The Peronnet–Thibault mathematical model applied to the record power profile in cycling

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1. Introduction

In cycling, the new concept of record power profile (RPP) allows the expression and the monitoring of the physical potential of the cyclist through the relationship between the different record power output (PO) and the time (Pinot and Grappe 2010, 2011). PO developed by a cyclist is becoming a biomechanical variable of performance, which is measured today in routine directly on the bicycle during training and competition. The RPP appears to be an innovative method for the cycling training process and the evaluation of the different physical capacities of the cyclist (Pinot and Grappe 2010).

In the 1980s, Peronnet and Thibault (1987, 1989) developed a physiological model of running performance. Their analysis provides a description of world running records. The model allows the computation of an objective measure of endurance: the index of endurance capability. They suggested that the slope of the relationship between the fractional utilisation of VO₂max and the running time from 7 min to 2 h (expressed on a logarithmic scale) may be a convenient index of endurance capability (Peronnet and Thibault 1987, 1989). Indeed, using the fractional utilisation of VO₂max, it is possible to compare the endurance capability in runners with different VO₂max and performance level. So, we wondered whether we could obtain the same relationship when applying this model within a broader range of time duration developed by the cyclists. To the best of our knowledge, that was not made yet.

The purpose of this study is to demonstrate that the relationship between the record PO expressed according to maximal aerobic power (%MAP) and the time (expressed on a logarithmic scale) is similar to the mathematical model of Peronnet and Thibault.

2. Methods

During a cycling competitive season (February–September), 20 cyclists carried out their training and competitions with a powermeter (SRM Professional Training systems, Schoberer Rad Messtechnik, Jülich, Germany) on their bike. Their mean (+ SD) age, height, body mass and MAP were 24 ± 4 years, 178 ± 4 cm, 67 ± 6 kg and 6.4 ± 0.4 W kg⁻¹, respectively. Ten cyclists were members of professional cycling teams. The others (n = 10) were elites and classed first category in France, six of whom belong to their U23 national team. All the cyclists were oriented to the high-performance level. All the data were analysed to determine the RPP of the cyclists. The different record PO corresponds to 9 maximal mean power (MMP) for times of 5, 10, 20, 30, 45, 60, 120, 180 and 240 min. The RPP of an athlete corresponds to the relationship between the 9 MMP and the different durations including all the races and trainings during one season of competition from a longitudinal PO follow-up. The PO in the RPP was expressed according to the cyclist’s body weight (W kg⁻¹). We chose the records PO on 5 min to express MAP, unlike to Peronnet and Thibault (1987) who have fixed the time sustained at MAP (expressed in maximal oxygen consumption) to 7 min.

3. Results and discussion

The average RPP of the 20 cyclists expressed in W kg⁻¹ according to a logarithmic scale of time represents a linear regression (R² = 0.99, p < 0.0001; Figure 1). The aerobic record PO linearly decreases between 5 min and 4 h similarly to the model of Peronnet and Thibault (Pinot and Grappe 2010). The record PO at 5 min (between 5.5 and 7 W kg⁻¹) was close to PO at MAP evaluated in laboratory from incremental exhaustion test (Lucia et al. 2001; Faria et al. 2005). The Peronnet and Thibault model takes into account the performances between 3000 m and marathon (between 7 min and ~2–3 h). In cycling, the average durations of the professional road races are between 5 and 7 h. In our cyclist population, half are elite cyclists and the races do not exceed 5 h. So, we took the record PO up to 4 h.
Our model allows the representation of the aerobic potential of the cyclist according to a linear regression following the equation:

\[ \text{PO} = -0.6 \ln T + 7.5 \] (with \( \ln T \) = natural logarithm of cycling duration in minutes).

If the decrease in PO (between 5 min and 4 h) is converted in the reduction of the fractional utilisation of MAP (%MAP), the relationship is also a linear regression \( (R^2 = 0.99, p < 0.0001; \text{Figure 2}) \). Thus, the relationship is similar to that observed by Peronnet and Thibault with the runners from speed measurements.

A definition generally employed for the endurance capability is the capacity to decrease the loss of power with the increase of the exercise duration (Peronnet and Thibault 1987). So, our results suggest that the slope of the linear regression between the record PO and the ln \( T \) could be an index of the endurance capability in cycling.

The mean index of endurance found in our study is \(-9.8\) that does not correspond exactly to the index values that Peronnet and Thibault found with the runners (–4 to –8).

A future study will deal with the analysis of the index of endurance in cyclists with different skills and competition levels.

4. Conclusions

The results of this study show that the relationship between the fractional utilisation of MAP (according to the record PO) and the time (expressed on a logarithmic scale) is linear from a longitudinal PO follow-up among a heterogeneous population of cyclists. So, the Peronnet and Thibault model seems to be suitable with record PO measurements in cycling to determine an index of endurance from the slope of the relationship.

References