6. Measuring and improving your Running Economy!

In previous papers we have discussed the breakthrough of running power meters and the results of our tests in the Dutch Sports Medical Center SMA Midden Nederland. We concluded that the Stryd power data are as good and reliable as the VO_2 data from a physiological lab. During our research we noted that the Running Economy (RE) of the 14 test runners was quite different. This lead us to conclude that measuring and improving the RE could be a promising application of the Stryd. In this paper we elaborate on this and explain how you could use a power meter to measure and improve your RE.

Which factors determine your Running Economy?

There is almost no topic that runners and coaches discuss more than the Running Economy. Almost everyone has an opinion on it. At athletics clubs much attention is paid to exercises and training to improve the running technique, which is supposed to improve your RE. Yet the question remains how we can understand this: what can science tell us on the Running Economy?

Studying the literature we noticed that usually this topic is discussed only in broad and general terms. Quantitative information on the influence of various factors on the RE are lacking. The literature survey in our book The Secret of Running (www.thesecretofrunning.com) revealed that the following aspects are believed to influence the RE:

1. Body posture
   A low body fat percentage, long legs, slim calves, small feet and narrow and flexible hips are associated with an improved RE.
2. Fuel mix
   A higher percentage of glycogen produces more power, so it improves the RE.
3. Running form
   Many factors are thought to have an impact on the RE, including cadence, GCT, stride length, 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.

That these factors will play a role seems logically. Obviously, it takes less energy to run with the slim calves of the Kenyan elite runners. Also it makes sense that glycogen produces more power than fatty acids. And it also makes sense that our running form will have an impact on our RE, as vertical and lateral movements cost energy and do not contribute to our forward speed.

Besides the fact that there is little quantitative information on the RE, we have to deal with another problem. This is the fact that we cannot control our body posture (except by reducing our body fat percentage) and the fuel mixture in our muscles (apart from carbo-loading before the marathon). So, the only factor that we can try to optimize is our running form.

The impact of the running form

The ideal running form is one of the myths of running. On television we see a big difference between the smooth strides of elite athletes like Haile Gebrselassie or Tirunesh Dibaba and the puffing and gasping of some joggers. But what is the secret of a good running form? Factors that are often referred to are a short ground contact time, a high cadence, avoiding heel landing, a strong drive by the arms in support of the running motion, a good knee lift and the stretching of the toes at the take off.

We all know examples of runners with a smooth running form. Hans and Ron are always impressed by their team mate Willem de Ruijter, see the figure. But does that beautiful running form lead to a better RE and which concrete steps should we take to improve our RE?

Figure: The smooth running style of Willem de Ruijter at the Dutch National Championships 3.000 m indoor.

How can we measure the RE?

The RE is defined as the amount of oxygen you use to run 1 km (per kg of body weight, the RE is expressed in ml O_2/kg/km). Until now, the RE can only be measured in a sports physiological laboratory by dividing the oxygen consumption of a runner by the speed of the treadmill:

RE = VO_2/v

The VO_2 is expressed in ml O_2/kg/min and v in km/min. As an example we use a VO_2 of 50 ml/kg/min and a v of 15 km/h, then the RE is 50/(15/60) = 200 ml O_2/kg/km.

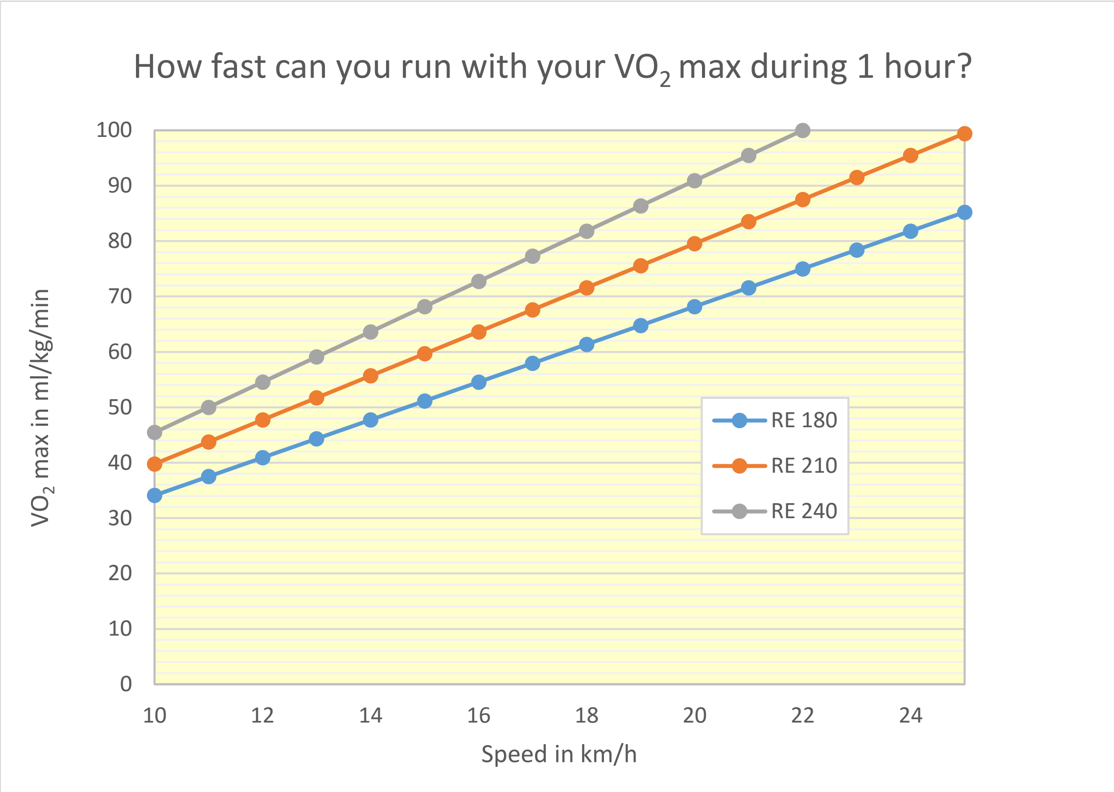
Very efficient Kenyan elite athletes like Wilson Kipsang have an RE of 180 ml/kg/min, whereas our 14 test runners had RE values varying from 213 to 248 ml O_2/kg/km. This means that our test runners use more oxygen at the same speed as compared to Kipsang. A high value of the RE means that you are NOT running economically. Consequently, you will run slower at the same value of the VO_2 max. Your VO_2 max and your RE together determine how fast you can run. We can calculate the maximum attainable speed with the formula:

$v_{max} = VO_2$ max/RE

The v_{max} is the speed that you can maintain for 10 minutes which corresponds to the duration of the VO_2 max. It is more interesting to calculate the speed corresponding to the functional threshold power (FTP) which you can maintain for an hour. As we have shown in our book, this speed is equivalent to 88% of v_{max}. In the table and graph we have calculated this attainable hour speed as a function of your VO_2 max and your RE.

To illustrate the big impact of your RE, let's check the table for a speed of 15 km/h. If you are running very economically with an RE of 180 ml/kg/min, you need a VO_2 max of only 51 ml/kg/min to maintain this speed during an hour. If, on the other hand, you are an uneconomical runner with an RE of 240 ml/kg/km, you need a VO_2 max of no less than 68 ml/kg/min to maintain the same speed! As we have explained earlier, the maximum value of the VO_2 max of world class athletes is around 88 ml/kg/min, so the values beyond this level are not possible in practice.

Required VO_2 max (ml/kg/min)			
	RE	RE	RE
v_{hour} km/h	180 ml/kg/km	210 ml/kg/km	240 ml/kg/km
10	34	40	45
11	38	44	50
12	41	48	55
13	44	52	59
14	48	56	64
15	51	60	68
16	55	64	73
17	58	68	77
18	61	72	82
19	65	76	86
20	68	80	91
21	72	84	95
22	75	88	100
23	78	91	105
24	82	95	109
25	85	99	114



How can you measure your RE with the Stryd?

With the Stryd you can measure your specific power **SP** (in Watt/kg) at a certain speed. According to theory you can calculate your energy cost of running **ECR** (in kJ/kg/km) by dividing the specific power by the speed **v** (in m/s):

ECR = SP/v

As an example we use a specific power of 4.1 Watt/kg and a speed of 15 km/h. The ECR can then be calculated as 4.1/(15/3.6) = 0.98 kJ/kg/km. This ECR-value corresponds to an RE of 201 ml O_2/kg/km. Remember that the energy value of 1 ml O_2 is 19.5 J and the metabolic efficiency is 25%, so:

ECR = 19.5*0.25/1000*RE, or
ECR = 0.004875*RE

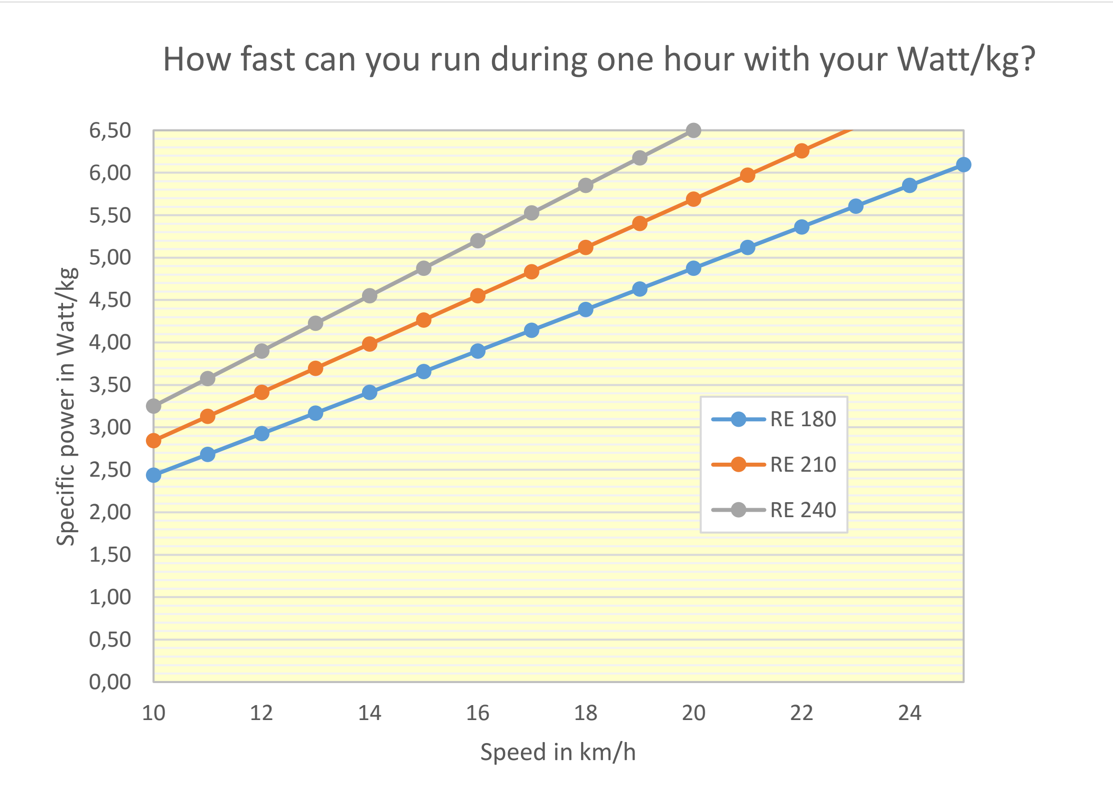
A high ECR-value means the same as a high RE: you are using a lot of energy and you are NOT running economically. Now the challenge is to change your running form so that you are able to reduce your specific power at the same speed and thus your ECR-value!

As we have previously derived a relation for the attainable speed as function of VO_2 max and RE, we can now do the same for your speed as a function of the specific power SP and the ECR. The relation is:

v = SP/ECR

For the sake of our readers who are more familiar with the RE, we have made a similar table and figure for the attainable speed as a function of the SP and the RE. As an example, let's look once more to a speed of 15 km/h. With an RE of 180 ml/kg km you can already maintain that speed with an SP of 3.66 Watt/kg. If, on the other hand, you are an uneconomical runner with an RE of 240 ml/kg/km, you need an SP of no less than 4.88 Watt/kg to maintain the same speed. In our book we have shown that an SP of 6.4 Watt/kg as the maximum limit of human performance. Values beyond this level cannot be maintained for 1 hour (we have marked these in red).

Required Watt/kg (Watt/kg)			
		RE	
v	180	210	240
km/h	ml/kg/km	ml/kg/km	ml/kg/km
10	2.44	2.84	3.25
11	2.68	3.13	3.58
12	2.93	3.41	3.90
13	3.17	3.70	4.23
14	3.41	3.98	4.55
15	3.66	4.27	4.88
16	3.90	4.55	5.20
17	4.14	4.83	5.53
18	4.39	5.12	5.85
19	4.63	5.40	6.18
20	4.88	5.69	6.50
21	5.12	5.97	6.83
22	5.36	6.26	7.15
23	5.61	6.54	7.48
24	5.85	6.83	7.80
25	6.09	7.11	8.13



The future: what should you do to optimize your RE?

The Stryd offers you the opportunity to measure your RE on a daily basis. It can be easily done by dividing your SP (in Watt/kg) by your speed v (in m/s):

ECR = SP/v

You can either use the ECR-value directly or transfer it into the RE, with the formula

RE = ECR/0.004875

We suggest that you note the ECR-value or RE every day in your running spreadsheet. Now you need to collect a lot of data and relate the values of ECR or RE with your running form, so cadence, GCT, oscillation, stride length, etcetera. Remember that the conditions of the run (weather, footing) may also have an impact. Therefore we recommend that you collect data regularly at a standard training course to get reproducible results. This should enable you to recognize the conditions in which you were able to run most economically, i.e. with the lowest value of ECR and RE.

We are very excited that power meters finally provide us with an opportunity to put a concrete number on the 'vague' parameter RE. We are sure that this will pave the way to concrete improvements in our RE. 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 measure and improve our RE! We are curious to the reactions and experiences of the readers, we welcome you to share these at www.thesecretofrunning.com**.**

Hans van Dijk, Ron van Megen and Guido Vroemen

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