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Power-velocity curve: relevance of the SRM Ergometer for simulated cycling performance and constant duration tests

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Abstract

Introduction: When trying to obtain cycling performance capacity, a controlled laboratory setting is required to obtain valid and reliable results [1]. Ecological validity is important, as several studies found poor agreement between lab and field time trials [2,3]. To perform realistic time trials on an ergometer, it is important that the cyclist is able to 1) choose its own cadence, 2) that the ergometer accounts for changes in kinetic energy and 3) the ergometer accounts for the non-linear relation between air-frictional forces and velocity. The SRM Ergometer has a free mode with a gear box and a big flywheel, so requirements 1 and 2 are fulfilled. It is unknown if the brake algorithm of the ergometer is linear or non-linear and how this mimics real life cycling. The aim of the present study is therefore to determine the relationship between the mechanical power output and the velocity in the SRM ergometer compared to cycling on a velodrome.

Methods: The relation between mechanical power output and velocity in incremental cycling on an SRM Ergometer (2Hz sampling rate) was determined with the ergometer set in the "Open End Test" mode, which allows the cyclist to freely choose his gear and self-select his pace. Power output and velocity were collected over 30 s intervals of steady state cycling per stage, resulting in the power-velocity curve. The SRM Ergometer was propelled using a dynamic calibration rig to simulate a pedalling cadence ranging from 60-160 rpm, with 10 rpm steps through gears 7-12 of the Rohloff nave. The rig was attached to the crank of the SRM Ergometer via a counterbalanced double universal joint. The axle was centred at the bottom bracket of the SRM Ergometer and attached to the crank at the position of the left pedal. By upshifting gears and increasing cadence, a range of velocities and accompanying power outputs could be evaluated. The calibration rig was powered by a 3 Ph – AC electro motor with a maximum power output of 2.2 kW. Data of 2 elite track pursuit cyclists were obtained for comparison with the ergometer. Cyclist 1 rode in standard position and cyclist 2 in aerodynamic position on a 250 m indoor velodrome in Alkmaar, the Netherlands, with an air density of 1.19 and 1.20 kg.m³ respectively. The track bikes were equipped with a SRM 7 track system. Sample rate was set at 2 Hz. Two laps at six different velocities were cycled, starting at 30 km/h with an increase in velocity of 5 km/h to 55 km/h. For SRM ergometer cycling as well as for track cycling, trend lines were added based on least-squares fit, and coefficients of determination were obtained. The best fits were used to predict power output at fixed speeds between 25 and 60 km/h for the ergometer and track cyclists. From these data Pearson product-moment correlation coefficient and absolute and relative differences in power output between the ergometer and track cyclist were determined Purpose: The objective of this study was to determine if exercise mode played a part in the acute immune responses to exercise.

Results: Power fit trend lines were found to resemble the best fit for the power-velocity curve for both the SRM Ergometer as well as in the real world situation (see Figure 1). This indicates that the SRM Ergometer uses a non-linear instead of a linear braking algorithm, related to the velocity of the flywheel. The correlation for the predicted power output at fixed speeds was perfect ($r=1.000$) between the SRM ergometer and both cycling position on the track, with a standard error of the estimate of 1.64 and 2.96 respectively for standard and aero position. At high velocities, the SRM Ergometer required a similar power output as standard cycling but a higher power output than required in track cycling in aero position at the same velocity (see Table 1).

Conclusion: The non-linear power-velocity curve of the SRM Ergometer that closely resembles the power-velocity curve of track cycling indicates that it mimics real life cycling behaviour and that it therefore could be used to simulate free ride efforts like time trials and constant duration tests to determine mean maximal power output. However, one must be cautious to use the velocity measured by the ergometer to predict field performance, as at the same power output the speed on the track is higher in aero position.

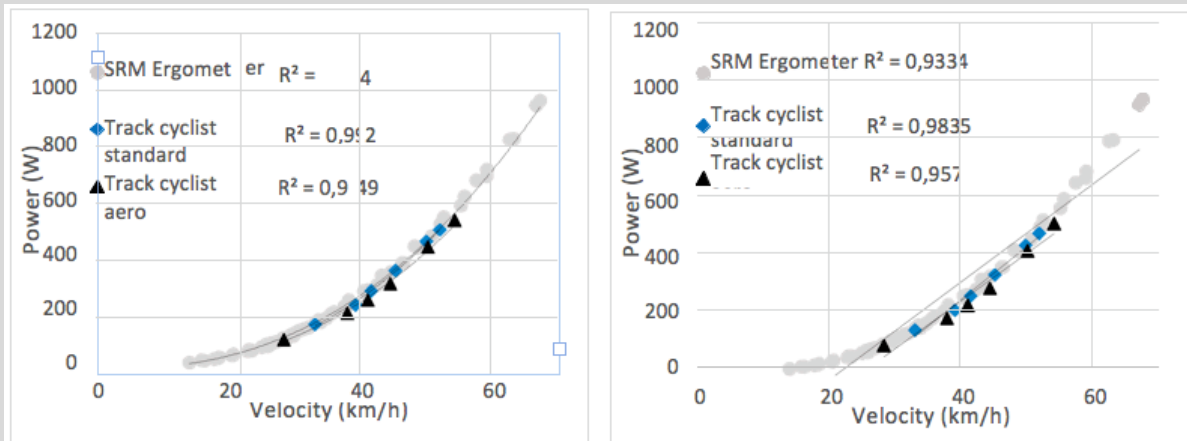


Figure 1 (Left). Linear curve fit of SRM Ergometer (filled circles), standard cycling (blue diamonds) and aero cycling (black triangles) data. (Right): Power curve fit of SRM Ergometer (filled circles), standard cycling (blue diamonds) and aero cycling (black triangles)

Table 1. Calculated power output at fixed speeds (25-60km/h) for SRM Ergometer and Track Cyclist positions, and the difference between them in %.

Velocity (km/h)	Power output SRM Ergometer (W)	Power output standard position (W)	Power output aero position (W)	Difference SRM Ergo - standard (%)	Difference SRM Ergo - aero (%)
25	89	80	78	11.3	13.7
30	137	126	122	9.0	12.3
35	199	185	179	7.1	11.2
40	274	259	248	5.5	10.2
45	363	348	332	4.1	9.3
50	467	454	430	2.9	8.5
55	586	576	544	1.8	7.8
60	722	717	674	0.8	7.2

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