Positioning and Power Demands During Cycling in a Sprint Triathlon World Championship

Simon Nolte[1*], Oliver Jan Quittmann[1]

[1]Institute of Movement and Neurosciences, German Sport University Cologne

*Correspondence: s.nolte@dshs-koeln.de

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Abstract

Purpose: To assess the power demands of male elite triathletes during the World Championships and investigate the relationship between power output and positioning at turns.

Methods: We analyzed power and position data from 5 out of 8 riders of the front group for the 2020 sprint triathlon World Championship. We created power profiles and distributions and investigated the influence of position on power output with Bayesian hierarchical models.

Results: Athletes of the same bike group experienced different power demands and employed different positioning strategies. With each position further behind during a turn, athletes had a higher peak (+24.2 W [4.8 36.7]; mean [95% credibility interval]) and 10 seconds mean power (+19.3 W [10.5; 27.1]) during the following acceleration. The positioning had a smaller effect on the 20 seconds mean power (+6.3 W [-1.4; 13.6]) and a negative effect on the 20 seconds mean power prior to the turn (-13.4 W [-20.8; -4.99]).

Conclusion: Positioning during cycling can influence the power demands, which may affect subsequent running performance. Athletes and their coaches should identify positioning strategies that fit the individual abilities best.

Keywords: *drafting; performance; pacing; physiology; race strategies*

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Introduction

Cycling in short distance and sprint distance triathlon is characterized by the permission of drafting (Bentley et al., 2002). Typically, athletes collaborate in groups during the bike segment to save energy and make up time. Acceleration, attacks and turns lead to a highly variable power output during cycling in short distance triathlon (Bernard et al., 2009; Etxebarria et al., 2014).

The relevance of cycling to the overall triathlon performance is up to debate. Studies usually correlate cycling and overall performance using split times or split rankings (Figueiredo et al., 2016; Gadelha et al., 2020; Ofoghi et al., 2016; Olaya et al., 2021; Sousa et al., 2021; Vleck et al., 2006). Results range from cycling being the most important segment for predicting overall race performance (Olaya et al., 2021) to cycling being considered more a "smooth transition towards running" (Piacentini et al., 2019). However, the group-riding character of draft legal races will bias every correlation analysis based on bike segment split times. Moreover, even athletes with identical split times may experience different physiological demands during cycling and will start the run segment with differing levels of fatigue.

Drafting is a main factor in reducing the physiological demands during cycling (Bentley et al., 2002). Riding behind other athletes reduces the power output, which saves energy and can ultimately lead to an improved running performance (Hausswirth et al., 1999, 2001). When riding in a line, the drafting effect increases for an individual with an increasing number of riders in front (Druenen & Blocken, 2023). But riding in the back of a bike group can also have its drawbacks: During attacks or turns, athletes in the back of a group may need to accelerate harder in order to stay in the group. This could lead to a more variable power output. A more variable power output in cycling increases fatigue (Etxebarria et al., 2019; Theurel & Lepers, 2008) and may ultimately lead to slower running times (Walsh, 2019). Thus, the positioning within a bike group may influence the power output and overall triathlon race results in a way that is not displayed in split times.

Previous studies analyzed cycling power output in short distance triathlon across different races or across different bike groups within a race (Bernard et al., 2009; Etxebarria et al., 2014). However, no research has yet quantified different power demands within a single bike group during a race. Moreover, no previous research examined to which extent the positioning within a bike group influences the power demands during draft legal triathlon races.

In this study we analyzed positioning and power data of riders in the front group of the 2020 sprint triathlon World Championship. Our results can help coaches and athletes to choose appropriate tactical strategies during the cycling segment of elite triathlon races.

Methods

We analyzed data from the 2020 male sprint distance triathlon World Championship in Hamburg. Due to the Covid-19 pandemic, the world championship title was awarded in a single race instead of a race series. We chose to analyze this particular race, as it featured a medium-sized front group, with television footage of the group being available for most of the race duration. The bike course consisted of six laps of 3.1 km, which included two turning points and two 90-degree corners each.

We retrieved power data from 5 out of 8 riders of the race's front group from public training platforms or as raw data via personal communication. All five athletes provided informed consent to the anonymized analysis of their data. One athlete did not measure power during the race and two athletes did not respond to our requests. All athletes of the front group were elite athletes regularly starting at the highest competition level in sprint and short distance triathlon. We cut and synchronized individual power data based on official race timing and GPS data.

We obtained position data from public television footage of the race. For the four turns in each lap, we determined the position of each athlete within the bike group. When the position was unclear, the data were excluded from further analysis.

Descriptive power data are presented as average power (including zero values), normalized power (Coggan, 2003), time over 500 W and 700 W and the number of peaks over 500 W and 700 W (where a peak was defined as a consecutive time series of power values exceeding the given threshold). We created power profiles for each rider by calculating the maximal effort for a consecutive duration for times ranging from 1 to 1200 seconds. We plotted the distribution of power data for each athlete using Gaussian kernel density estimation.

We investigated the influence of positioning on power output before and after turns. According to the preregistration, we used four outcome variables: the peak power (PPO) of the acceleration after the turn, the mean power for 10 and 20 seconds of the acceleration (MPO10, MPO20) and the mean power during the 20 seconds preceding the turn (MPO20prior). We defined the start of each acceleration by a rider on an individual basis as the first increase in power output exceeding 100W.

To investigate the relationship between positioning and power output before and after turns we ran a Bayesian hierarchical model with random slopes and intercepts for each outcome variable. The exact models in formula notation are available in the supplements. We utilized weakly informative priors and performed Markov chain Monte Carlo diagnostics by calculating Rhat and Neff values and by inspecting trace plots, rank histograms, and density plots of posterior draws (Gabry et al., 2019). We interpreted the main effect of position and its 95% (equal-tailed) credible interval. We additionally calculated overall and individual posterior mean predictions.

We conducted the full data analysis in R Version 4.2.0. The Bayesian models were fitted using Stan Version 2.21.0 via the rstanarm package Version 2.21.3 (Goodrich et al., 2020). This observational study was preregistered on OSF and approved by the local ethics committee (196/2021). All data and code are available at GitHub.

Table 1: Descriptive data for the power output of the five athletes.

Athlete	mean (W)	sd (W)	NP (W)	max (W)	Time over 500 W (s)	Time over 700 W (s)	Peaks over 500 W	Peaks over 700 W
A	366	199	384	827	314	75	70	23
B	354	209	372	976	279	101	83	24
*C	334	207	348	1052	264	71	80	22
D	338	208	357	1061	207	98	48	31
E	357	215	377	964	249	135	41	28

mean: Average Power, sd: Standard deviation; NP: Normalized Power; max: Maximum Power

*Power data for athlete C is missing for the first of six laps. We extrapolated the time and peaks over 500 W/700 W by multiplying the recorded data with the factor 1.2.

Results

The analyzed data show highly fluctuating power demands during the race (see Table 1). Athletes had to deal with around two dozen peaks over 700 W, summing up to a total time of 1-2 minutes over this threshold. Individual differences in the power demands also become apparent by comparing the individual power distributions and power profiles (see Figure 1). Most notably, while being part of the same bike group, the athletes spent a considerably different amount of time at high power outputs.

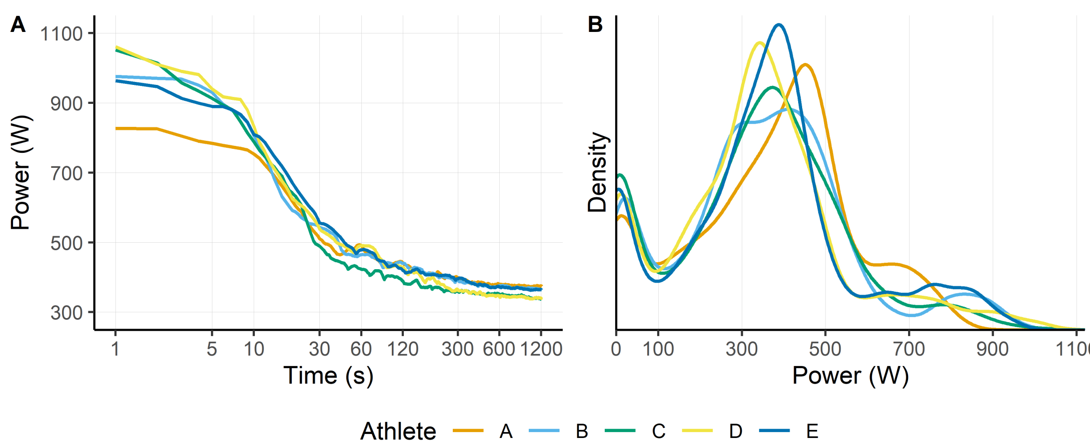

Figure 1: Power profiles and power distributions for the five athletes. (A) Profiles of maximum efforts over a specified duration. Note the logarithmic scaling of the x-axis. (B) Distributions of power data estimated via Gaussian kernel.

The positioning data show frequent changes in positions within the bike group (see Figure 2). The riders appear to have utilized different tactical approaches regarding positioning, with some athletes riding in the front positions for most of the time, and others predominantly riding in the back of the group or fully rotating through all positions. The position at turns was associated with a higher PPO (+24.2 W [4.8; 36.7]; mean [95%CI]), a higher MPO10 (+19.3 W [10.5; 27.1]) and a higher MPO20 (+6.3 W [-1.4; 13.6]) (see Figure 3). Conversely, the position was associated with a lower power output at MPO20prior (-13.4 W [-20.8; -4.99]).

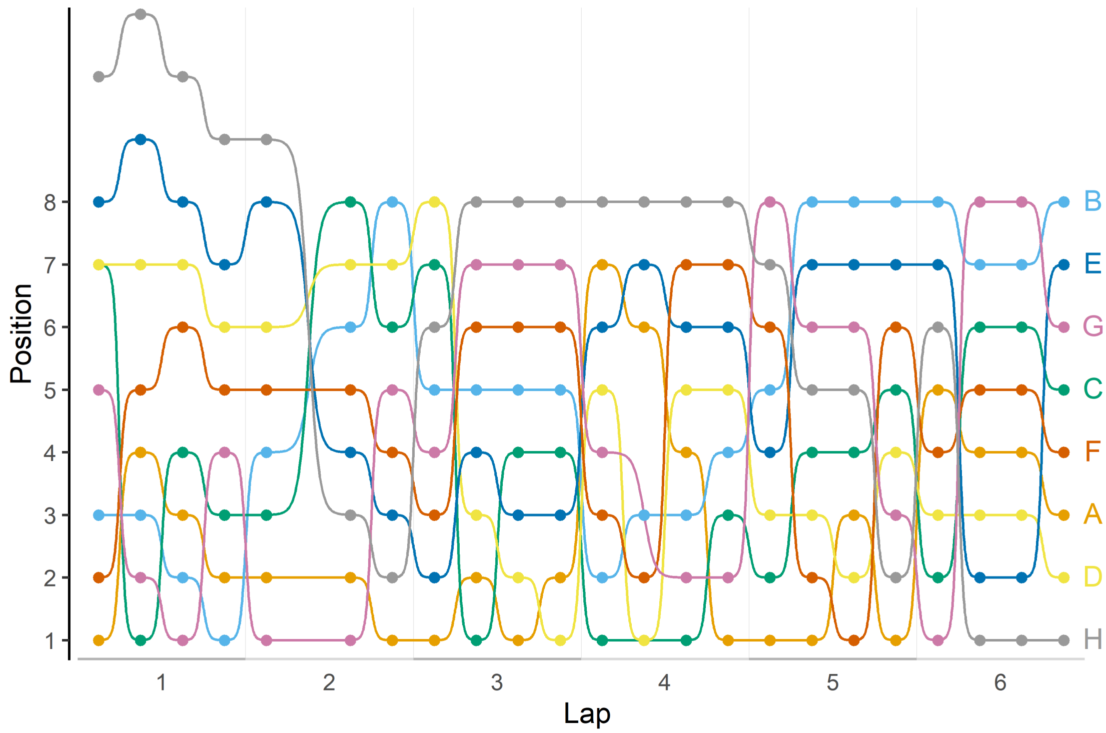

Figure 2: Positioning in the front group assessed at each of the four turns of each lap. Athletes employ different strategies in regard of positioning. For the first lap, the group consisted of more than eight athletes.

Discussion

The aim of our study was to analyze power demands within a bike group in sprint distance triathlon and investigate their relationship with positioning behavior in the group.

The investigated race required the athletes to proliferate highly varying power outputs (see Figure 1). The analyzed front group athletes had a considerably higher mean power output (350±13 W) than previously reported values in male elite Olympic distance triathlon (252±33 W and 265±19 W, (Bernard et al., 2009; Etxebarria et al., 2014). Moreover, the athletes had more and higher peaks of power output than reported elsewhere (Etxebarria et al., 2014). The short race distance, the tactical situation of one medium-sized front group, and a racecourse with many turns may have all contributed to the high-intensity character of the cycling segment. Our data demonstrate that cycling in modern draft legal triathlon races is much more than just a "smooth transition towards running" (Piacentini et al., 2019).

The power output distribution of the analyzed race varied between athletes, despite them

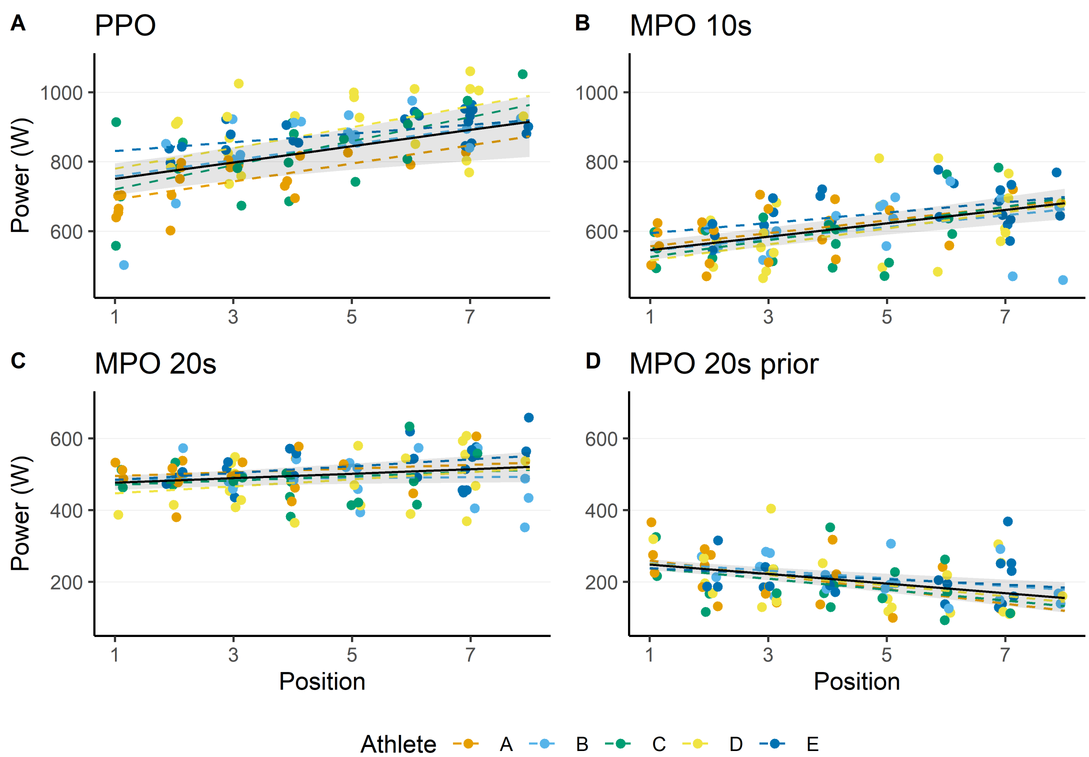

Figure 3: Power outputs before and after turns in relation to the positioning within the group. A position further in the back of the group is associated with larger peak and mean power outputs in the following acceleration. Dashed lines show individual posterior mean predictions. The black solid lines display overall posterior mean predictions, with the 95% confidence interval shaded in grey. A single data point for an athlete being at position 9 during the first corner of the race is available and was included in the analysis, but is not displayed.

being part of the same group (see Table 1, Figure 1). We expect the different positioning strategies inside the bike group (see Figure 2) to be the main factor for the varying power demands. Athletes in the front of the group at a turn have a lower peak and mean power in the following acceleration (see Figure 3). The observed effect of position on peak power is large (+24.2 W [4.8; 36.7]), as it suggests, that with each position placed further behind, an athlete has an PPO higher by 24 W. Accordingly, riding on the fifth position instead of the front at a turn, will require an 100 W higher acceleration peak on the mean level. The size of the effect decreases when considering mean power values over longer time frames (see Figure 3, Panel B and C). While a position in the back of a group is associated with a reduced power output before a turn (MPO20prior -13.4 W [-20.8; -4.99]), it should be noted that these power outputs are generally in a low to medium intensity range (see Figure 3, Panel D). Accordingly, the differences in power output before a turn will not have the same physiological relevance as the differences after a turn. Our investigated power data suggest that the benefits of riding turns at the front of the group outweigh the drawbacks.

The technical abilities of riding turns may influence the effect of positioning on power demands. We did not measure bike handling skills but controlled for individual differences by the hierarchical nature of our statistical model. As the effect of positioning on power output is consistent across individuals (see Figure 3), we can assume that it is present regardless of bike handling skills. However, athletes with poorer technical ability may likely need to sustain higher power outputs in acceleration compared to skilled athletes in general and even more when at the back of a group.

Variable power output during cycling increases fatigue (Theurel & Lepers, 2008) and may have a negative impact on subsequent running performance (Walsh, 2019). Therefore, choosing appropriate tactical approaches during cycling may affect overall triathlon performance. To investigate this effect in the field, researchers should collect larger samples of power and positioning data and correlate them with running performance while controlling for running performance levels.

Practical Applications

In theory, athletes should aim to be as far at the front as possible during turns, while gaining as much drafting effect as possible during all other parts of the racecourse. In practice, this strategy will be impossible to execute, as it slows down the bike group and disrupts any efforts of cooperative work. Thus, athletes and coaches should balance the benefits and risks of different positioning strategies, and ultimately choose an appropriate strategy based on the athlete's abilities.

Riding predominantly in the back of the group reduces the total amount of time in a medium-to-high intensity zone but magnifies the number of peaks and time at a very high-intensity. This strategy may be suitable for athletes mainly participating in short races (e.g., relays, junior races) or athletes with the physiological ability to recover quickly from intense bursts.

Riding in front of the group will reduce the intensity of acceleration, but requires more and longer medium-to-high intensity efforts due to the reduced effect of drafting. This strategy may work best for athletes also competing over longer distances with the ability to sustain a high power output over a prolonged time (e.g., a high critical power). Ultimately, athletes considering themselves strong in both continuous and sprint efforts can use the front position to make a race harder: They can deliberately perform accelerations after each turn, knowing that the riders behind them must make an even harder effort.

Conclusions

Cycling in modern sprint distance triathlon is characterized by highly variable power demands including sprint-like efforts after each turn. With a front position in the bike group during a turn, athletes can reduce the peak and mean power output of the following acceleration. However, this leads to a reduced drafting effect and comes with an increased mean power output before the turn. As the distribution of power output may influence running performance, athletes should choose an appropriate positioning strategy based on individual factors, such as experience, technical abilities, and physiological profile.

Contributions

Both authors contributed to the conception and design of the research and acquired the data. SN analyzed and interpreted the data and wrote the initial draft. OJQ revised the article for important intellectual content. Both authors approved the final version of the manuscript to be published.

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Data and Supplementary Material Accessibility

All data and code are available at https://github.com/smnnlt/trihamburg.

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