7. How to measure and improve your RE and ECR

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) and the Energy Cost of Running (ECR) of the 14 test runners was quite different. This lead us to conclude that measuring and improving the RE and ECR could be a promising application of the Stryd. In this paper we elaborate on this and explain our own experiments with the Stryd Pioneer to find out how you could use a power meter to measure and improve your RE.

How can you measure your RE and ECR with the Stryd?

With the Stryd you can measure your specific power **SP** (in Watt/kg) at a certain speed. According to the theory derived in our book The Secret of Running, 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, so
RE = 205*ECR

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!

Experimental data of Hans and Ron

During our daily workouts, we keep track of our ECR-value in our running spreadsheet. In order to get reproducible results, we usually train on the same course (12 km length, flat, asphalt). We have tried to find relations between the ECR and other data, such as:

1. Running style (shuffle, power stride, Pose style)
2. Cadence
3. Stride length
4. Vertical and horizontal oscillation
5. Fatigue
6. Footing (other than asphalt)
7. Hills

Below, we will share our preliminary results.

Impact of running style

We have consistently found that the ECR of the power stride is higher than that of the shuffle. An example of this is shown in the table below, where author Hans changed his running style a number of times. Clearly, the ECR of the power stride was always higher than that of the shuffle. It should be noted that several factors interact, as in this case the ECR also increases slightly during the workout as a result of fatigue. Below we will show an even more clear example of this. Also, the ECR increases with stride length and decreases with cadence, as will be shown below.

ECR				20-8-2016 Brisk		
Distance	Pace	Speed	Power	ECR	15 ^{o}	Stride length
m	min:sec	m/s	Watt	kJ/kg/km	some wind	m
1	5:34	2.99	152	0.88	shuffle	1.01
2	4:48	3.47	168	0.83	shuffle	1.13
3	4:30	3.70	187	0.87	shuffle	1.18
4	4:14	3.94	212	0.93	power stride	1.25
5	4:19	3.86	212	0.95	power stride	1.23
6	4:32	3.68	186	0.87	shuffle	1.17
7	4:28	3.73	192	0.89	shuffle	1.17
8	4:27	3.75	198	0.91	shuffle	1.22
9	4:27	3.75	203	0.93	power stride	1.22
10	4:09	4.02	231	0.99	power, high cad	1.25
11	3:50	4.35	260	1.03	power, low cad	1.42
12	4:34	3.65	180	0.85	shuffle	1.16
average	4:29	3.72	196	0.91		1.20

The impact of cadence

In general, we found that the ECR decreased with higher cadence. Another example of this is shown in the table below. Of course, a lower cadence will generally correlate with a larger stride length and higher vertical oscillation.

ECR				19-8-2016 Slow		
Distance	Pace	Speed	Power	ECR	18 ^{o}	Stride length
m	min:sec	m/s	Watt	kJ/kg/km	little wind	m
1	6:39	2.51	123	0.85		0.85
2	6:22	2.62	119	0.78		0.89
3	5:19	3.13	164	0.90		1.04
4	5:01	3.32	173	0.90		1.09
5	5:02	3.31	182	0.95		1.08
6	4:52	3.42	197	0.99	low cadence	1.21
7	5:03	3.30	181	0.95		1.09
8	4:42	3.55	196	0.95	high cadence	1.11
9	4:59	3.34	189	0.97		1.10
10	4:49	3.46	208	1.04	low cadence	1.18
11	4:59	3.34	190	0.98		1.11
12	4:38	3.60	219	1.05	very low cadence	1.29
average	5:11	3.22	183	0.98		1.08

The impact of stride length

In general, the ECR increases with stride length. Another example of this is shown in the table below. This increase makes sense as larger strides usually correlate with more vertical oscillation.

ECR				15-8-2016 Climax run		
Distance	Pace	Speed	Power	ECR	22 ^{o}	Stride length
m	min:sec	m/s	Watt	kJ/kg/km		m
1	5:59	2.79	155	0.96	head wind	0.96
2	5:31	3.02	169	0.96	cross wind	1.04
3	5:19	3.13	179	0.98	cross wind	1.09
4	5:05	3.28	191	1.00	tail wind	1.15
5	4:54	3.40	202	1.02	tail wind	1.18
6	4:43	3.53	208	1.01	tail wind	1.21
7	4:34	3.65	224	1.06	tail wind	1.24
8	4:22	3.82	238	1.08	cross wind	1.27
9	4:13	3.95	253	1.10	cross wind	1.30
10	4:04	4.10	271	1.14	head wind	1.31
11	3:49	4.37	296	1.17	head wind	1.37
12	4:44	3.52	217	1.06	head wind	1.16
average	4:47	3.48	212	1.05		1.18

The impact of horizontal and vertical oscillations

Obviously, both should be minimized in order to reduce ECR. An example of this is the run below, where author Hans deliberately increased his lateral movements during km 10 and minimized his vertical and lateral movements during km 12. During this run, he also found that running in Pose style seemed to decrease the ECR a bit.

ECR				18-8-2016 Slow		
Distance	Pace	Speed	Power	ECR	15 ^{o}	Stride length
m	min:sec	m/s	Watt	kJ/kg/km	little wind	m
1	5:40	2.94	151	0.89		1.00
2	5:04	3.29	160	0.84		1.11
3	5:06	3.27	169	0.89		1.09
4	4:58	3.36	171	0.88		1.11
5	4:59	3.34	176	0.91		1.11
6	4:29	3.72	185	0.86	Pose	1.24
7	4:53	3.41	177	0.89		1.13
8	4:27	3.75	193	0.89	Pose	1.24
9	4:57	3.37	181	0.93		1.14
10	4:48	3.47	218	1.08	Lateral movem.	1.18
11	4:51	3.44	184	0.92		1.16
12	5:03	3.30	171	0.89	Smooth	1.11
average	4:56	3.50	183	0.90		1.13

The impact of fatigue, footing and hills

We have noted the combined impact of these factors during our weekly long Sunday morning runs.

An example of such a run is shown below. During this run we found:

- An increase of the ECR due to fatigue (from 1.05 to 1.15)
- An increase of the ECR uphill (from 1.05 to 1.20)
- A decrease of the ECR downhill (from 1.05 to 0.95)
- An increase of the ECR due to sandy footing (from 1.05 to 1.15)

ECR				28-8-2016	De Traay with Ron	
Distance	Pace	Speed	Power	ECR	27.00	Stride length
m	min:sec	m/s	Watt	kJ/kg/km	sunny	m
1	6:51	2.43	141	1.00	with Atty	0.81
2	6:40	2.50	142	0.98	with Atty	0.86
3	6:02	2.76	159	0.99	partly with Atty	0.93
4	5:59	2.79	172	1.06		0.99
5	5:37	2.97	171	0.99		0.98
6	5:35	2.99	185	1.07		1.00
7	5:42	2.92	179	1.06		0.99
8	5:34	2.99	176	1.01		1.01
9	5:30	3.03	185	1.05		1.02
10	5:35	2.99	208	**1.20**	uphill Aart Jansen	1.01
11	5:14	3.18	210	1.14	uphill Aart Jansen	1.07
12	5:05	3.28	186	**0.95**	downhill Traay	1.09
13	5:11	3.22	199	1.07		1.08
14	5:13	3.19	204	1.10		1.09
15	5:19	3.13	210	**1.16**	uphill bike track Maarn	1.05
16	4:50	3.45	209	**1.05**	downhill bike track	**1.18**
17	5:12	3.21	199	1.07		1.09
18	5:23	3.10	205	1.14		1.06
19	5:05	3.28	210	1.10		1.11
20	5:04	3.29	220	1.15	uphill/downhill/sand	1.12
21	5:06	3.27	215	1.13	uphill/downhill/sand	1.11
22	5:12	3.21	213	1.15		1.09
23	5:12	3.21	209	1.12		1.08
24	5:19	3.13	215	1.18		1.06
25	5:12	3.21	210	1.13		1.09
26	5:12	3.21	215	1.16		1.09
27	5:03	3.30	218	1.14		1.12
28	5:16	3.16	206	1.12		1.07
average	5:25	3.08	194	1.09		1.04

How to improve your running during races

Obviously, the big question remains how a runner can improve his running form during races. This is by no means easy, in particular as a runner's style is the result of many years of training and racing. We have concluded that we should try to increase our cadence, try to run in Pose style and minimize our vertical and lateral movements. Obviously, during a track race, we have to run with the power stride and large stride length in order to achieve the desired speed. Author Hans tried to do this during a 10,000 meter race in the FBK stadium in Hengelo, the Netherlands. The results are shown in the table below. The results were quite satisfactorily for a 62-year runner, but Hans aims to continue

training to improve his running style in the time ahead. He hopes that slowly he will be able to maintain the optimum running form during the race (particularly, a higher cadence and minimizing lateral and vertical movements).

ECR				22-9-2016 FBK 10000 (37:41)			
Distance	Pace	Speed	Power	ECR	15 °	Stride length	Cadence
km	min:sec	m/s	Watt	kJ/kg/km	HR	m	ppm
1	3:45	4.44	274	1.06	150	1.46	183
2	3:41	4.52	291	1.11	163	1.47	185
3	3:43	4.48	305	1.17	166	1.46	184
4	3:41	4.52	304	1.16	165	1.47	185
5	3:42	4.50	306	1.17	165	1.47	184
6	3:46	4.42	302	1.18	163	1.45	183
7	3:46	4.42	306	1.19	162	1.42	187
8	3:42	4.50	305	1.17	163	1.45	186
9	3:42	4.50	305	1.17	161	1.45	186
10	3:43	4.48	308	1.18	160	1.44	187
last 170m	3:12	5.21	**351**	1.16	164	**1.72**	182
average	3:42	4.50	**301**	**1.15**	162	**1.46**	185

We are very excited that power meters finally provide us with an opportunity to put a concrete number on our running from. We are sure that this will pave the way to concrete improvements in our ECR and race results. We realize that this will not be easy because for us -and for most people- our running form will be 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. 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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