOR of an asphalt pavement, which has a lower resistance.

From literature, we concluded that on a level and hard course, the ECOR is typically 0.98 kJ/kg/km. Of course, this number will not be the same for everyone: it depends on many factors, including body posture, fuel mix and running form. Generally, it is believed that the ECOR of highly efficient elite runners could be as low as 0.90 kJ/kg/km, whereas the ECOR of inefficient joggers could be as high as 1.10 kJ/kg/km. So far, we have seen that our own data and those of many other runners are quite close to 1.00 kJ/kg/km.

Obviously, a lower ECOR means that you are running more efficiently and consequently you can run faster. So every runner should try to lower his ECOR! Unfortunately, we cannot change our body posture (apart from shedding excess body fat) and the fuel mix in our muscles (apart from carbo-loading before the marathon). The Kenyan elite runners share many advantages like slim calves, flexible hips and (relatively) long legs. So, the only factor that we can try to optimize is our running form.

Many factors are thought to influence the running form, including cadence, GCT, stride length, vertical oscillation, arm drive, foot strike, hip angle, knee lift, leg stretching, calves lift and ankle angle. However, opinions differ on exactly what constitutes the best running form. In a recent paper (http://hetgeheimvanhardlopen.nl/wp-content/uploads/2017/02/18.-Run-efficient-lower-your-ECOR.pdf), we found that the ECOR could be reduced by increasing the cadence.

The table below shows the impact of the ECOR on the correct pace of the author (FTP 250 Watt, body weight 58 kg, P= 4.31 Watt/.kg). Obviously, Hans could run much faster if he could reduce his ECOR to 0.90 kJ/kg/km! To be honest, we have not found the answer how he could achieve this….

Impact of ECOR	Pace/km min:sec
Standard	3:58
Low ECOR (0.90)	3:41
High ECOR (1.10)	4:24

Conclusions and outlook

The examples prove quite clearly that running at constant power is superior to running at constant pace, particularly when the conditions (resistances) during the workout or race are not constant. At any significant gradients and wind speeds, it will be detrimental or even impossible to run at a constant pace. Similarly, it will be necessary to adapt the pace in races with tougher footing, such as trails or crosses.

Theoretically, running at constant power is the best strategy to provide the best results. When running at constant power, the pace will be automatically reduced in tough sections (uphill, head wind, soft footing). In the easier sections of the race or workout, the pace will increase automatically.

Unfortunately, the present state-of-the-art running power meters, such as the Stryd, do not yet reflect the impact of the wind and the footing correctly. This means that presently the main advantage of running power meters is to maintain constant power in hilly courses.

In spite of these limitations, we are very excited that power meters do provide us with an opportunity to determine our ECOR on a daily basis, so we can try to optimize our running form. We are sure that this will pave the way to concrete improvements in our ECOR and race results.
We realize that this will not be easy because for us - and for most people - the running form has been habituated in many years of running. We will not be able to change it overnight. But with time and concrete data, we are confident we will be able to get some improvement.
We hope that many readers will join us in this effort. Let's share our data and conclusions on how we can improve our ECOR! We are curious to the reactions and experiences of the readers, we welcome you to share these at www.thesecretofrunning.com**.**

Thank you to the co-authors Ron van Megen and Guido Vroemen