METHODS TO ASSESS PERFORMANCE IN ELITE CYCLISTS IN THE FIELD

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The three Grand Tours (Giro d'Italia, Tour de France and Vuelta a España) have grown and evolved over time to become the most difficult and heralded sporting events in the world. Today's Grand Tours are usually composed of three stage types: flat, mountain and time trial (individual and team). Although the distances have gradually decreased from 1927, the Tour has maintained its current configuration of 21 stages raced over 3 weeks. Physiologically, there is good evidence to suggest that a top ten finish in any of the Grand Tours is likely to require a maximal oxygen uptake (VO_2 max) close to 85 ml/kg/min[1-3]. To develop such physiological capacities, a suitable genetic potential and years of training need to be combined. Typically, cyclists will do a lot of their training during races, using certain events as conditioning, without aiming at achieving the best possible finish. Many athletes therefore have more than 70 days of competition every year, some even approaching 100 days of racing. Given this high competition load, it is very difficult to objectively measure performance and training adaptations, as the race result usually does not reflect the pure physical performance, due to there being a large tactical element. It is therefore important to be able to monitor each athlete, regardless of their busy racing schedule, in order to optimise their training and improve performance. In this context, tools have been developed which allow an objective estimate of performance and an assessment of internal training load, even while racing.

THE SESSION RATING OF PERCEIVED EXERTION METHOD

A common approach used to assess the intensity of exercise, which integrates the perceptions of effort of the athlete, is the rating of perceived exertion (RPE). In this method, an athlete will subjectively rate how hard they perceived a training session to be. Many studies have shown that a single session-RPE (sRPE) rating accurately reflects the physiological intensity of an exercise session. sRPE is therefore a valid subjective method to quantify training

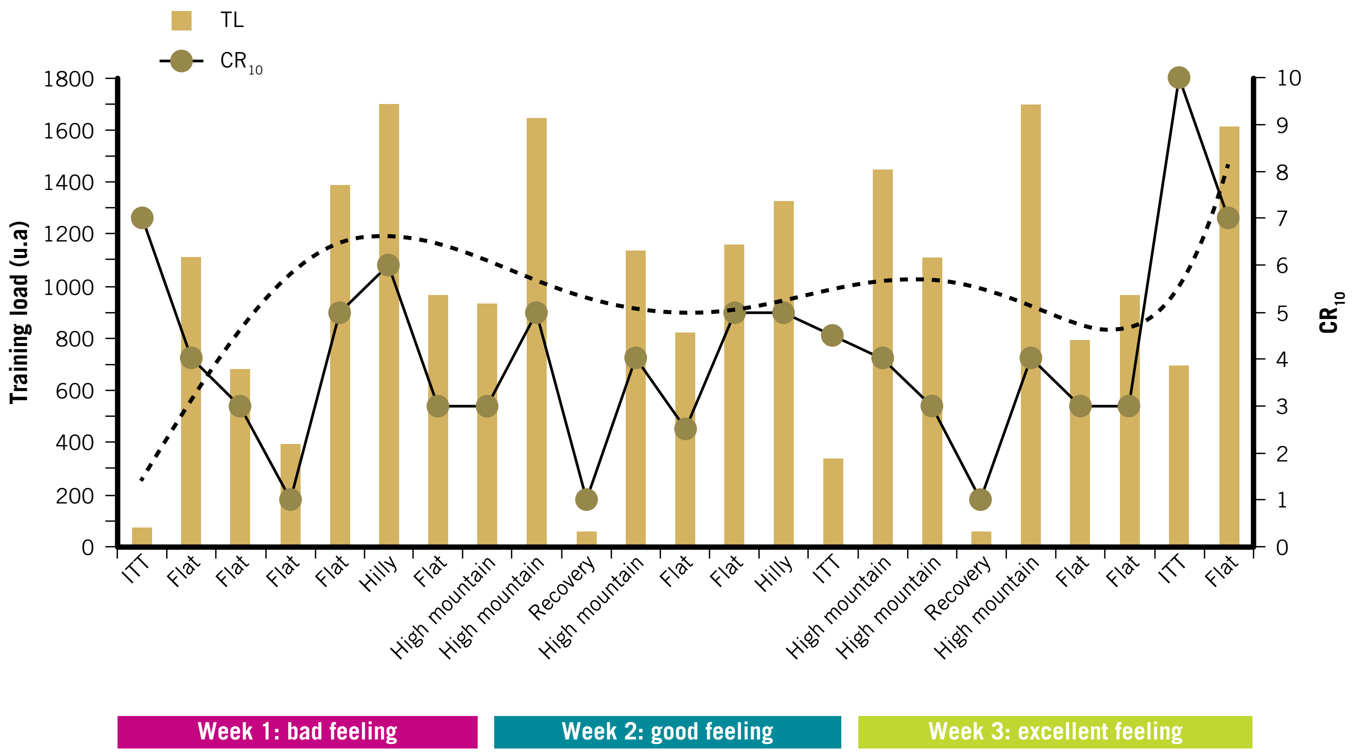


Figure 1: Training load (TL, left vertical axis) and RPE (according to the CR_{10} scale, right vertical axis) each day during the 3 weeks of a Grand Tour for a cyclist based on his subjective perception and the length of each stage. The dotted line shows the general trend of TL. RPE=rate of perceived exertion, ITT=individual time trial.

load (TL) for cyclists[4]. TL is calculated by multiplying the sRPE by the duration of the exercise bout to provide a measure of load in arbitrary units[4]. The intensity is described as a number (0 to 10) on the so-called CR_{10} RPE scale[5], with 0 being low-intensity and 10 being high-intensity. Figure 1 shows the evolution of both TL (measured in 'arbitratry units', u.a) and sRPE for each day during the 3 weeks of a Grand Tour for a cyclist, based on his subjective reporting of the sRPE for each stage. At the end of the race, the level of fatigue was not maximal and the athlete appeared to have some degree of freshness, indicated by the low sRPEs on many of the later stages. It can also be observed that when TL was very high for one stage, it is significantly reduced the next day, possibly owing to short-term fatigue. Overall, the cyclist in Figure 1 seems also to manage his physical capacities every day based on the characteristics of the different stages (time trials, flat, mountain), as high sRPE are observed during stages which are important for the overall classification of the race (mountain stages, time trials).

THE POWER PROFILE

The sRPE is, however, a subjective measure and it is clear that other, objective methods are needed to complement this approach. The development of new technologies to measure power output (PO) in watts (W) during competition provides opportunities to evaluate a cyclist's endurance performance. Taking into account a certain caution regarding the validity of the power meter data (due to potential drifts in calibration), it is now possible to monitor PO every day during the 3 weeks of a Grand Tour with a high reliability. This allows a more objective and accurate analysis of the cyclist's level of performance, taking into account the relationship of PO vs. time. A certain power output can only be sustained for a limited amount of time and this relation between PO and time is hyperbolic. The higher the exercise intensity, the shorter the exercise duration will be. This decrease can be explained by the interaction of the different bioenergetic processes contributing to energy supply. In general, we can consider that there is an average loss of 1 W every minute between 20 and 60 minutes during a maximal effort. So a cyclist who is able to maintain 400 W for 20 minutes will only maintain 360 W after 60 minutes[6].

An original study was conducted in a heterogeneous population of cyclists recording the personal best 'record' PO (i.e. the highest PO produced by a cyclist over a given duration) over the course of a competitive season to analyse the effect of the cyclist's race performance on the PO-time curve[6]. The 'Record Power Profile' (RPP) was measured for 13 effort durations (during training and races) of 1, 5, 30 and 60 seconds, and 5, 10, 20, 30, 45, 60, 120, 180 and 240 minutes (Figure 2). The PO can be expressed relative to the cyclist's body weight (W/kg) or as an absolute PO. Experience shows that the majority of the RPP are obtained in races except those of 1 and 5 seconds, which are generally obtained during training. This apparent anomaly can be explained by the fact that cyclists generally provide this type of effort (sprint) at the finish of a race, at which time they already have a degree of accumulated fatigue (20% PO average decrease compared to a rested state). In the above-mentioned example (Figure 2), one can observe that the RPP of the subject decreases by 0.6 W/kg (39 W) between 20 and 60 minutes. Typically, the power output level during different time intervals will also reflect each athlete's tactical role, with team helpers showing typically high RPP in the middle duration range due to work performed for their leaders, while sprinters show high RPP in the short durations, due to their role in winning races. Grand Tour contenders have typically higher RPP compared to team helpers of a similar weight.

The originality of the RPP is that it represents a valuable physiological signature of the physical potential of the cyclist. Thus, analysis of the power profile based on the RPP during a Grand Tour is worthwhile, as it allows an objective evaluation of each athlete's performance when comparing the race power outputs for different durations to historical data of the same athlete (Figure 3).

Figure 4 presents the comparison of the power profile of a cyclist during a Grand Tour (in blue) with his RPP (in red) to determine the so called 'stimulation profile' (in black) of the cyclist during the 3 weeks of the race. The stimulation level determines how much of his potential power the athlete is producing during a given race. In this case, the rider reaches between 90 and 100% for efforts of longer duration (>20 minutes), i.e. up to his expected level. However, for this cyclist, the level of stimulation for the shorter durations (45 seconds to 5 minutes) was lower (65 to

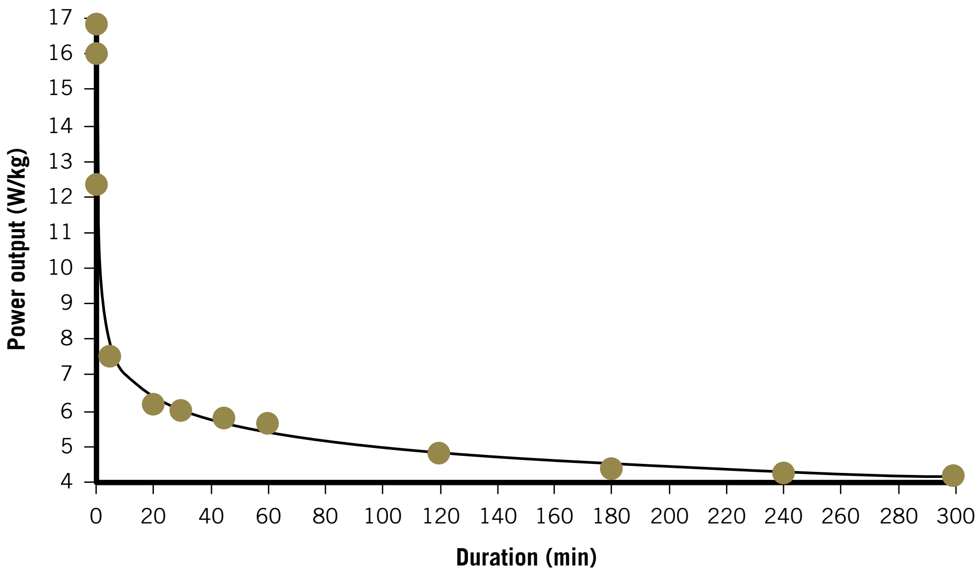
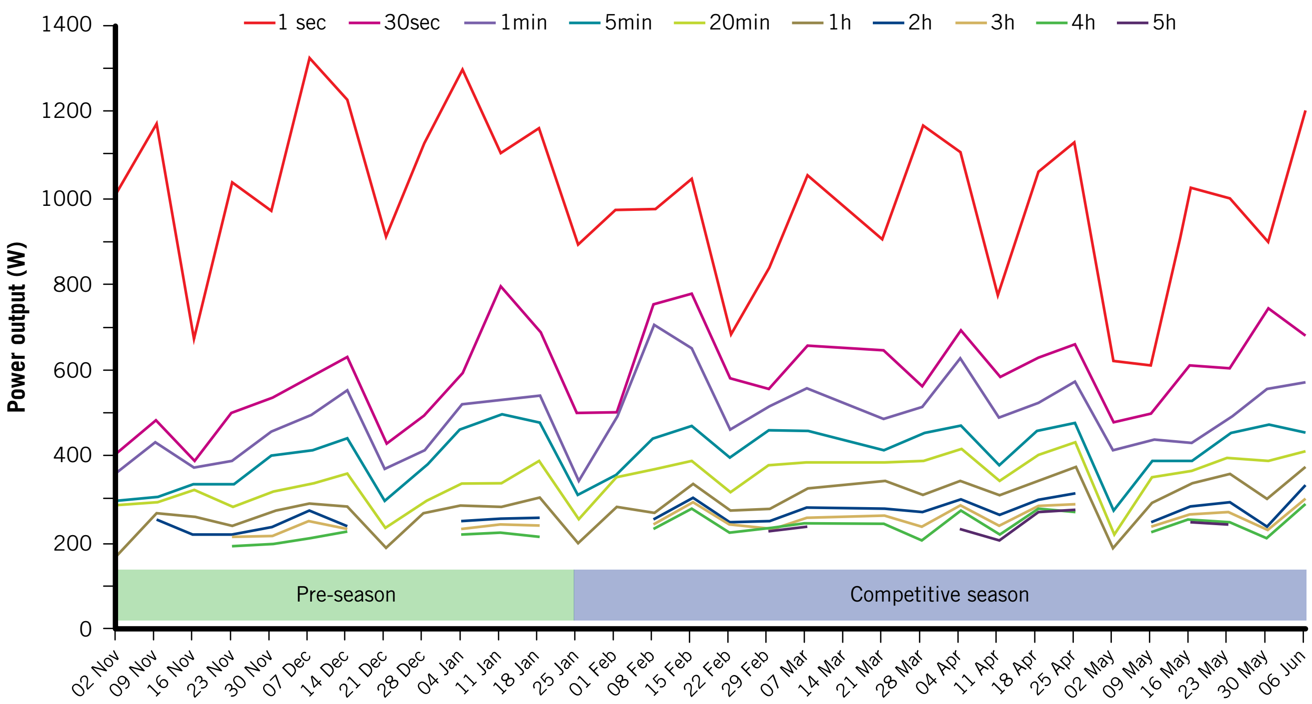


Figure 2: Example of a Record Power Profile (RPP) for a good climber established with data over several months. The vertical axis displays the power output of the athlete in W/kg bodyweight, the horizontal axis the duration of the effort.

Figure 3: Evolution of the different records power during a season.



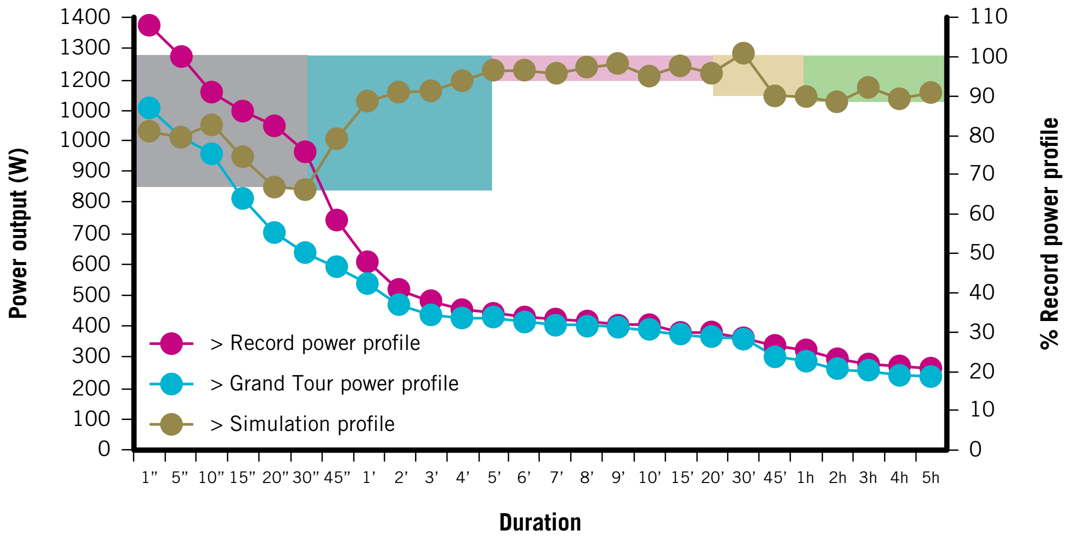


Figure 4: Comparison of a cyclist's power profile during a Grand Tour (in blue) with his RPP (in magenta) according to the different exercise intensity zones (rectangles of different colors) to determine the stimulation profile (in dark gold). RPP=record power profile.

95%), probably due to his role within the team, where his task was to work for his team leader, rarely having to make extreme efforts over short timeframes. Analysing the stimulation profile in this way for each cyclist in the team allows a better identification of the level of performance of the rider during the 3 weeks of racing. It can also be used to assess the collective strengths and weaknesses of a team. This is an attractive concept for the coach to use in order to track the cyclist's fitness. The coach will know precisely if the athlete is close to his optimal fitness and might use this information to advise the sports director accordingly with regard to tactical race planning.

MAXIMAL AEROBIC POWER

From a more physiological perspective, the most important variables in terms of power output are the maximal aerobic power (MAP), typically determined from a graded exercise test and the sustained time equivalent at MAP (T_{MAP}), denoting how long MAP can be maintained for. These measures are fundamental parameters in the training process in cycling. MAP is a marker used by several coaches and scientists to assess the aerobic potential of the athletes, to determine specific exercise intensities and to monitor the adaptation to training. In addition, T_{MAP} can be used to improve the models of interval training sessions by indicating both the optimal duration of effort and the appropriate recovery time between different interval series. A recent method was proposed for measuring MAP in real cycling conditions, thereby avoiding the bias and limitations that may be encountered in many laboratory protocols[7] (such as protocol-bias, motivation of the athlete and characteristics of the ergometer). MAP can be determined from RPP using the PO measurement from training/racing by analysing the linear decrease in record PO between 5 minutes and 4 hours when the duration is expressed as a logarithmic function of time ($PO\text{-}Log_{time}$). MAP is defined as the first record PO included in a confidence interval (range between 3 and 7 minutes) and T_{MAP} as the sustained time equivalent at MAP[7]. The average MAP and T_{MAP} reported for 26 professional and amateur cyclists was 456 ± 42 W (6.87 ± 0.5 W/kg) and 4.13 ± 0.7 minutes, respectively[7]. Professional cyclists had a shorter T_{MAP} (-13.5%) than amateur cyclists (3.86 minutes vs. 4.46 minutes) with a wide inter-individual variability of T_{MAP} (coefficient of variation = 17%) for all the cyclists (ranged between 3 and 6 minutes). MAP of professional cyclists (476 W, 7.02 W/kg) was higher than those of elite amateur cyclists (433 W, 6.70 W/kg). This represents a difference of 9.9% and 4.8% for the absolute MAP and the relative MAP between the two groups of highly-trained athletes.

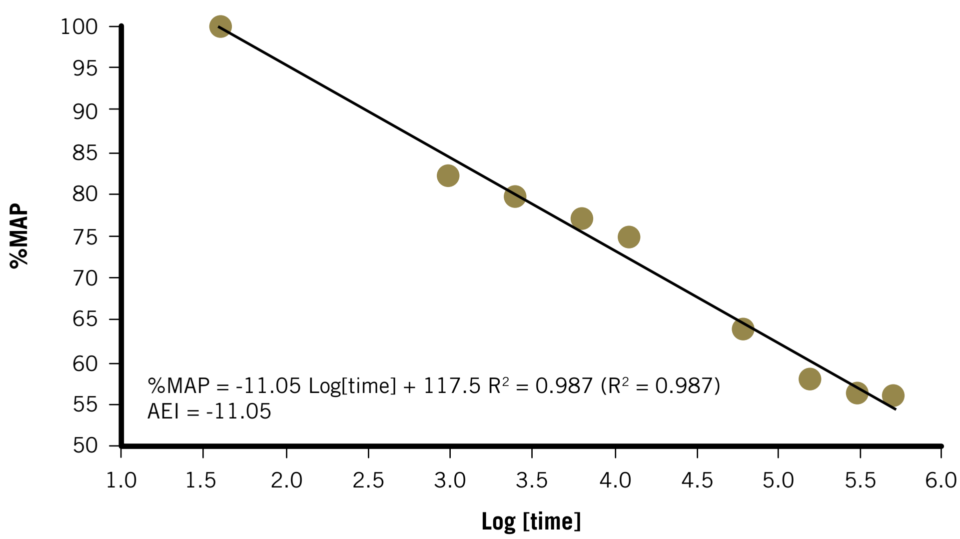


Figure 5: Relationship between the percentages of the records PO expressed according to MAP (vertical axis) and the logarithm of the duration (horizontal axis). The slope of the linear regression represents the Aerobic Endurance Index (AEI).

AEROBIC ENDURANCE INDEX

Peronnet and Thibault[8] developed a physiological model of running performance that allows the computation of an objective measure of endurance: the Aerobic Endurance Index (AEI). It corresponds to the slope of the relationship between the percentage of VO_2 max which can be sustained and the running time from 7 minutes to 2 hours. Using this model, it is possible to determine the AEI of a cyclist expressing all the record PO in terms of percentage of MAP (%MAP) between T_{MAP} and 4 hours according to the Log_{time}[7]. The slope of the relationship between %MAP and Log_{time} represents the AEI of the cyclist – the lower the slope, the higher the aerobic endurance (Figure 5). The AEI ranged between -8.3 and -11.3 for both professional and elite amateur cyclists, with no significant difference found between the two groups[8]. The AEI also reflects the capacity to limit a decrease in PO with increased duration of exercise. The higher the AEI, the better the aerobic endurance capacity.

The %MAP-Log_{time} relationship allows a coach to track various aspects of cyclist fitness without the need for laboratory testing:

1. He can compare the AEI of different cyclists.
2. He can monitor the changes in AEI over the years and the seasons.
3. He can draw the virtual %MAP-Log_{time} relationship for a cyclist who never reached his maximum physical potential over various exercise durations (to highlight potential areas of improvement for an athlete).

SUMMARY

During racing and training, subjective and objective methods to monitor the performance of the athlete are essential. The sRPE method to quantify training load is a simple and reliable tool for the coach. The objective measurement of power output in the field to obtain RPP permits the determination of the physical potential of an athlete and provides the possibility to analyse his performance based on previous data in-competition. Physiological measures such as the AEI can further help to fine tune performance in the field.

Using these methods allows coaches to characterise and monitor their athlete, even within a tight racing schedule and provide advice to athletes and their team management to optimise performance.

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A top ten finish in any of the Grand Tours is likely to require a maximal oxygen uptake close to 85 ml/kg/min

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