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A six-year monitoring case study of a top-10 cycling Grand Tour finisher

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Abstract
This study analysed the evolution of the physical potential of a twice top-10 Grand Tour cycling finisher (Tour de France and Vuelta a España) whose training was monitored between the ages of 18 and 23 years. The world-class cyclist's power output (PO) data and training indices were analysed over six years to determine the evolution of his record power profile and training load (TL), which were estimated by using the session rating of perceived exertion (RPE) method. The total annual duration and TL increased through six seasons by 79% and 83%, respectively. The record POs in all exercise intensity zones improved over the six years. The increases in TL, monotony (+34%) and strain (+162%) from the junior category to the world-class level significantly correlated with an improvement in his aerobic potential, which was characterised by an increase in the record POs between 5 min and 4 h. This case study of the performance level and training parameters of a world-class cyclist provides comprehensive insight into the evolution of a cyclist to the top level. Furthermore, determining the record power profile of this athlete over six competitive seasons illuminates the maturation of the physical potential of a top-10 Grand Tour finisher.

Keywords: *performance, elite cycling, training load, power output, physical potential*

Introduction

Long-term monitoring of training and performance data of world-class athletes is rare. As noted by Mikulic (2011), the rarity seems to be due to both limited access to elite athletes and the finite nature of the population. A few multiyear case studies described physiological changes in high-level athletes, including a female marathon world record holder (Jones, 1998, 2006), several Olympic and world champion rowers (Lacour, Messonnier, & Bourdin, 2009; Mikulic, 2011), a Tour de France cycling race winner (Coyle, 2005) and a top-level soccer referee (Weston et al., 2011). These case studies observed changes in performance and physiological parameters, such as maximal oxygen uptake ($\dot{V}O_2\,max$), which is generally considered the most important physiological measure in the assessment of potential for endurance exercise. Among these previous studies, only two provided insights into physiological and performance improvements that lead to the elite status of the athlete (Coyle, 2005; Mikulic, 2011). Unfortunately, the scientific validity of Coyle's study cannot be confirmed because of the subsequent confession of doping by the studied athlete (Lance Armstrong). To the best of our knowledge, no study has analysed the relationship between training load (TL) and improvement in the physical potential of a top-10 Grand Tour finisher.

In cycling, analysis of the power output (PO) provides a more valuable and relevant method for quantifying the TL and cycling performance than oxygen consumption (Bishop, Jenkins, & Mackinnon, 1998; Jobson, Passfield, Atkinson, Barton, & Scarf, 2009; Lucia et al., 2004; Nevill, Jobson, Davison, & Jeukendrup, 2006). PO is becoming a widely recognised biomechanical variable of performance because it is measured directly on the bicycle during training and competition. Moreover, the PO during competition is a reliable way of assessing physical potential (Bosquet, Leger, & Legros, 2002). Monitoring changes in the record POs over several years can be used to determine the record power profile and peak performance level of a cyclist (Pinot & Grappe, 2011). The record power profile is the relationship between different sequential records of PO, obtained during training and

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competitions, and the corresponding time durations between 1 s and 4 h (Pinot & Grappe, 2011). The record power profile changes in successive years can be used to track progress in all physical abilities specific to cycling.

In conjunction with tracking physical performance progress, monitoring of the TL is important to optimise performance. Different methods exist to quantify the TL of cyclists, from heart rate measurements, PO data and psychobiological indices, such as the rating of perceived exertion (RPE) (Jobson et al., 2009). Rodriguez-Marroyo et al. (2012) showed that the session RPE method, proposed by Foster et al. (2001), appears to be a valid and reliable technique for monitoring the TL in cycling. Although it is an easy and non-invasive tool for coaches to quantify the physiological load, the scientific literature lacks multiyear TL monitoring of high-level cyclists that would provide insight into the training process needed to reach the top level.

The purpose of the current study was to analyse the evolution of POs in the different exercise intensity zones of a twice top-10 Grand Tour cycling finisher (Tour de France and Vuelta a España) based on TL monitoring, between the ages of 18 and 23 years when he reached the top level. The Tour de France, the most famous cycling race in the world, has already been the main topic of several publications (Vogt, Schumacher, Roecker et al., 2007; Vogt et al., 2008). The present study can expand on the knowledge base of the physical abilities required to finish in the top-10 of this world-class event.

Methods

Participant

The participant provided written informed consent for his POs and TL data to be used in this case study, which was approved by a local ethics committee that complies with the international ethical standards described by the Declaration of Helsinki. Born in 1990, the cyclist's height is 1.80 m, and his optimal body mass, measured from his mean body mass during the periods of goal races, increased from 62 kg (2008) to 65 kg (2012–2013). During the preparatory period for the 2013 season, his $\dot{V}O_2\,max$ was 5.55 $L \cdot min^{-1}$ (85 $mL \cdot min^{-1} \cdot kg^{-1}$) according to an incremental test performed in a medical centre. The ramp test (25 $W \cdot min^{-1}$) was performed on an electrically braked cycle ergometer (Monark 839E, Stockholm, Sweden), and the ventilatory exchanges were measured with a K4b2 breath-by-breath portable gas analyser (COSMED, Rome, Italy). He began cycling competitively when he was eight years old. He started competing at the international level in 2008 in the under-19 category. In 2010, he turned professional by joining a World Tour cycling team after only one year in the under-23 category and became the youngest winner of a prestigious mountainous stage race, the "Giro of Valle d'Aosta." Categorised as a stage race cyclist and a world-class climber, this athlete's rankings in the overall classifications of stage races (from six days to three weeks) have progressively improved since turning professional. In 2012, he became the youngest cyclist to finish in the top-10 of the Tour de France since 1947. His results continued to improve in 2013 by placing in the top-10 of several World Tour one-week and three-week stage races. He came fourth in the Tour of Switzerland, eighth in the Tour of Catalonia and seventh in the Vuelta a España.

We did not alter the original training program planned by the cyclist's coach, who used the TL indices to elaborate it. With training and competition, he cycled between 14,733 km (2008) and 29,383 km (2013) per season. Most of the competitive seasons adopted the same model, outlined below:

1. A preparatory period of approximately 12 weeks, which included basic and foundation training (general physical preparation, cycling workouts at low to moderate intensities and strength training). During this period, non-cycling activities comprised 30–40% of total training time, while cycling activities (road cycling, mountain bike and cyclo-cross) represented the remaining 60–70%.
2. A competitive period divided into three macrocycles, each of which featured a specific period with the aim of improving his peak performance level. These consisted of five to six weeks of cycling workouts, mixing high-volume and high-intensity training with races used as training; two to three weeks of goal races, with tapering before and between the races; followed by one to two weeks of recovery. During the competitive period, training was exclusively comprised of road cycling workouts.
3. A rest period of between four and six weeks.

SRM measurements

The cyclist performed all training sessions and competitions over the six-year period from 2008 to 2013 with a mobile power meter mounted on his road bike (SRM Professional Training systems, Schoberer Rad Messtechnik, Jülich, Germany). He was instructed on the use of the SRM PowerControl (bike computer) and informed of the importance of performing the zero offset frequency procedure to obtain accurate PO data (Abbiss, Quod, Levin, Martin, & Laursen, 2009; Gardner et al., 2004). According to the manufacturer's recommendations, the calibration slope of the SRM was checked three times during each season using a static calibration to determine the relationship between the torque (Nm) and frequency (Hz) (Wooles, Robinson, & Keen, 2005). Data were sampled at 1 Hz. Throughout the six-year period, each of his road bikes was equipped with an SRM power meter. Data were not sampled over two periods of two weeks in 2009 and 2010 due to SRM breakdown.

SRM data analysis

After each training session and competition, the cyclist transferred his data from the power control to a web server (velobook.net, Velobook, Anglet, France). After downloading his files from the server, the data were screened in order to exclude the files that were erroneous. Possible errors occurred due to artefacts, incorrect calibrations, speed sensor defaults that falsified the average PO and waves of television motorcycles in some races which interfered with the power meter signal. Of the SRM files, 95% were considered valid and were subsequently analysed using TrainingPeaks software (WKO+, v3.0, Peaksware, CO, USA) in order to identify the cyclist's maximal mean power in each SRM file. The various record POs corresponded to the highest mean maximal powers developed each year by the cyclist on durations of 1, 5, 30 and 60 s and 5, 10, 20, 30, 45, 60, 120, 180 and 240 min. The term "record power output" is preferred instead of "maximal power output" because we consider that the highest PO obtained during competition and training, that is, the highest PO developed by the cyclist, is not the maximum that can be achieved by the athlete. The cyclist's record power profile was determined for each competitive season (from 2008 to 2013) from the relationship between the 13 highest record POs and the different durations. The PO in the record power profile was expressed in relation to the cyclist's body mass ($W \cdot kg^{-1}$) according to the methodology of Pinot and Grappe (2011).

The exercise intensity zones were defined as described by Pinot and Grappe (2011) in order to analyse the skills of the cyclist according to the levels of POs in different exercise intensity domains (Pinot & Grappe, 2011): zone 1, moderate exercise intensity (record POs between 1 and 4 h); zone 2, heavy exercise intensity (record POs between 20 and 60 min); zone 3, low part of the severe intensity zone (record POs between 5 and 20 min); zone 4, high part of the severe intensity zone (record POs between 30 s and 5 min); and zone 5, force-velocity (record POs between 1 and 30 s).

Quantification of internal training load

The internal TL was determined by multiplying the training duration (min) by the session RPE as described by Foster et al. (2001). After each training session and competition, the cyclist was asked to rate the intensity of the whole session on the 10-RPE scale, modified by Foster et al. (2001), before uploading the SRM file to the web server. Prior to using the web server, the athlete was familiarised with the scale for rating perceived exertion. The "strain" and "monotony" were calculated in accordance with the method of Foster et al. (2001). The monotony index characterises the variability of training and was calculated weekly by dividing the weekly mean TL by the standard deviation. It allows to follow the training variability over the weeks. The product of the overall weekly TL by the monotony index corresponds to the index of strain. It is important to monitoring the strain because excessive training strain has shown to be related to overtraining and illness (Foster, 1998).

Statistics

Statistical analysis was performed using SigmaPlot 12.0 software (Systat Inc., San Jose, USA). Descriptive statistics were used, and all data were expressed as mean ± standard deviation with coefficient of variation (CV). Pearson's zero-order correlation coefficients were computed by the least squares method to describe the relationship between selected variables.

A non-parametric Kruskal–Wallis test was used to analyse the differences in the weekly TL, duration, monotony and strain according to the season. When a significant effect was detected, a post hoc comparison was made using Dunn's test. Statistical significance was set at $P < 0.05$.

Results

In total, 2208 sessions were analysed during the six-year study period from 2008 to 2013. These sessions were divided into 1727 workouts and 481 competitions (including 68 time trials). Figure 1 shows that the total annual duration and TL increased over the six seasons by 79% (from 526 h to 943 h) and 83% (from 159,165 Arbitrary Unit (AU) to 291,608 AU), respectively. The increases in the total annual duration and TL were quite substantial (+60% and +62%, respectively) between the ages of 18 and 20 years, becoming more moderate (less than 10% each year) when the athlete turned professional in 2010.

All the weekly training indices increased significantly ($P < 0.05$) between the six competitive

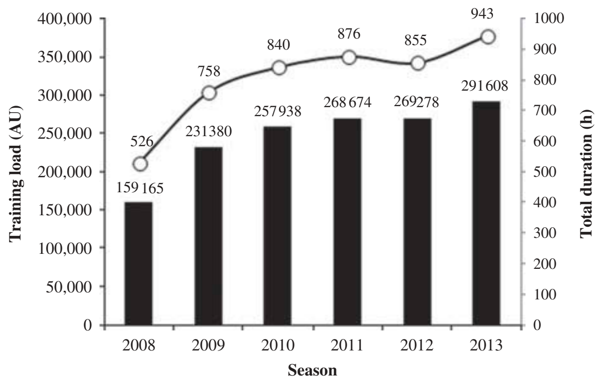

Figure 1. Changes in the annual training load (black bar) and total duration (white circle) (AU: Arbitrary Unit).

seasons with only significant differences between 2008 and all the other seasons (Table I). The mean weekly duration and the TL increased by +79.2% and 83.2%, respectively. The highest values of the mean weekly duration (18.1 h), TL (5608 AU) and strain (9148 AU) were reached in 2013, whereas the highest mean weekly monotony (1.32 AU) was reached in 2012. The monotony and strain indices increased by 36.1% and 162.1%, respectively, with higher coefficients of variation in the last two seasons (74% and 54% for monotony and 87% and 135% for strain). The maximal weekly RPE of each season increased by 28.1% from 5.7 AU (in 2008) to 7.3 AU (in 2012). Moreover, the number of weeks with a high-mean RPE (between 5 and 8 AU) increased from 4 (in 2009) to 11 (in 2012 and 2013).

Figure 2 shows the changes in the record POs for the six competitive seasons within the different exercise intensity zones from the annual record power profile of the cyclist. The changes in the record POs differed according to the exercise intensity zones. In zone 5, the record POs on 1 and 5 s increased slightly during the first four years of the monitoring, before reaching a peak level in 2012. During the following year, these record POs decreased but were greater than in 2011. In zone 4, the record PO on 30 s oscillated between 11.9 and 13.2 $W \cdot kg^{-1}$, whereas the record PO on 1 min peaked at 10.5 $W \cdot kg^{-1}$ in 2013. In zones 2 and 3, the majority of the record POs increased progressively between 2008 and 2012. Between 2012 and 2013, some record POs were slightly higher (10, 45 and 60 min) and others were lower (5, 20 and 30 min) in 2013, but the differences were never greater than 0.1 $W \cdot kg^{-1}$. Further, between 2009 and 2013, the record POs within zone 1 showed stochastic evolution, with the best performance level reached in 2013 for 3- and 4-h durations.

Table II shows the improvements in the different record POs between the first year of monitoring and the year where the maximal annual record PO was reached. The highest improvement was on 4 h, with an increase of 31.6% between 2008 and 2013. The lowest increase was on 2 h, with an increase of 6.9% between 2008 and 2011. Otherwise, all the record POs between 5 and 60 min increased between 12.5% and 15.4%.

Table III shows that the evolution of the mean weekly training duration, TL, monotony and strain are positively correlated with the improvement in the record POs on 5, 10, 20, 30, 45, 60, 180 and 240 min. The mean weekly RPE was correlated with the changes in the record POs on 30 s and on 5, 10, 30, 180 and 240 min.

Discussion

This case study used training monitoring to analyse the six-year evolution of PO in the different exercise intensity zones of a cyclist who finished twice in the top-10 overall classification of Grand Tours at the age of 23 years. Cycling Grand Tours (Tour de France, Vuelta a España and Giro d'Italia) are extreme endurance events, with the athlete covering approximately 3500 km in 21 stages over three weeks. The overall classification of these races is usually decided in mountain ascents and time trials. Some studies have presented PO data of Grand Tours (Vogt, Schumacher, Blum, et al., 2007; Vogt, Schumacher, Roecker, et al., 2007; Vogt et al., 2008) or PO distributions from a one-year

Table I. Changes in the mean weekly duration, RPE, training load (TL), monotony and strain from 2008 to 2013. The values are expressed as mean ± SD (CV) (AU: Arbitrary Unit).

Season	Duration (h)	RPE (AU)	TL (AU)	Monotony (AU)	Strain (AU)
2008	10.1* ± 5.3 (53%)	3.22 ± 1.51 (47%)	3061* ± 1698 (55%)	0.97* ± 0.44 (45%)	3490* ± 2315 (66%)
2009	14.3♠± 5.9 (41%)	3.64 ± 1.46 (40%)	4366# ± 2208 (51%)	1.20 ± 0.53 (44%)	5909 ± 4144 (70%)
2010	16.1 ± 6.5 (40%)	3.60 ± 1.49 (42%)	4960 ± 2541 (51%)	1.20 ± 0.54 (45%)	6978 ± 5740 (82%)
2011	16.9 ± 7.3 (43%)	3.57 ± 1.54 (43%)	5167 ± 2750 (53%)	1.23 ± 0.62 (51%)	7603 ± 6631 (87%)
2012	16.4 ± 8.0 (49%)	3.59 ± 1.81 (51%)	5178 ± 3204 (62%)	1.32 ± 0.98 (74%)	8935 ± 12,092 (135%)
2013	18.1 ± 8.1 (45%)	3.70 ± 1.71 (46%)	5608 ± 3254 (58%)	1.30 ± 0.71 (54%)	9148 ± 9293 (102%)

Notes: * significant difference between all seasons ($P < 0.05$), # significant difference with 2008 and 2013 seasons, ♠ significant difference with 2008, 2011 and 2013 seasons.

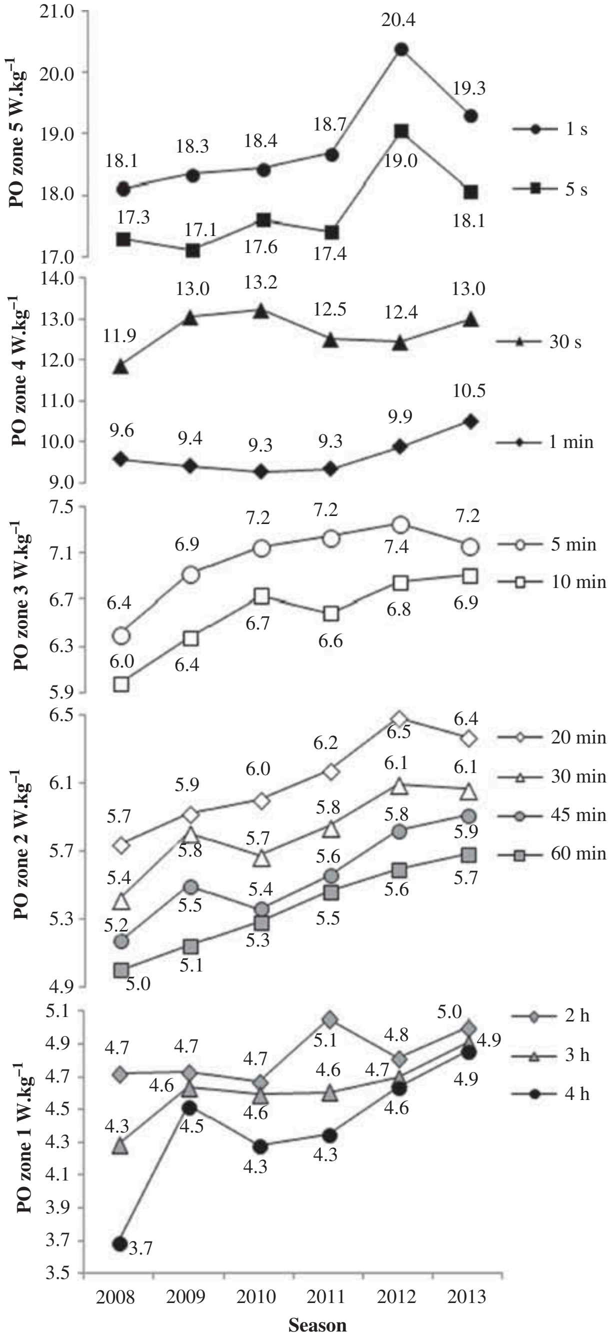

Figure 2. Changes in the different record power outputs (PO) throughout the six competitive seasons within the five exercise intensity zones.

follow-up of world-class cyclists (Nimmerichter, Eston, Bachl, & Williams, 2011), but none have reported the POs of a cyclist in contention for a high overall ranking. Moreover, there are few long-term monitoring studies of the performance and training of world-class endurance athletes, as mentioned by Lacour et al. (2009). This study is the first to describe the performance level required for ranking in the top-10 of cycling Grand Tours. It includes data on the athlete's record power profile and the evolution of his training parameters between the junior category and world-class level.

Table II. Improvements in the different record power outputs (PO) between the first season in the junior category (2008) and the maximal values.

Duration	Record PO gain (%)	Season
1 s	12.6	2012
5 s	10.1	2012
30 s	11.3	2010
1 min	9.7	2013
5 min	14.7	2012
10 min	15.4	2013
20 min	13.0	2012
30 min	12.5	2013
45 min	14.3	2013
1 h	13.7	2013
2 h	6.9	2011
3 h	14.4	2013
4 h	31.6	2013

The main finding of this study was that increases in the TL, monotony and strain from the junior category to the world-class level were significantly correlated with improvement in the aerobic potential of the cyclist characterised by an increase in the record POs between 5 min and 4 h. The record POs in all exercise intensity zones improved over these six years of training. The high $\dot{V}O_2$ max of the cyclist demonstrates his huge endurance capability. The $\dot{V}O_2$ max trainability is determined by both genes and the environment (Tucker & Collins, 2012), and approximately 50% of these two $\dot{V}O_2$ max traits are heritable (Bouchard et al., 2000). As Tucker and Collins (2012) suggested, elite sporting performance is the result of the interaction between genetic and training factors. Thus, both the talent identification and management systems to facilitate optimal training are crucial to sporting success. The athlete in the present study had the opportunity to evolve during the six seasons within well-structured cycling teams.

Programming the TL is very important to enhance the athlete's performance, and hence the necessity to quantify it. As demonstrated by Rodriguez-Marroyo et al. (2012), the session-RPE method, proposed by Foster et al. (2001) and representative of the combined intensity and duration of training sessions, is a valid method for quantifying and monitoring the TL in cycling. The follow-up of the world-class cyclist showed that his session RPE TL progressively increased over the six-year period. The annual training duration increased by 79% (from 525 h in 2008 to 942 h in 2013), with the mean weekly duration increasing from 10.1 h in the junior category to 18.1 h in his fourth professional season, while at

Table III. Correlations between the evolution of the different record power outputs (POs) and the mean weekly training indices during the six-year follow-up. The Pearson coefficients were expressed when a correlation was significant.

Record PO	1 s	5 s	30 s	1 min	5 min	10 min	20 min	30 min	45 min	60 min	120 min	180 min	240 min
Duration	NS	NS	NS	NS	0.93**	0.95**	0.82*	0.83*	0.81*	0.89*	NS	0.90*	0.86*
RPE	NS	NS	0.84*	NS	0.82*	0.84*	NS	0.80*	NS	NS	NS	0.91**	0.93**
TL	NS	NS	NS	NS	0.94**	0.96**	0.84*	0.86*	0.83*	0.90*	NS	0.90*	0.87*
Monotony	NS	NS	NS	NS	0.94**	0.94**	0.90*	0.95**	0.90*	0.89*	NS	0.90*	0.94**
Strain	NS	NS	NS	NS	0.93**	0.96**	0.95**	0.93**	0.92**	0.96**	NS	0.90*	0.89*

Notes: * significant correlation with $P < 0.05$, ** significant correlation with $P < 0.01$, NS: non-significant

the same time, the mean weekly RPE remained stable. His mean weekly TL evolved from 3061 AU to 5608 AU (+83%). The changes of category, associated with his rise to the professional level, can easily explain the strong increase during the first three years (+62%). However, the TL continued to increase until 2013, although it slowed down (+9%) between 2011 and 2013. Therefore, the physical potential of the athlete improved simultaneously with the evolution of the training parameters. Indeed, the evolution of the TL, monotony and strain was significantly correlated with the improvement in the athlete's aerobic ability, whereas this is not the case for the stochastic evolution of his anaerobic potential. It should be noted that this cyclist has focused his training on the development of his main strengths since he was in the junior category with endurance workouts and specific intervals spent in zones 2–3 in ascents. The risk associated with the increased TL is that the athlete goes into non-functional overreaching and overtraining syndromes. Other training data, such as monotony and strain indices, obtained from the TL can be used to follow the adaptation to long-term training and avoid non-functional overreaching or overtraining (Foster, 1998). Thus, the evolution of the TL is associated with that of monotony and strain, but the increase in the CV shows the high variability of the training, notably in the last two years. This variability associated with the increase in the number of weeks at mean high intensity (RPE between 5 and 8 AU) is indicative of the dynamic model of training performed by this athlete.

Monitoring the record power profile through six competitive seasons showed the improvement in the physical potential of this world-class cyclist. It should be noted that the improvements in the different record POs were higher when the PO was expressed as the absolute PO (W) because of the increase in the optimal body mass of the athlete during the study period (+3 kg in five years). However, the increases in the record POs varied according to the different exercise intensity zones. This confirms that the record power profile can yield relevant data on improvements in the cyclist's capacities (Pinot & Grappe, 2011) and that data obtained during competition are relevant and valuable in the assessment of physical potential. As explained by Sassi, Marcora, Rampinini, Mognoni, and Impellizzeri (2006) and Lamberts, Rietjens, Tijdink, Noakes, and Lambert (2010), maximal exhaustion tests are generally disruptive and not well accepted by high-level athletes during periods of training, especially when they are close to important competitions.

The follow-up of the record POs can be used to assess the cyclist's improvements in physical skills within the different exercise intensity zones. Within the force-velocity zone, the cyclist's record POs improved progressively on 1 and 5 s during the first four years of the monitoring, before reaching a peak level in 2012, with increases of 12.6% and 10.1%, respectively, compared to 2008. These record POs were realised during the season when he focused intensively on sprint qualities. During the following year, the record POs decreased, but were still greater than in 2011 (+3.5%).

In the high part of the severe intensity zone, the record POs on 30 and 60 s oscillated during the six seasons within a narrow range of 0.8 $W \cdot kg^{-1}$ and 1.1 $W \cdot kg^{-1}$, respectively. The performance at maximal effort of short durations reflects the cyclist's anaerobic capacity, which corresponds to his major physical weakness. The record POs (13.2 $W \cdot kg^{-1}$ on 30 s and 10.5 $W \cdot kg^{-1}$ on 1 min) do not constitute a high peak performance compared to maximal field POs reported in previous studies (Ebert et al., 2006; Pinot & Grappe, 2011; Quod, Martin, Martin, & Laursen, 2010; Vogt, Schumacher, Roecker et al., 2007; Vogt et al., 2008). This shows that the high part of the severe intensity zone is the least improved physical capacity (+11.3% on 30 s and +9.7% on 1 min).

Conversely, the record POs within the heavy intensity zone 2 and the low part of the severe intensity zone 3 express the major strength of the athlete and correspond to his aerobic power ability. Several studies have shown correlations between aerobic physiological variables, such as $\dot{V}O_2$ max, lactate and ventilatory thresholds and cycling performance between 4 and 60 min (Bentley, McNaughton, Thompson, Vleck, & Batterham, 2001; Coyle et al., 1991; Nimmerichter, Williams, Bachl, & Eston, 2010). Thus, the record PO values of the cyclist measured at 7.4 $W \cdot kg^{-1}$ on 5 min, 6.5 $W \cdot kg^{-1}$ on 20 min, 6.1 $W \cdot kg^{-1}$ on 30 min and 5.7 $W \cdot kg^{-1}$ on 1 h represent the highest field PO values when compared to those reported in the scientific literature (Nimmerichter et al., 2010; Pinot & Grappe, 2011; Quod et al., 2010; Vogt, Schumacher, Roecker et al., 2007; Vogt et al., 2008). They characterise a high level of aerobic power ability. As demonstrated by Pinot and Grappe (2011), among cyclists, climbers have the highest record POs within zones 2 and 3 when the PO is normalised relative to their body mass. The record POs of the cyclist within zones 2 and 3 progressively improved, with a mean gain of 14% between the ages of 18 and 23 years. It increased between 2008 and 2009 by 6%, on average, and then by 2.5% annually until 2012. Since 2012, the improvement seemed to slow down. Therefore, the observed improvements seem to be in agreement with previous studies, which showed that the evolution of the $\dot{V}O_2$ max in some high-level athletes peaked when they reached 20–22 years of age but could slightly increase over several years in other athletes (Jones, 1998; Messonnier, Bourdin, & Lacour, 1998; Mikulic, 2011; Rusko, 1992).

Finally, the record POs between 1 and 4 h in the moderate exercise intensity zone also improved over the six years before reaching a peak level in 2013. Their evolution showed a limit in the estimation procedure of the record power profile because it requires the cyclist to achieve maximal effort on each duration between 1 s and 4 h. This is why the record PO on 2 h only increased by 6.9% and the record PO on 4 h improved by 31.6%, because competitions are less than 4 h in duration in the junior category.

Conclusion

This case study provides comprehensive insight into the evolution of a world-class cyclist from maturation to the top level by monitoring his performance and training parameters. The determination of the record power profile of this athlete over six competitive seasons illustrates the physical potential of a cyclist who finished several times in the top-10 overall ranking of Grand Tours. The follow-up of the different TL indices and annual record POs provides information on the improvement in the physical capacities specific to cycling. In the dynamic model of training undertaken by this athlete over the six years, the evolution in the TL (from the increase in both the duration of weekly training sessions and the number of weeks at high intensity) and strain was correlated with an improvement in aerobic ability. This study provides a real example of how PO data and perception indices of training stress can be used to monitor training and aid the progression of an athlete to a top-class level.

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