

Online Resource 2

Supplementary results for:

Steinarsson, A., Jakobsdóttir, G., Benediktsson, S. S., & Jóhannsson, E. (2026). *Aerobic endurance and physiological thresholds estimated from submaximal heart-rate kinetics: Comparison with cardiopulmonary exercise and sprint testing* [Unpublished manuscript]. Faculty of Health Promotion, Sport and Leisure Studies, University of Iceland.

¹Faculty of Health Promotion, Sport and Leisure Studies, University of Iceland, Reykjavík, Iceland.

Correspondence: Erlingur Jóhannsson, erljo@hi.is

Submaximal test model fitting

The model fitted exercise intensity, HR_{max} , and endurance (E) to the heart-rate response during exercise and recovery. Figure S2 illustrates representative fits from two participants with substantially different endurance values ($E = 0.52$ and $E = 0.87$).

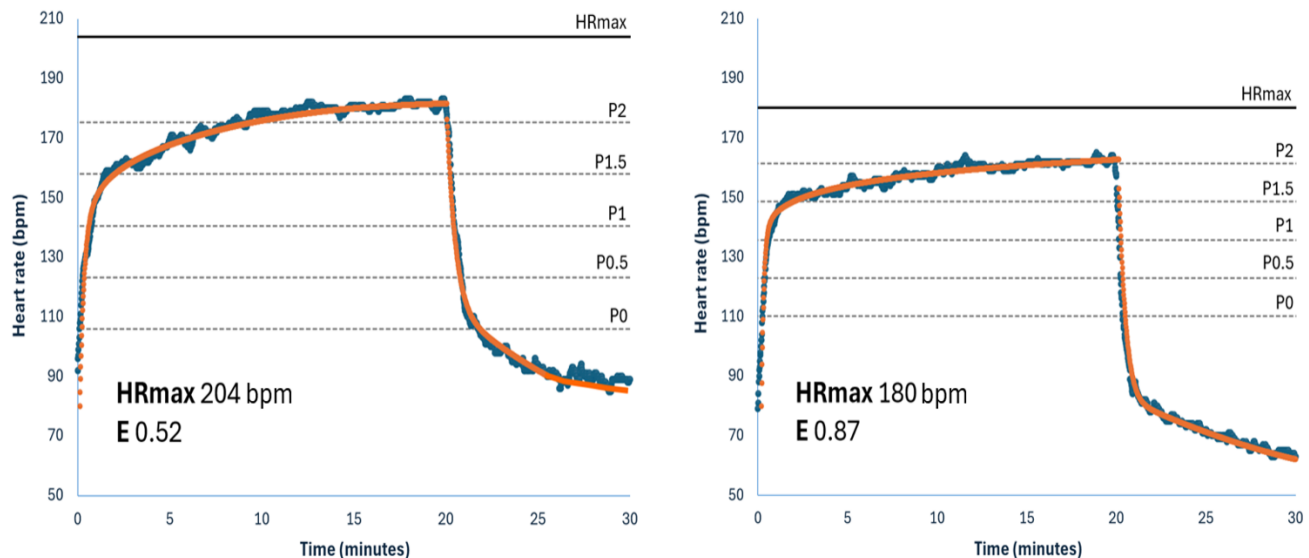


Fig. S2 Representative model fits from participants with lower and higher aerobic endurance. Observed heart rate (blue) and modelled heart rate (orange) during 20 min of submaximal running followed by recovery are shown for a participant with $E = 0.52$ (left) and a participant with $E = 0.87$ (right). Horizontal lines indicate model-derived HR_{max} and heart-rate thresholds P_0 – P_2 .

The contrasting profiles also illustrate how E is expressed within the fitted model. In the higher- E participant, P_0 was positioned closer to HR_{max} and the P_0 – P_2 threshold range occupied a smaller fraction of the total heart-rate range. The post-exercise recovery trajectory was also lower, corresponding within the model to less accumulated heart-rate debt. In the lower- E participant, P_0 was lower relative to HR_{max} , the P_0 – P_2 range was broader, and the recovery component was larger (Fig. S2).

Sprinting test results

The 50-m sprinting test was performed as a reference test against model-derived maximum speed. Table S1 summarizes mean split times and speed at successive 10-m splits in the 50-m sprinting test, for men and women.

Table S1 Mean total time and split times for males and females at 10-m intervals in the 50-m sprint test.

Gender	Parameters	10 m	SD	20 m	SD	30 m	SD	40 m	SD	50 m	SD
Male	t_{split} (sec)	1.88	0.10	1.38	0.10	1.32	0.10	1.29	0.11	1.31	0.13
	t_{acc} (sec)	1.88	0.10	3.26	0.19	4.58	0.28	5.87	0.39	7.18	0.52
	Speed (kph)	19.19	1.01	26.23	1.85	27.49	2.04	28.01	2.40	27.80	2.73
Female	t_{split} (sec)	2.13	0.18	1.63	0.16	1.58	0.18	1.59	0.20	1.62	0.21
	t_{acc} (sec)	2.13	0.18	3.76	0.34	5.34	0.51	6.93	0.71	8.55	0.92
	Speed (kph)	17.02	1.34	22.33	2.13	23.04	2.56	22.96	2.79	22.60	2.84

Figure S3 shows mean interval split speeds ($\pm$ SD) in the 50-m sprinting test for men and women.

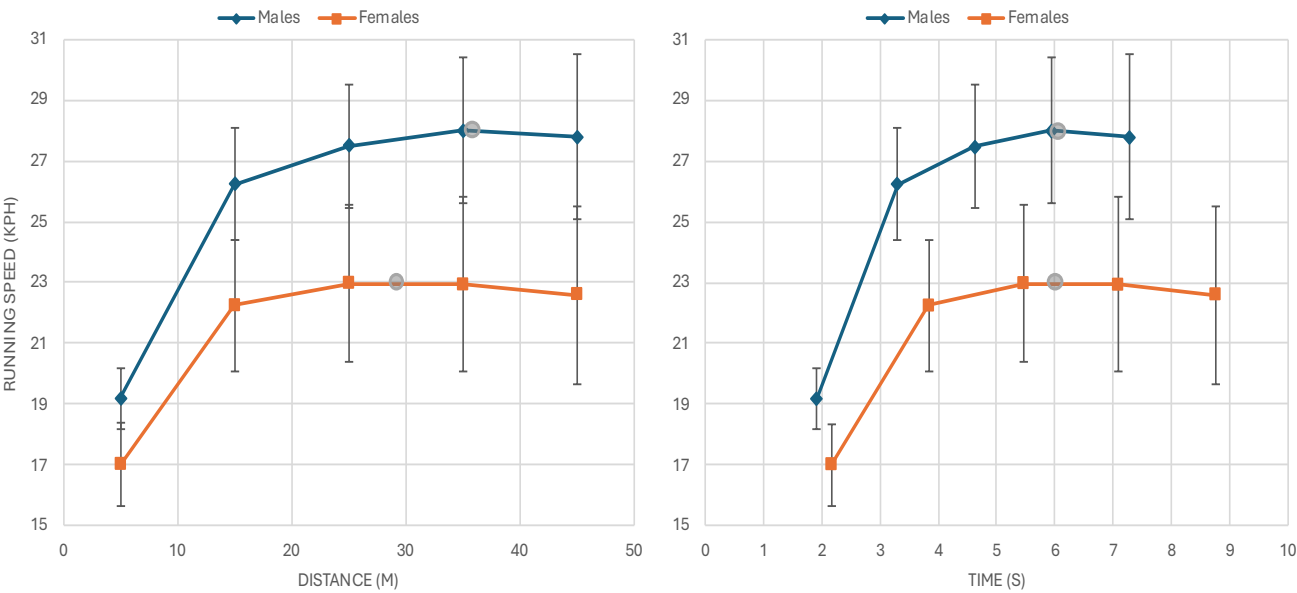


Fig. S3 Mean interval speeds reached by males and females at 10-meter intervals in the 50-meter sprinting test. A) Mean rolling speed (kph $\pm$ SD) plotted against distance covered. B) Mean rolling speed plotted against time lapsed. Grey markers indicate approximate top speeds.

Cardiopulmonary exercise test (CPET) results

The CPET was performed as a reference test against model-derived values. Table S3 summarizes CPET results for men and women, in addition to those shown in Table 2. Table S2 summarizes regression details for model and reference comparisons.

Table S2. CPET results summarized by sex

CPET measure	Women, mean $\pm$ SD (<i>n</i>)	Men, mean $\pm$ SD (<i>n</i>)
VT ₁ speed (km·h ⁻¹)	9.19 $\pm$ 1.07 (15)	11.40 $\pm$ 2.04 (22)
VT ₂ speed (km·h ⁻¹)	10.57 $\pm$ 1.50 (15)	13.10 $\pm$ 2.39 (22)
Speed at VO _{2max} (km·h ⁻¹)	13.69 $\pm$ 1.59 (19)	16.05 $\pm$ 2.67 (26)
VT ₁ heart rate (bpm)	149.27 $\pm$ 9.29 (15)	151.32 $\pm$ 5.89 (22)
VT ₂ heart rate (bpm)	164.07 $\pm$ 9.45 (15)	168.09 $\pm$ 7.37 (22)
HR _{peak} (bpm)	182.27 $\pm$ 9.61 (15)	186.61 $\pm$ 7.17 (22)
VO ₂ at VT ₁ (mL·kg ⁻¹ ·min ⁻¹)	29.97 $\pm$ 3.23 (15)	36.83 $\pm$ 5.87 (21)
VO ₂ at VT ₂ (mL·kg ⁻¹ ·min ⁻¹)	35.31 $\pm$ 4.69 (15)	43.39 $\pm$ 7.57 (21)
Running economy (mL·kg ⁻¹ ·km ⁻¹)	185.87 $\pm$ 10.45 (15)	185.33 $\pm$ 9.59 (19)
Peak respiratory exchange ratio	1.145 $\pm$ 0.043 (15)	1.136 $\pm$ 0.047 (21)
Peak cardiac output (L·min ⁻¹)	17.73 $\pm$ 2.36 (15)	27.50 $\pm$ 3.15 (20)
Peak metabolic equivalents (METs)	12.22 $\pm$ 1.45 (15)	14.75 $\pm$ 2.37 (20)

Values are mean $\pm$ sample SD, with available *n* in parentheses.

Table S3. Regression details for model and reference comparisons.

Reference outcome	Model predictor	<i>n</i>	Intercept (95% CI)	Slope (95% CI)	R ²
CPET VT ₁ speed	V _{1.5}	37	-0.062 (-0.668 to 0.545)	1.007 (0.950 to 1.063)	0.97
CPET VT ₂ speed	V ₂	37	-1.210 (-2.330 to -0.090)	1.080 (0.995 to 1.174)	0.94
CPET VT ₁ heart rate	P _{1.5}	37	14.877 (-14.390 to 44.150)	0.902 (0.708 to 1.100)	0.72
CPET VT ₂ heart rate	P ₂	37	-1.010 (-29.230 to 27.210)	1.010 (0.842 to 1.180)	0.81
CPET vVO _{2max}	V ₃	38	-0.390 (-1.870 to 1.090)	1.002 (0.908 to 1.095)	0.93
CPET VO _{2max}	Model VO _{2max}	38	-0.019 (-6.611 to 6.573)	0.980 (0.846 to 1.114)	0.86
CPET HR _{max}	Model HR _{max}	37	4.465 (-14.220 to 23.150)	0.956 (0.857 to 1.060)	0.92
Max sprint speed	Model V _{max}	42	-0.084 (-1.306 to 1.137)	1.001 (0.954 to 1.048)	0.98
<i>E_r</i>	Model <i>E</i>	37	-0.096 (-0.218 to 0.026)	1.122 (0.940 to 1.304)	0.82
<i>E_r</i>	Model <i>E</i> (Deming)	37	-0.194 (-0.321 to -0.048)	1.269 (1.048 to 1.462)	—
<i>E_r</i>	Model <i>E</i> (Passing–Bablok)	37	-0.201 (-0.350 to -0.052)	1.274 (1.047 to 1.529)	—

Model VO_{2max} = 3.09 $\times$ V₃.

Table S4. Agreement in participants fitted with an adjusted drift-scaling factor φ and with the default ($\varphi = 1$).

Outcome	n , φ adjusted	Bias / MAE, φ adjusted	n , default	Bias / MAE, default	p
VT ₁ speed (km·h ⁻¹)	19	0.06 / 0.23	18	-0.04 / 0.26	0.84
VT ₂ speed (km·h ⁻¹)	19	-0.15 / 0.54	18	-0.20 / 0.44	0.64
VT ₁ heart rate (bpm)	19	0.92 / 3.60	18	-0.61 / 3.16	0.49
VT ₂ heart rate (bpm)	19	1.22 / 3.23	18	1.02 / 2.77	0.42
HR _{peak} vs HR _{max} (bpm)	19	-3.18 / 3.50	18	-4.39 / 4.50	0.22
VO _{2max} (mL·kg ⁻¹ ·min ⁻¹)	20	-0.81 / 2.40	18	-1.21 / 2.82	0.29
vVO _{2max} (km·h ⁻¹)	20	-0.30 / 0.47	18	-0.44 / 0.61	0.045
Maximum speed (km·h ⁻¹)	22	-0.07 / 0.35	20	-0.04 / 0.46	0.56
E_r versus E	19	-0.012 / 0.055	18	-0.018 / 0.044	0.40

Bias is reference minus model. p , Mann–Whitney U test on absolute errors (uncorrected for multiple comparisons).