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Hamish Ferguson *, Chris Harnish, J Geoffrey Chase

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Article

Performance Progression over a Three Months of Periodized Training for Track Cycling Sprinters

Hamish Ferguson [1,*], Chris Harnish [2] and J. Geoffrey Chase [1]

[1] Centre for Bioengineering, Mechanical Engineering Department, School of Engineering, University of Canterbury, Christchurch, New Zealand
[2] School of Physical Education, Mary Baldwin University, Staunton, VA
* Correspondence: hamish.ferguson@pg.canterbury.ac.nz

Abstract: 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, we compared these relations over a 3-month period. Our hypothesis is large improvements in power would come from training either for sprint power or sprint capacity, and this would be reflected in the data. A total of publicly available 25 datasets. 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. 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.

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Key Points

1. We studied a group of national level track cycling sprinters to observe their progression in performance leading into a key event.
2. We observed riders who made large gains in 30-s power (a good measure of sprint cycling performance), medium gains and small gains.
3. Based on the line of best fit between 30-s and 120-s power we observed riders who were above the line who displayed high levels of race winning power, and riders below the line who displayed good capacity for sprint cycling competitions featuring repeated sprints.
4. The riders with greatest improvement over a 12-week period were those riders below the line, who had good capacity, and as they progressed towards a major competition changed their focus on capacity to race winning power.
5. This data supports the concept of long to short periodization of training in track sprint cyclists

Introduction

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 [1]. 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. Getting the training mix correct is essential to ensure the rider reaches key competitions in the best physical form to meet event demands. The prioritisation 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 [1].

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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 between improving testing measures which were not subsequently reflected in results at the event [2]. Another study observed 6 high performance male athletes, towards a peak event, describing the training zones used [3]. 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 [3]. A study of 2 running sprint athletes who both opted for a periodized approach observed distinct changes in performance between preparation and competition phases [4].

However, most academic discourse is focused on discussing different coaching approaches [5–8]. Further, most studies of sprint periodisation across many sports is based on short term studies using a student population, rather than an athlete population, whether performance or high-performance athletes. Finally, as seen above, most studies include relatively very limited numbers of athletes. 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 [1]. 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 [9]. 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.

The authors believe 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, we presented such a model (Figure 1) where the slope of the line of best fit for a group of sprint cyclists indicates the qualities riders should develop [9]. For athletes below the line in Figure 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. Figure 2 illustrates the data used from Ferguson et al. (2023) to determine the line of best fit. Code is provided in Ferguson et al. [9] which a coach or sport scientist can use to determine the line of best fit for a training group.

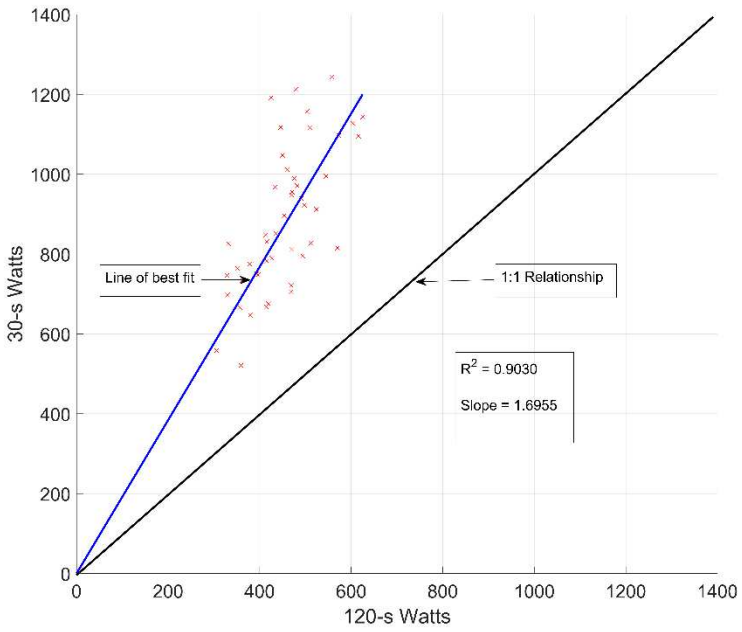

Figure 1.

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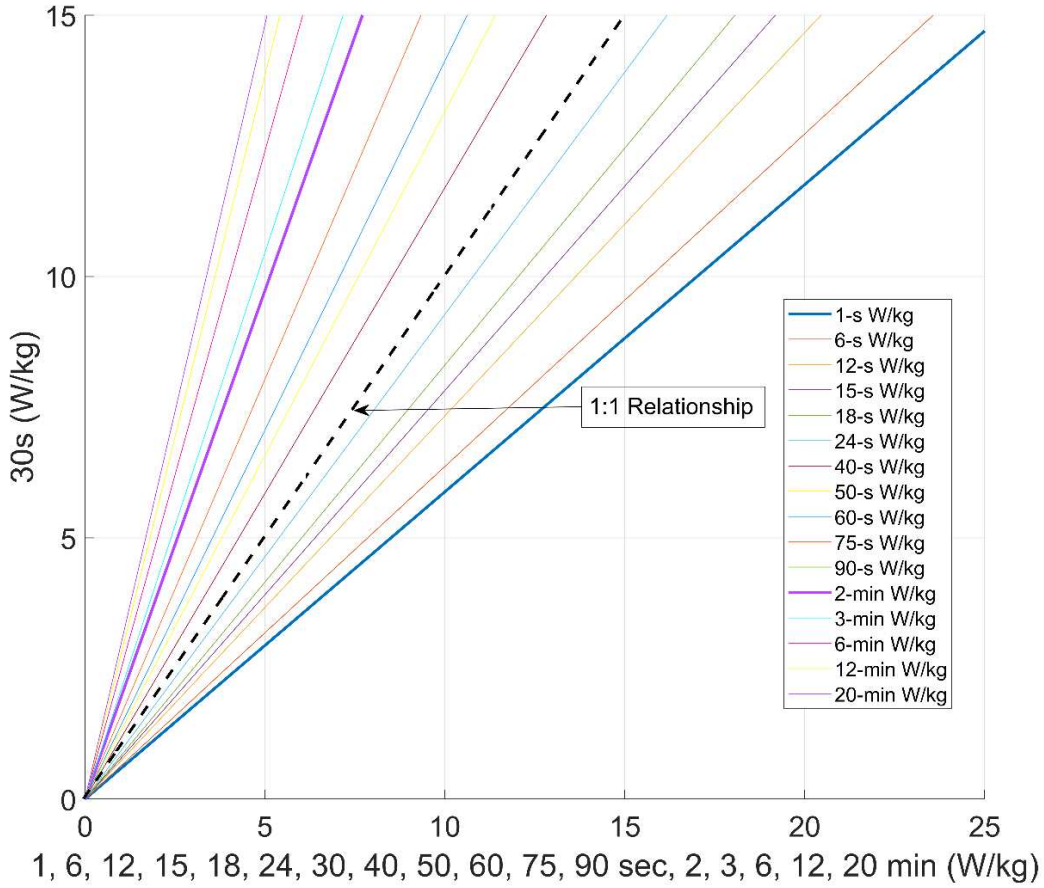

Figure 2.

The discussion of sprint cycling periodisation revolves around two approaches, called *short to long*, and *long to short* [5]. 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. As mentioned above, 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 hypothesises where poor performance may mean losing scholarships or sponsorships. Further the numbers of athletes in limited available studies is often quite small.

This lack of analysis is where descriptive studies applying modelling to tease out the areas of performance with the strongest relationships can be useful. This 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.

The present study qualitatively evaluates and then quantifies the training effectiveness of a 3-month training period leading into a main competitive event. We tracked the training of both race winning speed, and event winning capacity, and narrate how effective the training was to develop both. In Ferguson et al. [10] the slope of the line of best fit for a group of sprint cyclists, also shown in Figures 1 and 2, provides a good base for assessing whether a rider needs to developing speed, such as when they are below the line, or to develop capacity when they are above the line. Riders close to the line could seek to develop both. In this use approach, training is modified based on their balance of capacity and peak power.

For the plan of three training blocks in this study we hypothesize:

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.

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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 to track the evolution of performance and simultaneously adapt training based on measured, performance related power metrics.

Methods

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 analyse 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.

Overview

From Ferguson et al. (2023), we took all 56 sets (44 Male, 12 Female) and examined them 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 we were found 25 datasets (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, we identify the peak power for two durations over 3 x 4-week blocks of training leading towards a peak performance. Data were plotted on a chart with a line of best fit taken from Ferguson et al. [10]. For each dataset used, narration is provided based on the progression to the key event and the progress made.

From the data on Strava we identified the peak 30-s and 2-min power 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 analysed. 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 peak power 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. It is also a good measure of capacity for a sprint cyclist.

Data were plotted in Matlab (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. [10]. Results will detail the peak power for each block and we narrate each dataset to differentiate between 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).

Results

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,

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Keirin, team sprint and 500/1000 metre time trial events. Figure 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. [9] 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.

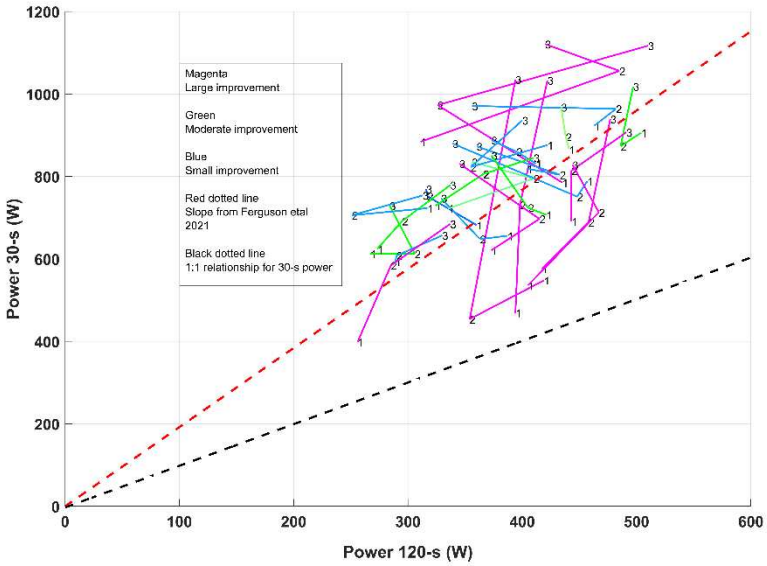
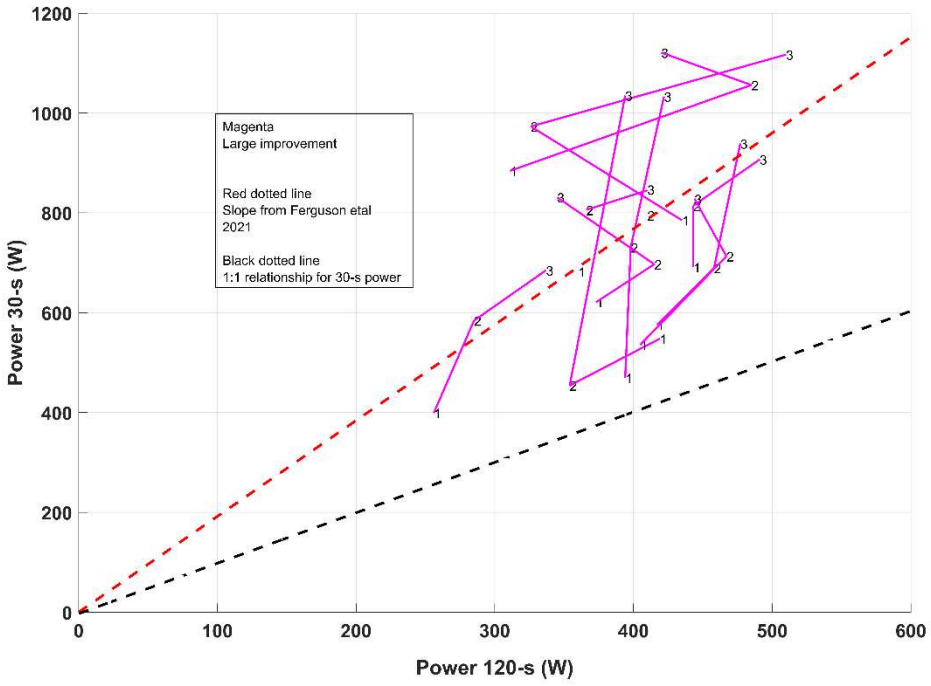


Figure 3.

The lines in Figure 3 are colour coded by the amount of improvement seen over the study. Figure 4 breaks down Figure 3 into the three classifications of 30-s power gains to highlight the improvements from large to small and clarify where they sit around the line of best fit. Appendix 1 narrates all of these improvements for each rider in specific.



a

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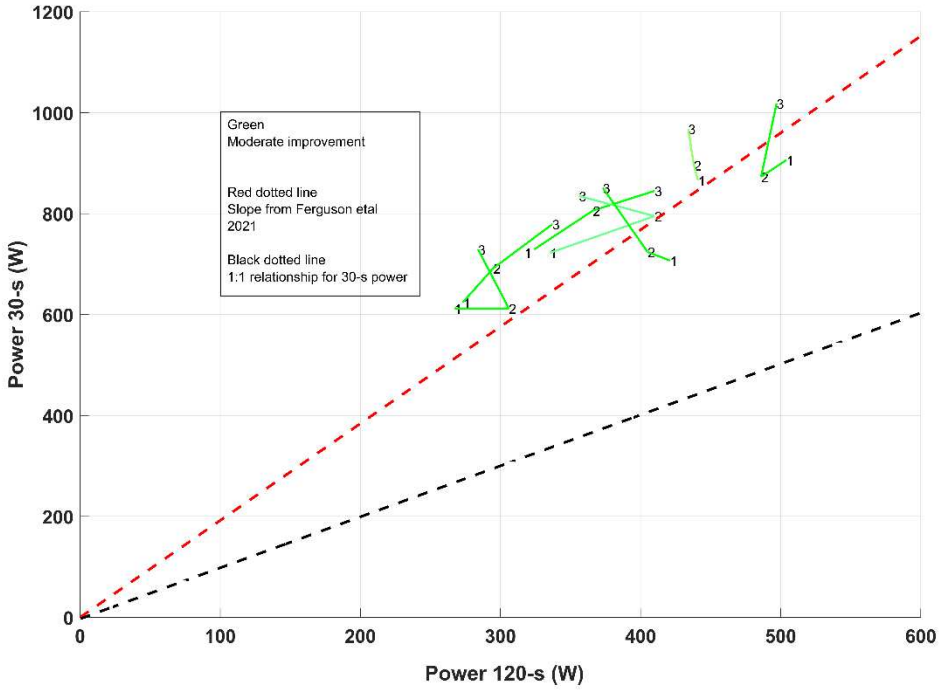

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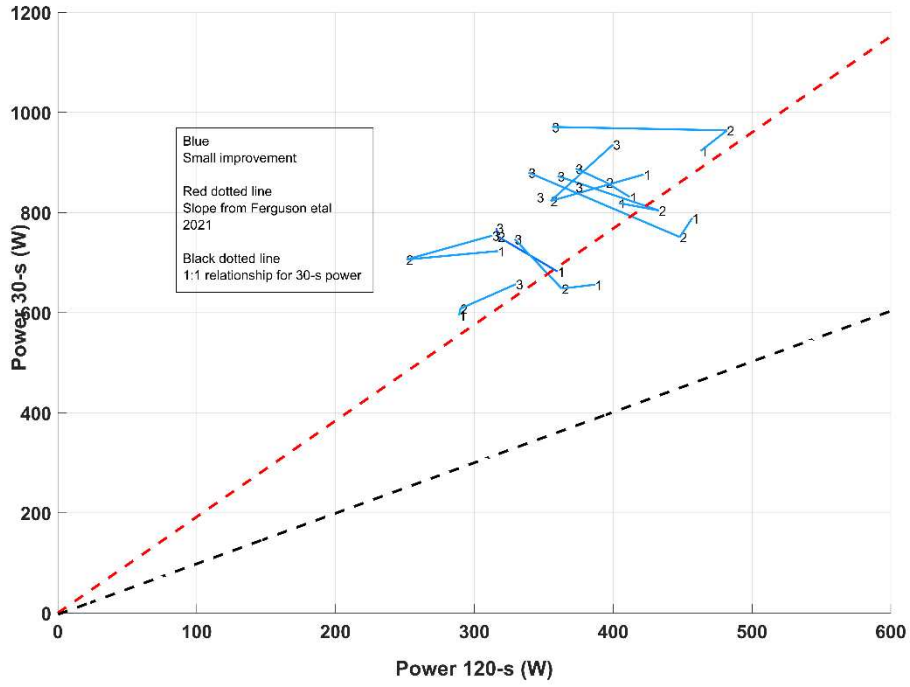

c.

Figure 4.

Discussion

The main aim of this research is to narrate the progress of sprint cycling athletes as they build towards a peak power performance in 30-s power and use the qualified results and narration to evaluate outcomes in terms of the hypotheses given. In narrating the differences between large, moderate, and small improvements, those cyclists who showed the greatest improvement in 3-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 [2], 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. 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 [3]. When discussing the two common approaches of short to long and long to short [5], our data suggests the long to short approach was more common in those who achieved big improvements in performance, where this approach also tends to match our 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.

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 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. Our results 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. For each dataset we narrate their individual progression towards a peak performance in this context (Appendix 1).

Practical Applications

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 programme. 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 figure 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 [1].

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 [9], and are very similar for male and female riders [11]. A pursuit balancing speed to race 2-4 kilometres 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.

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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 [8]. In particular, in this study, peak performers, achieving the highest in 30-s power, made the biggest progression in power, effectively employing a long to short approach [5], and a more conventional periodized approach to training, preparation, and competition phase's [12]. As mentioned in the methods, the selection of data excluded any females from the analysis, where Ferguson et al. [11] 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.

Conclusions

Our 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.

Author Contributions: Hamish Ferguson conceived the study, conducted the research, wrote the code to perform analysis, and wrote the first draft. Hamish Ferguson, Chris Harnish and Geoffrey Chase all contributed equally in editing the final manuscript.

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Data Availability Statement: Data and code used in analysis is freely available upon reasonable request.

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Appendix 1. Training narrative for each individual

All cyclists used for this study was known to the lead researcher, hence the ability to narrate the approach they used to achieve their performances in a given season. The table is colour coded to match the power gain achieved in Figures 3 and 4.

1	Male	18	This is a progression of the rider towards a national event, combined with a relocation to a new area, and starting working so training was constrained. He started well below the line at the conclusion of block 1, was closer up towards the line after block 2, and with settling in to his new setting was able to push well ahead of the line to make a large increase in 30-s compared to block 1.
2	Male	17	In this progression the rider is building towards an Oceania championship coming off winter training and limited riding on a velodrome. After block 1 they are below the line, after block 2 are still below the line, however with improving weather and access to an outdoor track and a motorbike to provide motorpacing the rider was able to produce a large increase in 30-s power, pushing above the line.

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3	Male	17	U19 athlete training for a regional championship. Rider mixing commitments in schools road cycling with sprint cycling saw them start below the line, move upwards parallel to the line before in the final block being able to focus on sprint cycling to push above the line and achieve good performances in the regional championship.
4	Male	18	This is the progression of a rider towards a regional event, where he successfully broke a U19 national record for the flying 200-m as well as competing in a 1000-m TT, sprint and Keirin series. He starts below the line, moves well above the line after the first block and proceeds to train towards the line in block 2 to finish closer towards the line and achieve a top performance.
5	Male	16	U17 athlete mixing their focus on sprint, track endurance and road cycling events. Stayed below the line the whole time and their performances in all three branches of cycling achieved mixed results.
6	Male	55	Masters athlete training towards a test camp with a reluctance to do actual competition due to previous crashes. This training approach does allow a level of constancy, but no competition is likely to not draw the best out of the rider. They start below the line and push above the line and up and further away from the line in the third block.
7	Male	26	This is a rider training towards a National Championship. All 3 block are performed above the line and the rider produces very good 30-s power but struggled in competition to sustain this power over a series, and even within certain rides if pacing was poor (too fast at start) or was forced into a long sprint. To be better prepared for all competition possibilities they need to train more capacity.
8	Male	17	U19 athlete preparing for a national championship. All numbers were below the line as the rider was racing in the sprint events, but had a mixed focus looking towards road cycling events beyond the track championship. This approach led to average performances at the national championships.
9	Male	55	Masters athlete training towards a test camp with a reluctance to do actual competition due to previous crashes. This training approach does allow a level of constancy, but no competition is likely to not draw the best out of the rider. They started below the line, moved up parallel to the line and pushed up and above the line in block 3.
10	Male	50	Masters athlete building to an open national championship riding the 1000-m TT, sprint qualifying and round 1 of the sprints. Rider starts above the line and progresses upwards running parallel with the line.
11	Male	16	U19 athlete preparing for a national championship. Started below the line and proceeded above the line in block 2 and made further progress in block 3. This progression was reflected in performances at the national championship.
12	Male	49	This is a masters rider training towards a open event where he rides a 1000-m time trial and a flying 200-m. Did not

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			qualify in the flying 200-m to move into the sprint rounds. Rider is above the line for all three blocks. Indicating they needed more capacity work to lay the foundation for a better all-round performance.
13	Male	45	Masters athlete building to a World Championship in their 5 year age group. Rider above the line for all three blocks. Suffering a back injury so efforts tempered at time. Moderate gains were made. Time were not good relative to previous performance, however with good tactical racing two medals were achieved.
14	Male	42	Masters athlete building to a National Championship. Athlete stayed above the line. In block 2 pushed closer to the line and in block 3 away from the line, not achieving a big increase in power. Results were good at the national championship, however rider relied more on tactics than speed.
15	Male	17	In this progression, after block 1 the rider is below the line and in block two moves downward alongside the line. In block 3 the rider is able to push above the line and achieve good power to win an U19 national sprint title.
16	Male	42	Masters athlete building to a World Championship in their 5 year age group. Rider above the line for all blocks pushing up and away from the line slightly. Medal won at the Championship, but not the fastest times recorded.
17	Male	17	U19 cyclist competing at a national championship in their grade. Rider below the line and pushed closer below the line before moving over the line and upwards. This move from capacity to more power for competition was matched with good results for this rider medalling in the U19 sprint event.
18	Male	43	Masters athlete building to a National Championship. Athlete stayed above the line. Rider started below the line and moved closer to the line in block 2 then made a large push for power in the third block. A large increase in sprint power was not realised and performances were reflected in this.
19	Male	49	Masters athlete training for open competition 1000-m TT and sprint qualifying. Starts just below the line and makes a big push above the line and makes very little progress in the final block suggesting a more balanced approach to building sprint power and sprint capacity.
20	Male	50	Masters rider preparing for a open competition riding the 1000-m TT and sprint qualifying. Above the line for all blocks, very little gain between block 1 and 2, but better gain in block three. Athlete suffering from back injury.
21	Male	44	Masters athlete building to a National Championship. Athlete stayed above the line. Rider was above the line for all three blocks pushing away from the line in block 2 and while trying to refocus on capacity did not gain much power. However results were excellent for this event.
22	Male	42	Masters cyclist building towards a regional championship racing sprint and endurance events. Athlete started below the line and made a big push for power in block 2 with

			regular carnival racing, but was able to perform more mixed training which saw them move back towards the line and achieve good power at the regional championship.
23	Male	43	Masters cyclist building towards a regional championship racing sprint and endurance events. Rider started above the line, made a big push for capacity in block 2 before pushing for power in block 3 achieving good sprint performances and average endurance performances.
24	Male	48	Masters cyclists building towards a world championship in his 5 year age group. All blocks above the line and block 2 moved closer to the line, however a big push to deliver more power mean a large move away from the line and minimal gain in power, reflected in average performances at the world championships.
25	Male	50	Masters rider competing in their 5 year age band at a World Championship. Riding the 500-m TT and match sprint series achieving 4 rides before being eliminated. Athlete suffering from back injury. Athlete makes a big push for power from block 1-2 and this, plus injury, means there is not a large gain in power in the final block.

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