19. Impact of wind on Energy Cost of Running (ECOR)

In our book (www.thesecretofrunning.com) we have discussed the Energy Cost of Running (ECOR) in several separate chapters.

First, we have shown 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 your body posture and your running style. 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). The Kenyan elite runners share many advantages like slim calves and (relatively) long legs.

Calculate your ECOR

However, we can try to optimize our running style in order to lower our ECOR. The Stryd gives us the tool to do this as can calculate our ECOR on a daily basis:

ECOR (in kJ/kg/km) = Specific power (in Watt/kg) divided by the speed (in m/s)

This means that every day we can try to optimize our running style and see the impact on our ECOR. We suggest that you note the ECOR-value every day in your running spreadsheet. Now you need to collect a lot of data and relate the values of ECOR 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 are able to run most economically, i.e. with the lowest value of ECOR.

Impact of cadence on ECOR

In a previous paper (http://hetgeheimvanhardlopen.nl/wp-content/uploads/2017/02/18.-Run-efficient-lower-your-ECOR.pdf) , we showed that the ECOR can be reduced by increasing the cadence. Obviously, increasing the cadence will automatically also lead to a reduction in stride length, oscillation and Form Power.

Impact of hills on ECOR

In another previous paper (http://hetgeheimvanhardlopen.nl/wp-content/uploads/2017/02/17.-The-Energy-Cost-of-Running-on-hills.pdf) , we showed that uphill the ECOR is increased and downhill it is decreased. 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.

An experiment to test the impact of the wind on ECOR

Author Hans performed such an experiment on Thursday 02-03-2017. He did this during his daily training run of 12.2 km on a standard level, asphalt paved course. He ran at constant cadence and at a pace a little below 5 minutes/km. He noticed that after km 6 he faced a rather strong head wind, so at km 7 he turned around to run with a tail wind. At km 8 he turned again to face the head wind once more and at km 9 he made a final turn to measure once more the impact of the tail wind. The results of the experiment are presented in the table below:

Results experiment wind 02-03-2017														
Distance	Pace	Speed	Power	ECOR	Wind	Cadance	Stride length	V.O.	GCT	FP	FP/P	LSS	F_{vert}/mg	HR
km	min:sec/km	m/s	Watt	kJ/kg/km	25 km/h	spm	m	cm	msec	Watt	%	kN/m	%	bpm
1	05:31	3.02	174	0.99	cross	185	0.99	8.2	244	51	29%	9	91%	117
2	05:09	3.24	183	0.97	cross	184	1.09	8.3	239	51	28%	8	82%	124
3	04:54	3.40	198	1.00	cross	185	1.11	8.4	235	53	27%	8	83%	129
4	04:42	3.55	203	0.99	cross	185	1.16	8.4	232	53	26%	8	83%	133
5	04:45	3.51	205	1.01	cross	185	1.15	8.4	230	53	26%	8	83%	140
6	04:39	3.58	207	1.00	cross	186	1.18	8.3	228	53	26%	8	82%	141
7	04:36	3.62	208	0.99	**head**	186	1.18	8.1	226	53	25%	8	80%	**147**
8	04:24	3.79	219	**1.00**	**tail**	187	**1.24**	**8.6**	**220**	**55**	25%	8	85%	148
9	04:45	3.51	203	1.00	**head**	185	1.14	8.1	230	53	26%	8	80%	**150**
10	04:27	3.75	222	**1.02**	**tail**	184	**1.25**	**9.0**	**218**	**56**	25%	8	89%	147
11	04:33	3.66	212	1.00	cross	184	1.21	8.7	223	55	26%	8	86%	147
12	04:42	3.55	208	1.01	cross	184	1.17	8.5	227	54	26%	8	84%	148
13	04:42	3.55	210	1.02	cross	183	1.17	8.8	226	54	26%	8	87%	148
Average	04:42	3.55	203.5	0.99	-	185	1.15	8.4	229	53.2	26.1%	8	83%	140

The table shows that the ECOR was **NOT** influenced by the wind. This confirms the statement by Stryd that the footpod does not (yet) reflect the impact of wind.

The small increase in ECOR values at the tail wind sections were probably caused by the fact that Hans automatically increased his stride length, oscillation and FP a little during these sections. Overall, the ECOR values were all close to 1.00 kJ/kg/km as could be expected from earlier runs at these cadence.

The impact of wind according to theory

In our book (www.thesecretofrunning.com), we have shown that theoretically the impact of wind can be calculated by the formula:

$$\mathbf{P_a = 0.5\rho c_d A(v+v_w)^2 v}$$

This means that during the conditions of the experiment (running speed v= 3.6 m/s, wind velocity v_w= 6.9 m/s), the required power to overcome the air resistance P_a is 57 Watts during the head wind section. During the tail wind section P_a is -3 Watts, so the wind actually helped pushing Hans forward!. When we divide P_a by the body weight of Hans (58 kg) and his speed (3.6 m/s), we can calculate the theoretical impact of P_a on the ECOR. The result is that the ECOR increased by 0.27 kJ/kg/km during the head wind sections and reduced by 0.01 kJ/kg/km during the tail wind section (both relative to the standard value of 0.98 kJ/kg/km). We note that during calm weather the power required to overcome the air-resistance P_a is equal to 7 Watts, which has an impact on ECOR of 0.03 kJ/kg/km.

Obviously, the big impact of the head wind was NOT reflected by the Stryd data, which again confirms that the footpod does not measure the impact of wind.

Actually, the big impact of the head wind was reflected much better by the Garmin-data, as the heart rate (HR) of Hans increased significantly (by some 5bpm) and his pace decreased significantly (by some 20 sec/km) during the head wind sections.

Discussion and conclusions

The experiment has revealed a clear result: the impact of the wind is NOT reflected by the Stryd data and the ECOR-values. Stryd acknowledges that the current technology does not handle wind. So, for all the benefits of the Stryd (including the use in hilly courses, the use for optimization of running form and the use to run at perfect power during training and race) we cannot use it to optimize our power and pace in windy conditions. It would be very welcome if Stryd could develop the technology

for this. Stryd is currently working on two possible solution 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.

Of course, there are still a number of buts…

First, this is just one experiment, so it needs to be verified by other experiments. We will certainly do this, and we hope other Stryders will follow our example. Second, we do not know yet to what extent these results depend on the running style of Hans. Other runners may get different results. Third, the results have been obtained during a training run at lower than race speed. So, we still need to see the impact during a race.

In spite of these limitations, we are very excited that the Stryd provides us with an opportunity to determine our ECOR on a daily basis so we can try to optimize our running style. 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 measure and improve our ECOR! We are curious to the reactions and experiences of the readers, we welcome you to share these at www.thesecretofrunning.com**.**

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