Will it make the bike go faster?

A case study of a physiologist supporting a female endurance track cyclist.

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1. Philosophy: A Holistic Approach to Athlete Development.

This case study details the support I provided as a physiologist working as part of a multidisciplinary team to a female cyclist aiming to compete in endurance-based track cycling events at a major international competition.

My philosophy as a physiologist is built around four core values which will continue to be displayed throughout this case study: These values are:

- **Person-Centred:** The athlete's well-being and goals were paramount. Training plans and interventions were tailored to her specific needs, preferences, and feedback. Taking a person first, then athlete approach to support.
- **Integrity:** All support adhered to ethical guidelines and anti-doping regulations. Open communication and collaboration with the athlete and the support team fostered trust.
- **Interdependence:** Recognition of my role within the broader support team. Regular communication with coaches, strength and conditioning coaches, physiotherapists, nutritionists, and sports psychologists ensured a holistic approach to optimising performance.
- **Adaptability:** Training plans and interventions were flexible, adjusting to the athlete's progress, fatigue levels, and unforeseen circumstances while still aiming to keep the main priorities.

2. Background.

2.1 Training History.

The athlete had a background in gymnastics and endurance athletics with limited experience in competitive cycling, only taking up the sport in university. She was identified by the head coach after delivering a strong performance in a university level competition. The athlete was self-coached and not receiving any sport science support at this time. The National cycling program inducted her onto the development programme with the allocation of Physiology and Strength and Conditioning (S&C) support services. All support was to be provided remotely due to university commitments and the athlete's location.

2.2 Initial consultation and assessment.

Due to remote support requirement, the first consultation took place online which included head coach, athlete, physiologist(myself) and the S&C coach. The first meeting centred around current and previous training experiences, short- and long-term plans and the athletes' motivations. As a physiologist, I was seeking to understand more about where the athlete was in terms of physiological capabilities, training load, health, and wellbeing as well as experience of working with a physiologist to best support the transition onto the national cycling development programme. My intention when working with new athletes is to seek to understand where they are on their journey and provide physiology support at the appropriate level, working with the athlete on their development journey and empowering them in all aspects of their support.

3. Exercise testing.

With the remote requirements of support and not having access at the university to a sport science laboratory, I was tasked with how I would assess current physiological capabilities and how I would monitor progress and effectiveness of the programme over time. As a sports physiologist, I approached this task in two ways. Initially I conducted a literature search to better understand the theoretical concepts underpinning sport and exercise testing and secondly, I engaged with other performance physiologists from national and international high-performance teams. There was a strong consensus from both practitioners and the research findings on the validity and reliability of using a Power Duration Assessment or a Critical Power Test to assess physiological capacity remotely. Critical Power (CP) is a graphical representation of the relationship between power output and sustainable exercise duration in cycling (Basset & Passfield, 2000). CP can be visualized as the horizontal asymptote (flat line seen in Fig 1) in a graph plotting power output against sustainable time. This curve shows how power output affects how long you can maintain that effort. CP represents the point where the curve flattens out, indicating you can't sustain higher power aerobically (Vanhatalo et al 2011).

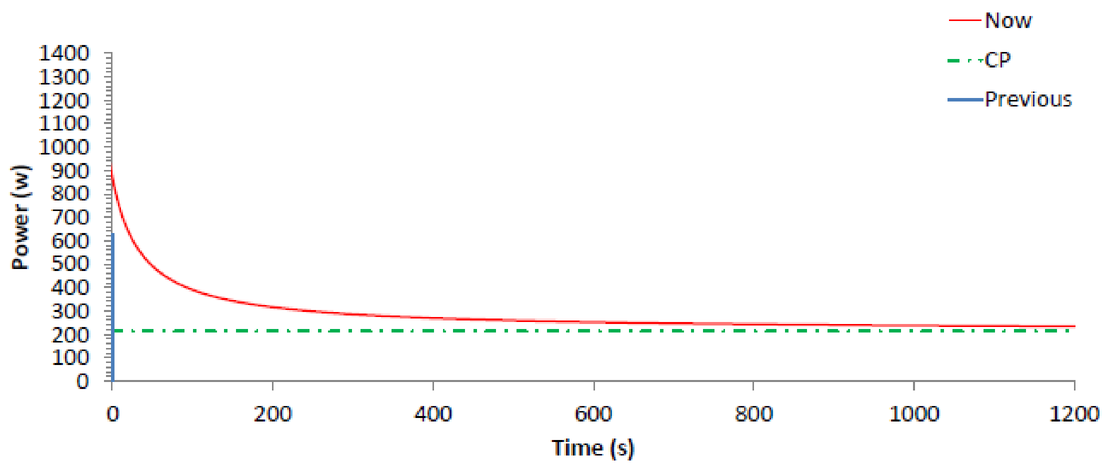
Several studies have investigated the reliability of CP testing protocols. A meta-analysis by Burnley and Jones (2018) demonstrating high reliability of CP measures across various populations and testing protocols, as well as being able to predict endurance performance in both laboratory and field settings (Chidnok et al., 2013; Skiba et al., 2012). Overall, the literature supports the reliability and validity of Critical Power testing in cycling. What was key to me in the decision-making process was the consistent findings across studies and its use in both laboratory and field settings, demonstrated the robustness of CP measurements, making it a valuable tool for myself, the athlete, and coach.

To better understand the delivery environment, I again consulted with the athlete in relation to their equipment, training environment and previous experience of any performance testing. I then collaborated with other physiologists from other national and international high-performance teams on the design of the athlete friendly protocol outlined in Appendix 1 to assess critical power remotely. The protocol was designed based on the literature to be easy to understand, have all relevant information and provide a step-by-step guide. The protocol was shared directly with the athlete, and I talked through each part of the test and how it would 'look' and 'feel' on the day. I then followed up with a conversation two days later to allow time for reflection on the protocol and if there were any questions or supporting information required. The athlete then performed a familiarisation of the protocol to understand power requirements and pacing strategy.

After a successful familiarisation the athlete performed the first critical power test with the results included in the Fig.1 report below.

Power-Duration Assement

[redacted]



Date	Critical Power (W)	Anaerobic Energy (kJ)	Peak Power (W)	3-min Power (W)	5-min Power (W)	12-min Power (W	Bike
[redacted]	219	23.3	869	348		251	TT
Best							

Training Zones	Z1 U	Z2 U	Z3 U	Z4 U	Z5 Mins	Z5 Power
Power	150	205	260	300	10	310
HR	140	160	170	185	8	320
Power/Weight	2.3	3.2	4.0	4.6	6	330
					5	345
[redacted]		CP:Mass	AE:Mass	PPO:mass	4	360
		3.4	363	13.5	3	385
					2	425
					1	530

Notes:

The training zones represent the UPPER value for each zone and to be used as a guide for training zones.

Critical power represents the external power output that can be sustained for a prolonged period of time without fatigue, using the body's aerobic system. The upper boundry of critical power is highest power sustainable without drawing from the anaerobic energy system. The anaerobic energy is the fixed amount of work that can be completed above crticial power.

Fig 1 Critical Power Test Report

This initial testing gave me baseline information on the athlete's current level of aerobic and anaerobic capabilities. Post testing, I organised a testing review to get feedback from the athlete on how it went, ease of use of the protocol and how it felt. This approach really highlighted the importance of the familiarisation pretesting and created time to reflect on how important communication is between athlete and practitioner to develop strong relationships and understanding of why the athlete is being asked to undertake assessments from different practitioners. It can be quite overwhelming for a new athlete transitioning onto a high-performance programme with multiple inputs from multiple practitioners. Creating 'buy in' and understanding from the athlete in the initial stages is key to developing the relationship and empowering the athlete to have ownership of their own development plan. I was then able to discuss all aspects of the CP data acquired displayed in report shown in Fig 1 above including the training zones which I updated within a digital training monitoring platform to accurately monitor training in line with individual testing results. It was important to communicate that this was baseline testing to help inform the coach, athlete and physiologists training prescriptions providing a platform to track and understand how she was responding to the training.

4. Training Monitoring.

I wanted to be able to track both internal and external training load to understand more about the individual athlete's response to training. It is well documented that tracking training load allows practitioners, coaches and athletes to quantify the volume, intensity, and frequency of training sessions. By monitoring training load over time, I would be able to adapt training to elicit specific physiological adaptations, enhance fitness levels, and optimise performance outcomes (Impellizzeri et al., 2019). Due to the requirement of the sport and accessibility of equipment combined with a strong research evidence base, I chose to use heart rate monitoring and rated perceived exertion as methods of monitoring the athlete's internal load. Heart rate reflects the cardiovascular response to exercise intensity, making it a valuable indicator of effort and physiological stress during cycling (Jeukendrup., 2011). It allowed me to understand more about the intensity distribution of each session and ensure that the athlete was training within planned intensity zones.

I was also very keen to include a subjective metric of Rating of Perceived Exertion (RPE). RPE measures how hard an individual feels they are working during exercise. As a physiologist practitioner, I have always found using RPE a very powerful tool to understand more about the athlete and how they feel they are tolerating training. It empowers athletes to adjust their training intensity based on how they're feeling on any given day, which can be particularly important considering fluctuations in energy levels, training load and competition demands. It can also act as an important communication tool to understand how the athlete is coping with each training day and training block and adjust accordingly.

Alongside internal training load I also wanted to collect external training load metrics to monitor the training that the athlete was undertaking daily. Through the digital training monitoring platform and the athlete's bike computer I was able to track metrics such as distance ridden, time spent cycling, and elevation gain for insight into the overall workload placed on the body. Power meters have revolutionised training monitoring in cycling by providing cyclists, coaches and practitioners with accurate and objective measurements of power output during training and competition. As well as training volume metrics, I also collected data on power output which was collected through a power meter on the cranks of the bicycle and gave a precise measurement of the mechanical work performed during cycling and a great insight into the power distribution of each training session and how it aligned to training zones from critical power testing. This objective metric serves as a valuable tool for monitoring training intensity, workload distribution, and pacing strategies (Jeukendrup et al., 2000). This allowed me to assess current training in line with characteristics of power required for elite level endurance track cycling events. It also allowed me to understand more about the relationship between the external and internal training load being placed on the athlete.

Figs 2 and 3 below highlight internal and external metrics collected from a session. I was able to assess training on a session-by-session basis as well as monitor progress over time discussed in the next section. Utilising both internal and external training monitoring gave me a great insight into how the athlete was responding to training and highlights the importance of both subjective and objective data supporting the idea that there is no one single metric that can be used to monitor training load effectively.

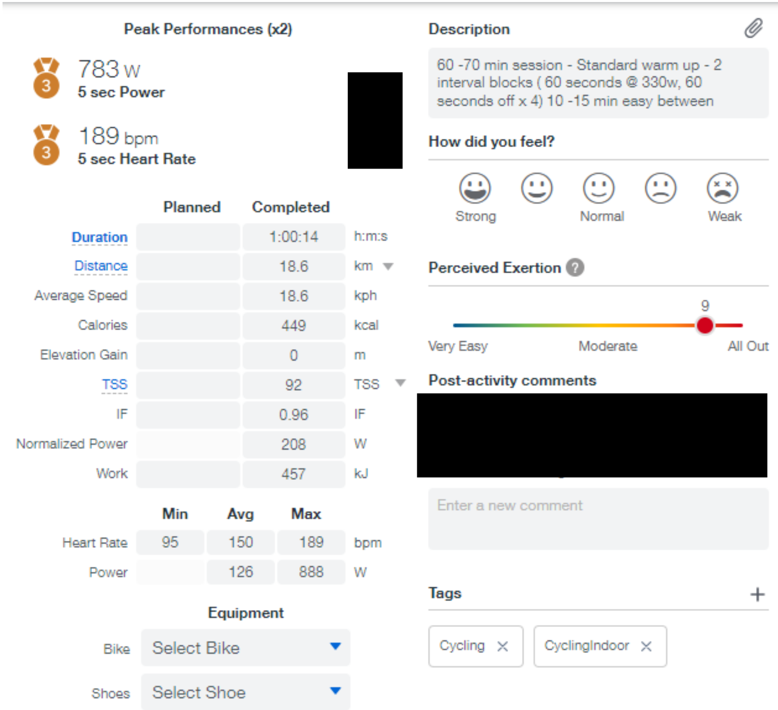
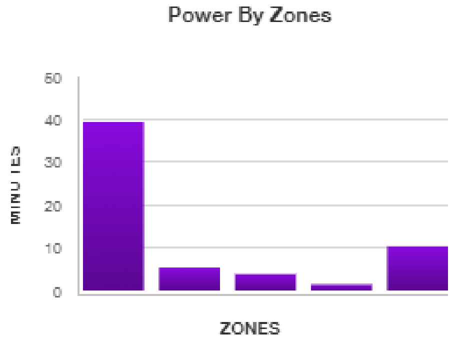
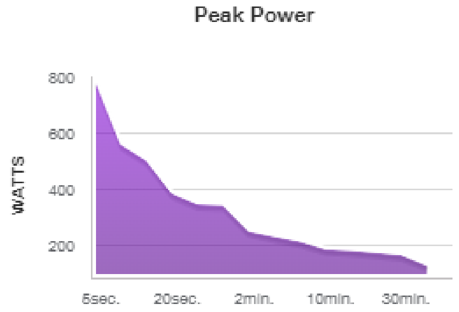


Fig 2 Training data collected on the digital training monitoring platform post session.

Fig 2 displays some of the key internal and external metric collected after a training session including duration, distance, heart rate and power as well as RPE and some athlete feedback.





1 0 - 125 Watts	0:39:21
2 126 - 175 Watts	0:05:19
3 176 - 220 Watts	0:03:48
4 221 - 255 Watts	0:01:28
5 256 - 2000 Watts	0:10:18

Peak 5 sec.	783	Watts
Peak 10 sec.	556	Watts
Peak 12 sec.	498	Watts
Peak 20 sec.	382	Watts
Peak 30 sec.	344	Watts
Peak 1 min.	341	Watts
Peak 2 min.	248	Watts
Peak 5 min.	229	Watts
Peak 6 min.	211	Watts
Peak 10 min.	184	Watts
Peak 12 min.	179	Watts

Fig 3 Power distribution post training session.

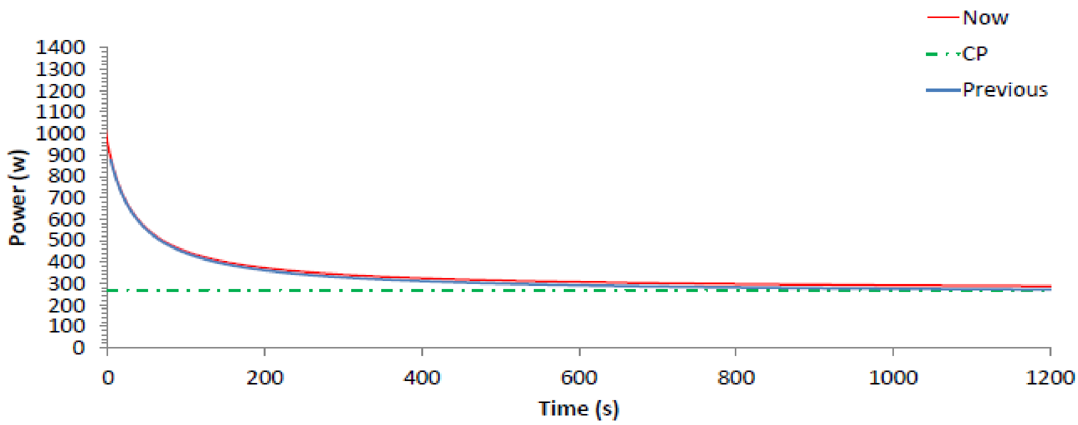
Fig 3 then goes into more detail on the same session outlining the time spent in each of training zones relevant to the individual athlete. I would then assess if this was in line with the training planned and feedback to athlete and coach.

5. Monitoring progress.

As the athlete trains, their critical power curve can shift upwards, indicating the ability to sustain higher power outputs for longer durations. This objective measure provides valuable feedback on the effectiveness of training programs. Below is a similar report shown Fig 1 which was for baseline testing with Fig 4 highlighting changes over time. As part of the annual plan, I always included three or four critical power tests at key phases throughout the year depending on race calendar to best understand how the athlete was responding to training and what changes are needed to make the plan. By assessing and analysing each training block between each test, I was able to develop a better understanding of the athlete's individual response.

Power-Duration Assement

[redacted]



Date	Critical Power (W)	Anaerobic Energy (kJ)	Peak Power (W)	3-min Power (W)	5-min Power (W)	12-min Power (W	Bike
[redacted]	272	24	949	405		305	TT
	250	26.4	936	397		287	TT
	246	24.96	940	385		281	TT
Best	272	24	949	405		305	

	Training Zones				Z5	
	Z1 U	Z2 U	Z3 U	Z4 U	Mins	Power
Power	150	205	260	300	10	310
HR	140	160	170	187	8	320
Power/Weight	2.3	3.2	4.0	4.6	6	330
					5	345
Date	Body Weight	CP:Mass	AE:Mass	PPO:mass	4	360
[redacted]		4.2	370	14.6	3	385
		3.8	404	14.3	2	425
		3.8	385	14.5	1	530

Notes:
The training zones represent the UPPER value for each zone and to be used as a guide for training zones.
Critical power represents the external power output that can be sustained for a prolonged period of time without fatigue, using the body's aerobic system. The upper boundry of critical power is highest power sustainable without drawing from the anaerobic energy system. The anaerobic energy is the fixed amount of work that can be completed above crticial power.

Fig 4 Critical power test report over time.

As well as monitoring progress in testing, I also monitored progress of key metrics over time. Outlined below in Fig 5 is a record of the training volume in hours over the five-year period that the athlete has been on the programme. This along with other the other metrics was key for us in managing training, workload, and injury risk as well as understanding performance improvements over time.

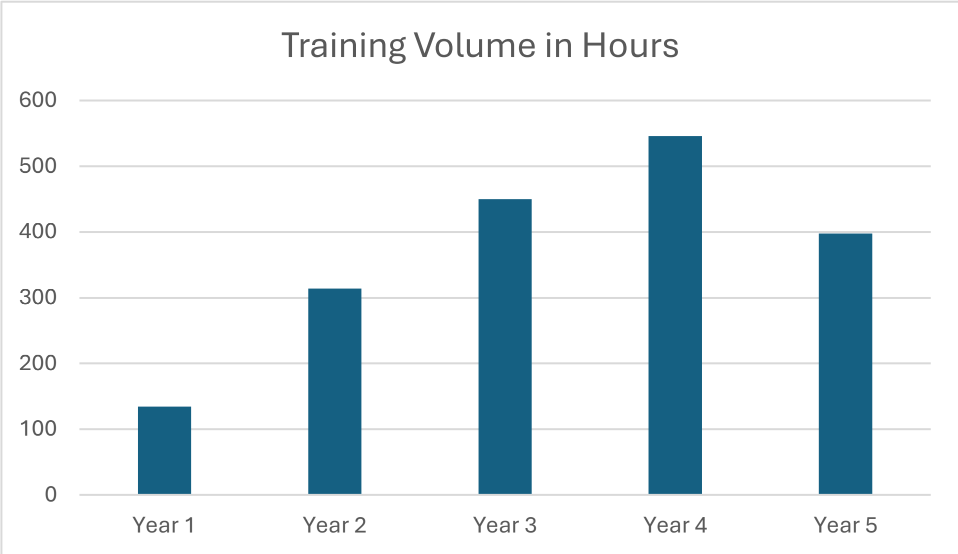


Fig 5 Training volume over five-year period.

6. Multidisciplinary working.

With ever increasing expertise in sport science and medicine teams and more organisations seeking an effective high-performance model for supporting athletes, there is increasing interest in understanding the most effective operational model of sport science and medicine support. While adopting a high-performance organisational structure can be seen as straightforward, the challenge that consumes a lot of teams is how to make it work in practice. As Paul Gamble (2020) outlines *"Integration is what everybody is searching for, true collaboration is the holy grail we all aspire to, but that is several steps down the path".* The integration of a sport science and medicine and coaching team is interdependent by nature and is reliant on a range of different factors coming together to produce the desired outcome (Smith, 2003).

As the athlete's performance progressed and transitioned onto the High-Performance Programme, the sport science and medicine support expanded from a physiologist and S&C coach to a full multidisciplinary team (MDT). This ensured a more holistic approach to athlete support but didn't come without its challenges. The coach, athlete and MDT had to communicate more effectively and have clarity in delivering. A good example of the interdisciplinary team approach came during the off-season when the coach, athlete and MDT support team wanted the athlete to focus on developing strength and increasing muscle volume. Collectively, we all fed into an end of season review and agreed on the most important factors to focus on in relation to improving performance into the next season. As an MDT we met on a weekly basis to discuss all supported cyclists so there were good relationships for healthy ‘check and challenge’ within the planning, keeping the athlete central to what we wanted to do. Designing it **with** the athlete not for the athlete was key in developing a plan everyone bought into.

Through understanding event demands and the multifaceted nature of performance, encompassing physiological, biomechanical, and tactical factors combined with existing literature as a performance team we prioritised strength and conditioning blocks throughout the off season to improve knee extension maximum force (Kordi et al. 2017) and maximise muscle volume of the quadriceps (Parker-Simpson et al. 2018). These had been put forward by the S&C coach and nutritionist respectively and after thorough debate and discussion these became key performance indicators for the off season. Skinfold measurements of thigh girths were taken as an objective metric for quad muscle volume. With the S&C coach collecting data in the gym to measure improvements in max force. Within the annual calendar we dedicated a 16-week S&C blocks to achieve sufficient overload, as well as focusing on the nutritional requirements to support hypertrophy. My role within this block as a physiologist was to support the optimisation of the training week through maximising the impact of the strength session while maintaining aerobic qualities. Individual variability in training responses and adaptation must be considered when implementing concurrent training in elite athletes. Research by Ahtiainen et al. (2016) highlighted the importance of personalised training prescriptions tailored to athletes' specific needs and goals. Despite concerns about potential interference effects between resistance and endurance training adaptations, several studies have shown that elite athletes can achieve significant gains in muscular strength, power, and aerobic capacity concurrently (Wilson et al., 2012; Grgic et al., 2020). This suggests that a well-designed concurrent training programmes can enhance overall athletic performance without compromising specific training goals.

This project within the overall plan was effective in seeing both improvements in thigh girth and increases in maximum force and exemplifying the benefits of collaborative and integrated performance support. Both the clarity of the performance plan and the understanding of the importance of interdisciplinary work were central to achieving complete buy in from the whole team leading to its effectiveness and having a very positive impact on performance.

7.0 Will it make the bike go faster?

As a practitioner, I have experience of trying to deliver textbook physiological interventions in a very applied setting. The strong relationship with coach and athlete always brought our conversations back to “Will it make the bike go faster”. So, after health and wellbeing the most important metric we tracked was performance and how all the interventions we were putting in place impacted on performance. The key performance metric we tracked was time-based improvements in endurance cycling performance. Typically, the national championship was the main yearly competition target, and the annual performance plan periodised and tapered towards performing at this competition. Outlined below is the athlete’s performance progression across the four years.

Year	Percentage improvement in performance
Year 1	1.18%
Year 2	1.77%
Year 3	2.05%
Year 4	1.35%

Table 1 Athlete’s percentage improvement in performance across four years of the training programme.

Displayed above in Table 1 is the performance improvement over four years of just over 6 percent going into the major international competition.

The athlete was subsequently selected and delivered a strong performance at the major international competition, achieving personal best times in multiple endurance-based cycling events. The combined integrated efforts of the physiologist, coach, nutritionist, and sports psychologist contributed to the athlete's success, highlighting the importance of a holistic support team approach.

8.0 Conclusion

This case study demonstrates the effectiveness of physiology support through taking a person-centred integrated support team approach to athlete development with integrity, adaptability, and collaboration central to how I worked. The use of the critical power testing, training monitoring, multidisciplinary working and performance tracking provided valuable insights into the athlete's progress towards “making the bike go faster”, ultimately contributing to her success at the major international competition and progressing onto the highest level of international competition.

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