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Track Cycling Sprinters' Training Progression Over Three-Month Period

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Abstract: There is a paucity of data on the progression of track cycling sprinters, and particularly the evolution of training and performance over a training cycle or season. Following our prior research showing strong relationships between sprint cycling power and endurance cycling power, we compared these relations over a 3-month period building towards a key event where maximal 30-s power was achieved. Our hypothesis is large improvements in power would come from training either for sprint maximal power or sprint maximal capacity, and this would be reflected in the data. A total of publicly available 25 datasets, over a 3-month period were used and broken into 1-month blocks. These data were plotted against the line of best fit for 30-s and 2-min power to assess if training towards the line led to better 30-s power, in contrast to focusing only on peak power. We observe the best performances came from riders who start below the 30-s vs 2-min power line of best fit, with greater capacity and ability to ride fast over a sprint series, and progressing towards focusing on specific power in the final block leading into a competition. These results support the hypothesis of combined capacity and power training based on rider-specific relationship to the line of best fit between these measures versus a strictly maximal power training focus.

Keywords: Track Cycling, Coaching, Sports Performance, Performance Modelling

1. Introduction

There is a paucity of data on the progression of track cycling sprinters, and the evolution of training and performance over a training cycle. Following prior research showing relationships between sprint cycling power and endurance cycling power (Ferguson et al., 2023a, 2023b; Ferguson, Zhou, Harnish, & Chase, 2021), this study compares these relations over a 3-month period. The hypothesis is large improvements in power would come from training either for race winning sprint power or sprint capacity to sustain power over several races and recover fast in between, and this outcome would be reflected in the data.

In particular, this study examines the potential of training relative to a position on a plot of endurance versus sprint power similar to the power curves in prior chapters. A specific goal is to examine how training "towards the line", whether in a position above or below the previously developed power relationship lines for two power durations, would provide the best gains in a period of training before a major event. The study takes a narrative approach to a series of riders in examining these outcomes, as this approach allows inclusion of confounding effects, such as injury, illness, or training which does not follow the goal. It thus examines riders and training towards peak events in the context of these power-duration

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curves, but without intervening, so the analysis is observational and narrative in assessing the hypothesis.

This study investigates the mix of training leading into a key competition, or performance challenge in track cycling sprint cyclists. Track cycling sprint cyclists are athletes who focus on shorter distance, high intensity and speed events (Ferguson, Harnish, & Chase, 2021). Track cycling sprint cyclists need a mix of both pure speed to race between 65-80 kph for distances of 200-m to 1000-m, and the durability to race over several rounds, as all Olympic and World Championships sprint events require multiple performances to progress to the medal rounds (Ferguson, Harnish, & Chase, 2021). Getting the training mix correct is essential to ensure the rider reaches key competitions in the best physical form to meet event demands. The prioritization of training over different blocks of training should aim to develop both the speed and capacity to perform in racing, and the proportion of each should reflect the current fitness level of the athlete relative to the event demands (Ferguson, Harnish, & Chase, 2021).

There is limited research tracking sprint performance in a variety of events. One study looking at the progression of a national squad leading into the London Olympics showed a disparity, where improving testing measures in training were not subsequently reflected in results at the event (Wiseman, 2015). Another study observed 6 high performance male athletes, towards a peak event, describing the training zones used (Desgorces et al., 2023). While this study described the different training zones, and the split on-bike training to resistance training, it did not compare the training to resultant performance in a key event (Desgorces et al., 2023). A study of 2 running sprint athletes who both opted for a periodized approach observed distinct changes in performance between preparation and competition phases illustrating the importance of individuality (Hicks, Drummond, Williams, & van den Tillaar, 2022).

However, most academic discourse is focused on discussing different coaching approaches (Dorel, 2018a, 2018b; Douglas, Ross, & Martin, 2021; Haugen, Seiler, Sandbakk, & Tønnessen, 2019). Further, most studies of sprint periodisation across many sports are based on short term studies using a student population, rather than an athlete population, whether performance or high-performance athletes. Finally, most studies include limited numbers of athletes, thus reducing the ability to draw any significant conclusions, either statistically or via the evidence as presented. All these issues reduce the ability to assess and quantify the impact of training on resulting performance outcomes.

Currently, the study of sprint cycling revolves primarily around the generation of peak power and how this single value translates into peak speed (Ferguson, Harnish, & Chase, 2021). While this approach is a fruitful area of research to understand one, easily measured component of performance, peak power shares less of a relationship with performance over sprint durations than actual performance metrics (Ferguson et al., 2023a). Common sprint racing durations had a the highest relationships, while 1-s had closer relationships with 45-60 second power, and the strong relationship extended out to 20-min (Ferguson et al., 2023a). Hence, there is a gap in linking peak power and sprint performance, which might be closed by assessing the impact of training across a range of sprint performance durations.

A better approach is to examine actual sprint performance and pacing of sprinting over an individual race and across races within a series or event. From these data, performance modelling could identify the strongest relationships between training approaches and competition performance. Recently, in Ferguson, Harnish and Chase (2021), a model was presented (Fig. 1) where the slope of the line of best fit for a group of sprint cyclists indicates the qualities riders should develop (Ferguson et al., 2023a). For athletes below the line in Fig. 1, there is a need to train peak power, or towards the line, and for those above, the need to train for capacity, again towards the line. Fig. 2 illustrates the data used from Ferguson et al. (2021) to determine the line of best fit. Code is provided in Ferguson et al. (2023a) which allows a coach or sport scientist to determine the line of best fit for a training group.

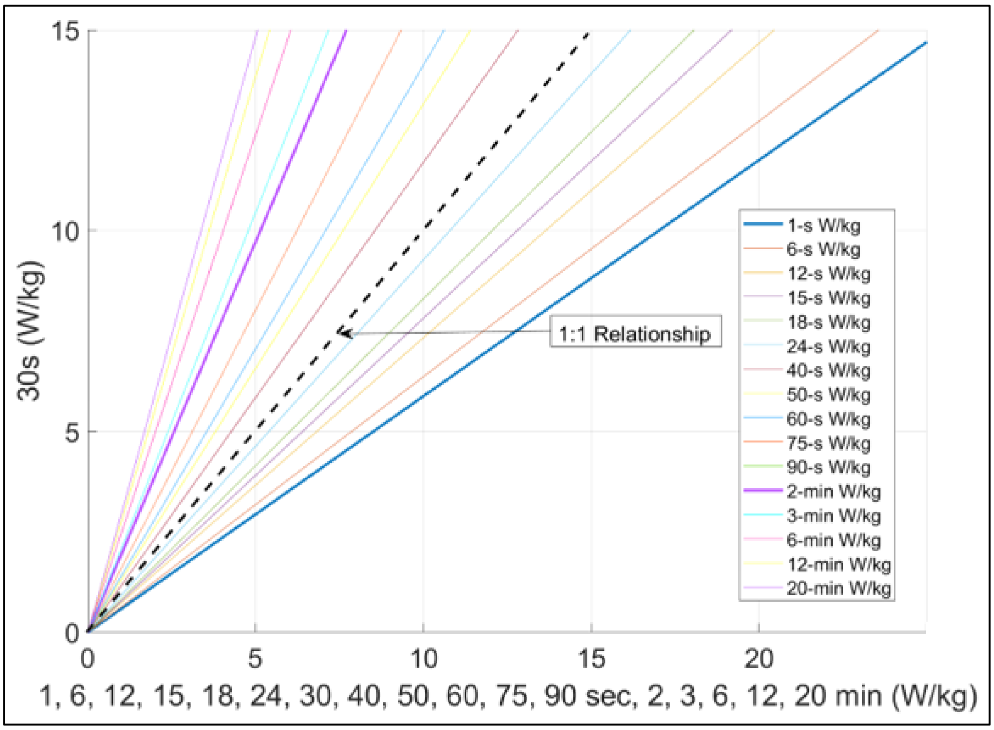

Figure 1. Illustrating the line of best fit for various durations against a common duration of sprint cycling performance: 30-s.

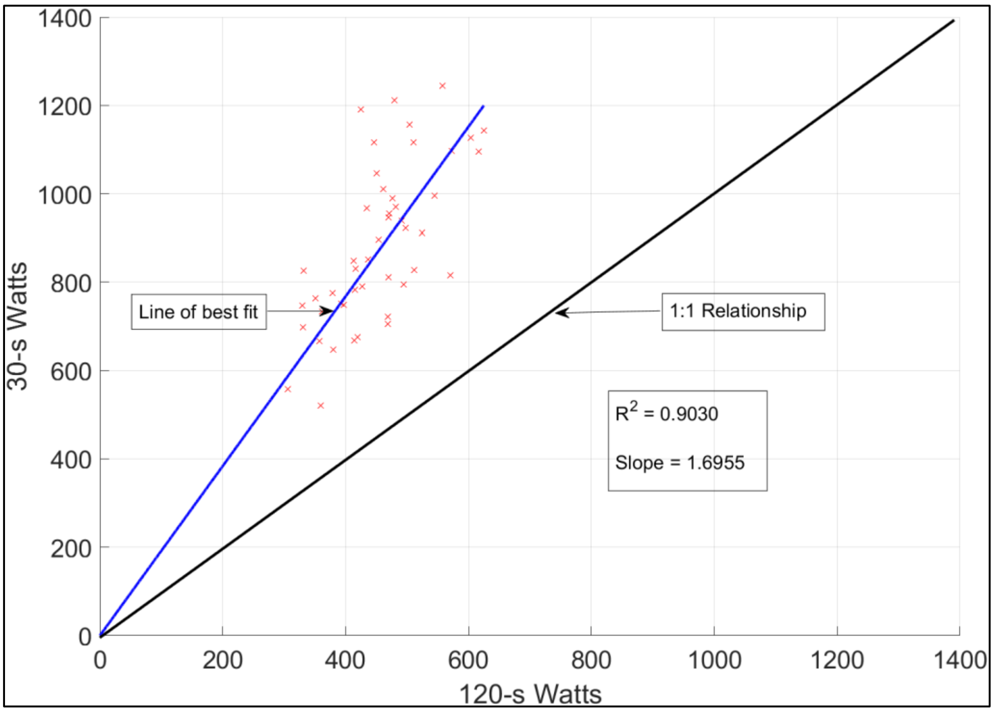

Figure 2. Illustrating the relationship between 30-s power and 120-s power, which provides the line of best fit which can be used to make training decisions. The line illustrating a 1:1 relationship between 30-s and 120-s power is also displayed.

The discussion of sprint cycling periodisation revolves around two approaches, called *short to long*, and *long to short* (Haugen et al., 2019). Short to long, starts with peak power, strength and speed and adds speed endurance as the athlete approaches key events. Long to short, starts with capacity and progresses through to speed work. The challenge with these approaches is high performance athletes with Olympic aspirations are very rarely used in academic research. There may be descriptive research based on current practice, but there is no testing of hypotheses where poor performance may mean losing scholarships or sponsorships. Further the numbers of athletes in limited available studies are often quite small, limiting the potential conclusions drawn and the ability to generalize them to other riders.

This lack of analysis is where descriptive studies applying modelling to tease out the areas of performance with the strongest relationships can be useful. The approach requires a method of quantifying or understanding the relationship between speed and capacity. Such a tool would allow coaches or/and researchers to plot the progress of an athlete towards performance in a goal event.

For the three training blocks in this study, it is hypothesized:

A. Riders performing below line should (first) train up for greatest gains in the ability to deliver
power, then train over in phase 2 before up again before event.

B. Riders performing above the line of best fit should (first) train over (towards the line) for capacity to increase their ability to sustain their higher levels sprint power for longer durations and multiple rounds in an event.

Together, they create a training and monitoring approach "training towards the line" to track the evolution of performance and simultaneously adapt training based on measured, performance related power metrics.

2. Methods

2.1. Data Access and Use

All methods were approved under the University of Canterbury, Christchurch, New Zealand Human Research Ethics Committee gave exemption approval for publicly available data (2022/06/EX). This study relied on the open source Strava website to identify and analyze data. Data were downloaded from the Strava app according to the Strava Privacy Policy (https://www.strava.com/legal/privacy) and no personal information was taken from the Strava site.

2.2. Overview

From Ferguson et al. (2023a), 56 sets (44 Male, 12 Female) were found, and examined to determine if there was firstly, 12 weeks of training and racing power meter data. From here the 12-week period was broken into 3 x 4-week blocks, and again the data was examined to determine if there was sufficient maximal 30-s and 120-s power meter measured efforts. From this examination, 25 datasets were found (all male) of sufficient length (12 weeks or longer), and enough data in each of the 3 x 4-week blocks to proceed with the analysis.

All data were obtained from Strava, as previously stated. The use of a single open-source site ensures all data were stored similarly, and any computations used similar data structures and density. The Sauce extension, https://www.sauce.llc/, was then used to download a *.tcx format file containing power meter data for each set of rider files from competition and training sessions for 3-12 months prior to and including either a NZ Championship or World Master's Championship event. Athletes were identified as sprinters based on results from national championships result. From these data, the mean maximal power (MMP) for two durations over 3 x 4-week blocks of training leading towards a peak performance was identified. Data were plotted on a chart with a line of best fit taken from Ferguson et al. (2021).

From the data on Strava 30-s and 2-min MMP were identified over a 12-week period leading into an event, or performance challenge. A total of 25 datasets with 12-weeks of continuous training were eventually analyzed. These 12-weeks were then broken into 3 x 4-week blocks to reflect a general periodized process to peak, where the highest 30-s and 2-min MMP outputs should be achieved in the final block.

Peak 30-s power was chosen as this value reflects sprint cycling power from a wide variety of sprint events, while 120-s power was chosen as a power output reflecting sustained performance, for sprint cyclists. The 120-s duration was also used because of the high likelihood of a sprint cyclist doing a maximal effort of this duration in each block. Power at the $\dot{V}O_{2MAX}$ is a good indicator of capacity for a sprint athlete (Weyand, Lin, & Bundle, 2006).

2.3. Data analysis

Data were plotted in Matlab R2023b (The MathWorks, Natick, MA) and the slope of 30-s and 120-s was added to the plot to compare data from Ferguson et al. (2021). Jamovi 2.4.2 (Jamovi, Sydney, Australia) was used to evaluate the differences between the progression in the three groups.

3. Results

The data was split into three groups based on the improvement in 30-s power between block 1 and block 3. A large improvement in 30-s power (200-watts or greater), a moderate increase (100-200 watts), and a small increase in 30-s power (less than 100-watts) was used to define each level of improvement group within the sample.

ANOVA analysis describes the differences for the three different levels of improvement ($F(2, 13.5) = 32.0$; $p < 0.001$; ES = 0.763). Table 1 is the Games Howell post hoc test showing the differences within the three levels of improvement. Table 1 validate the differences between the three levels of improvement.

Table 1. Games – Howell Post Hoc

		Big	Medium	Small
Big	Mean difference	—	-209	-267.2
	p-value	—	0.002	< .001
Medium	Mean difference		—	-58.0
	p-value		—	< .001
Small	Mean difference			—
	p-value			—

The key finding was the different rider-specific evolutions towards a peak 30-s power for a key event, which showed very distinct patterns despite all 25 datasets focused on performance in sprint, Keirin, team sprint and 500, 750, or 1000-meter time trial events, depending on age and junior/masters category. Fig. 3 shows progressions for all 25 riders over the three months (12-weeks) towards a peak 30-s power, reflective of sprint performance over all events. Also plotted in Fig. 3, is the slope line of best fit from Ferguson et al. (2023a) for 30-s and 2-min power for sprint cyclists. All rider-specific trajectories of 30-s and 120-s power evolve around this line during the 3x4-week blocks. The lines in Fig. 3 are color coded by the amount of improvement seen over the study.

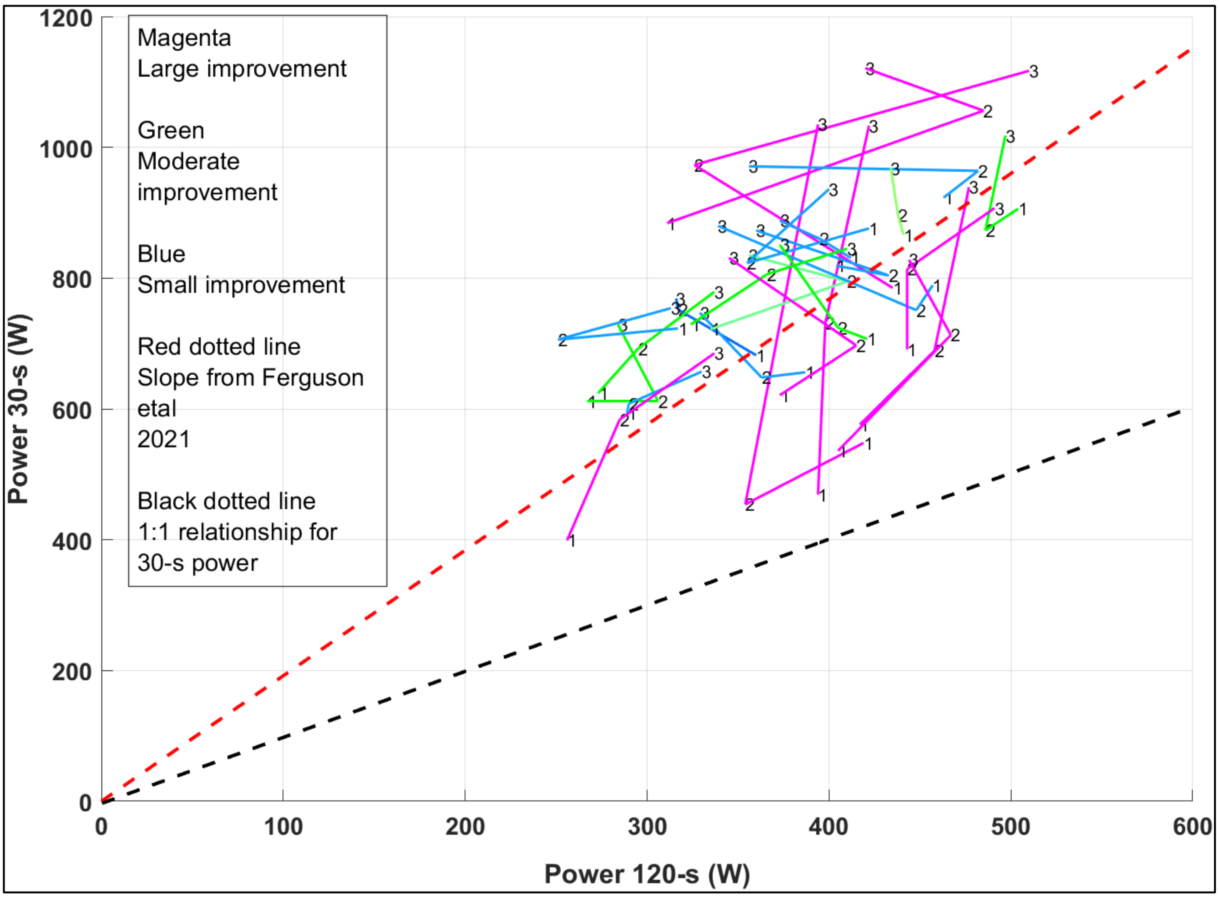

Figure 3. 30-s and 120-s power for all 25 datasets with the progression from block 1, to 2 to 3. The red dashed line is the slope of the line for 30s and 120-s power data for sprinters from Ferguson et al 2021. Black dashed line is the 1:1 relationship between 30-s power.

4. Discussion

The main aim of this research is to describe the progress of sprint cycling athletes as they build towards a peak power performance in 30-s power and use the qualified results evaluate outcomes in terms of the hypotheses given. In defining the differences between large, moderate, and small improvements, those cyclists who showed the greatest improvement in 30-s power were below the line of best fit having greater capacity than peak power in block 1, and/or even block 2, before pushing above the line focusing on higher power. Athletes with moderate or improvements in power tended to start above the line, and those who saw small improvements in performance typically started well above the line. These cases show riders with a greater balance towards peak power over capacity in block 1. However, for those latter riders, a focus on capacity first and pushing towards power in the third block appears the optimal strategy.

Compared to Wiseman (2015), describing a national team building towards an Olympic Championships, where increases in 4-s power throughout the training cycle were reflected with poor performances in a key event, showing the metrics inadequacy to predict performance. Athletes with the best improvements in this study went from being strong on capacity, reflected in a better balance between their 30-s and 120-s power, where they were on or below the line of best fit. They also built towards being stronger in race winning power, as they got closer to a key event. A similar approach in 6 high performance sprinters is observed, where the balance of low intensity training (for recovery and capacity) is reduced, and leading into key events the volume of race winning power training is increased (Desgorces et al., 2023). When discussing the two common approaches of short to long and long to short (Haugen et al., 2019), the data suggests the long to short approach was more common in those who achieved big improvements in performance, where the approach also tends to match the main hypotheses for most athletes in this study.

Likely reasons for the differences observed between the groups, was a focus on peak power training over capacity. However, no sprint event is a one-off ride, and each event requires a fine balance between race winning speed and the capacity to both recover quickly, and repeat race winning power in subsequent rounds. Thus, as illustrated in Ferguson et al. (2023a), a mixed approach is likely to deliver better results.

Data points below the line suggest a sprint cyclist who should focus on building their speed by pushing up towards the line of best fit. However, riders above this line should aim to build their short-term endurance capacity, by pushing across (right) towards the line, effectively aiming to hold the speed they have and hold it for longer durations, before pushing peak power in latter training phases. The results presented indicate focusing on training towards this line of best fit, whether starting above or below, or being above or below at the end of any 4-week block, would be the optimal training approach for each individual athlete.

4.1. Practical Applications and Coaching Implications

This paper offers coaches and trainers options to enhance their coaching and planning of performance while taking a balanced and measurable / quantified approach to preparing track sprint cyclists, with progress monitored in each phase. This qualified approach allows the coach more options to ensure variety, engagement, and enjoyment in the program. Coaches can now utilize new knowledge to ascertain if the athlete is speed strong or capacity strong and use the early blocks to build more balance in the athlete. Those sprint cyclists who can train more for capacity and entertain racing in longer events on the track in the early blocks building towards training for specific power required in competition. Finally, in terms of goal setting the approach allows multiple targets for the athletes to chase rather than just a peak power Fig. bearing little relation to overall performance in sprint cycling competition.

In practice, those athletes in the large improvement group were below the line focused on capacity, and then in block 2 they pushed a little above the line, focusing on 30-s power and maintaining 2-min power, before focusing on the 30-s power in the final block. The early focus on capacity did not limit their sprint winning power by the end of the block and may have enhanced it. This potential limitation has been a main reservation of coaches when prescribing training for sprint cyclists (Ferguson, Harnish, & Chase, 2021).

While this study has focused on sprinters the same principles should apply to track endurance and road cycling. The same principles would apply, using race winning speed and power relative to each event, where these trade-offs are shown in (Ferguson et al., 2023a), and are very similar for male and female riders (Ferguson et al., 2023b). A pursuit balancing speed to race 2-4 kilometers and the endurance required to race a qualifying heat, recover fast for a final, and have the fitness to withstand a large volume of training.

4.2 Limitations and Impact

Limitations of these data are the athletes were of a national level and are already more likely to be doing a wide variety of track cycling events, and even some level of road cycling. However, some participants achieved master's world championship level performances, or U19 level national records. None of the riders used in this study regressed in their power leading into a key competition.

This last point is interesting, as these riders made significant power gains from mixed and capacity focused training, when the current common convention in sprint-training is to target peak power all season long (Douglas et al., 2021). In particular, in this study, peak performers, achieving the highest in 30-s power, made the biggest progression in power, effectively employing a *long too short* approach (Haugen et al., 2019), and a more conventional periodized approach to training, preparation, and competition phase's (Bompa, 1996). As mentioned in the methods, the selection of data excluded any females from the analysis, where Ferguson et al. (2023b) showed greater variation in power in females compared with men, in sprint cyclists.

Future research should use aim to use larger groups of participants. Research should be done with international athletes, in an early non-Olympic year to ascertain potential improvements to the coaching process and track the progression of female sprint cyclists.

5. Conclusions

This narrative review of 25 datasets of riders preparing towards peak performance shows those athletes who start the process 12 weeks out from a peak performance from a position of strong capacity are able to make bigger improvements in the final block. This provides coaches with a tool to monitor the training status of an athlete as they build towards peak performance. And the means to use the tool to guide the training to guide speed dominant sprinter to build more capacity, and the capacity strong rider to build more speed.

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