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Performance Analysis of a World-Class Sprinter During Cycling Grand Tours

Paolo Menaspà, Chris R. Abbiss, and David T. Martin

This investigation describes the sprint performances of the highest internationally ranked professional male road sprint cyclist during the 2008–2011 Grand Tours. Sprint stages were classified as won, lost, or dropped from the front bunch before the sprint. Thirty-one stages were video-analyzed for average speed of the last km, sprint duration, position in the bunch, and number of teammates at 60, 30, and 15 s remaining. Race distance, total elevation gain (TEG), and average speed of 45 stages were determined. Head-to-head performances against the 2nd–5th most successful professional sprint cyclists were also reviewed. In the 52 Grand Tour sprint stages the subject started, he won 30 (58%), lost 15 (29%), was dropped in 6 (12%), and had 1 crash. Position in the bunch was closer to the front and the number of team members was significantly higher in won than in lost at 60, 30, and 15 s remaining ($P < .05$). The sprint duration was not different between won and lost (11.3 ± 1.7 and 10.4 ± 3.2 s). TEG was significantly higher in dropped (1089 ± 465 m) than in won and lost (574 ± 394 and 601 ± 423 m, $P < .05$). The ability to finish the race with the front bunch was lower (77%) than that of other successful sprinters (89%). However, the subject was highly successful, winning over 60% of contested stages, while his competitors won less than 15%. This investigation explores methodology that can be used to describe important aspects of road sprint cycling and supports the concept that tactical aspects of sprinting can relate to performance outcomes.

Keywords: total elevation gain, competition analysis, Tour de France, drafting, winning strategy

Road-cycling sprint performance is influenced by a variety of factors including individual and team tactics, technique, and the physiological characteristics of the cyclist. Road sprinters have the distinctive ability to excel in mainly flat cycling competitions,^{1,2} in which the final sprints are initiated from high speed.³ In professional cycling the sprinters often make up a very small proportion of the team (eg, 2 out of 30 riders). This factor, together with the complexity of road sprinting, may be the reason for the lack of scientific research detailing the characteristics important to successful road sprinting. Indeed, several studies have described the physiological demands of competition and the characteristics of other specialty cycling groups, including time trialists, climbers, and off-road cyclists.^{1,4–6} Furthermore, a number of studies have examined the physiological characteristics of track sprinters.^{7–9} However, we are currently aware of only 1 study that provides a detailed description of road sprint-cycling performance, and that study was on a single cyclist performing a single sprint.³

There has been little, if any, research describing the tactical approach adopted by road sprint cyclists.

Bullock et al¹⁰ examined bunch position in World Class short-track speed skaters and observed unique positioning strategies in winners over 3 different race distances. Similar to cyclists, speed skaters gain an advantage by drafting but also face the disadvantage of passing a competitor as they approach the finish.¹¹ It is possible that a similar evaluation of sprint cycling could be useful for understanding performance.

Sprints are an extremely important aspect of professional road cycling. In fact, many stages (eg, ~7 out of 21) in each of the Grand Tours (ie, Giro d'Italia, Tour de France, and Vuelta a España) are designed specifically for sprinters. Noticeably, among professional road sprinters, only a few are able to win Grand Tour stages, and even fewer can win repeatedly. For example, examination of the sprint results in recent Grand Tours (2008–2011) indicates that 79 stages (of 252 total stages, 31%) were won by only 24 sprinters. Five sprinters won 54 stages of which 1 sprinter won 30 stages. Due to his outstanding results, this cyclist was selected as the primary subject of the current investigation. The aim of this investigation was to provide a detailed description of the sprint performances of a professional world-class sprinter during Grand Tours to extend methodology used for evaluating road sprints. A secondary aim was to compare performances of this cyclist against those of his closest rivals to identify key factors that may influence sprint performance.

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Methods

Subject

The subject in this investigation was a 26-year-old professional road cyclist (1.75 m, 69 kg, 22.5 body-mass index) specializing in sprints. At the time of investigation, and in the previous 3 cycling seasons, this cyclist was ranked highest among international professional male sprinters according to a specific international ranking (cqranking.com).

Design

This study incorporates a single-case-study longitudinal design evaluating data retrospectively. Performance data were publically available, and this research project was approved by a university human research ethics committee. We, the authors, do not have any potential conflicts of interest.

Methodology

Performance data and videos from Grand Tours between 2008 and 2011 were taken from online public-access Web sites and official race results. All the Grand Tour stages won by specialist sprinters were analyzed, and the subject's race results were classified as rate of victory and defeat per participation. For the purpose of this investigation, cyclists have been classified as sprinters when their best performances were achieved in relatively flat competitions finishing at high speed (eg, last kilometer at an average speed of $\sim 60 \text{ km} \cdot \text{h}^{-1}$) and against a relatively large number of competitors. Sprint stages were classified into those in which the subject won or lost the sprint or was dropped before the sprint (ie, WON, LOST, and DROPPED). To determine tactical differences between stages WON and LOST, video footage of 31 stages was also analyzed for the subject's position in the bunch and the number of teammates in front of him at 60, 30, and 15 s remaining, average speed of the last kilometer, and sprint duration. Sprint duration has been defined as the amount of time elapsed between the moment the subject started to sprint (ie, moved off the wheel in front and often began sprinting out of the saddle) and the finish line. Moreover, race distance, total elevation gain (TEG), and average speed of 41 stages were determined to establish a relationship with stages WON, LOST, and DROPPED. The TEG has been calculated using the altitude data presented in altimetric-profile maps. Based on the number of wins in Grand Tour stages, the second to fifth most successful sprinters during the period under investigation were also identified; they won 7, 6, 6, and 5 stages, respectively. The performances of these cyclists were compared with the subject's performances to provide a descriptive head-to-head analysis. When performing head-to-head comparisons, only stages performed by both participants were compared. In the sprint comparison, sprinters were considered in contention for the sprint when they both finished in the top 20 for the stage.

Statistical Analysis

The average speed of the last kilometer and the sprint duration were compared between stages WON and LOST using independent-sample *t* tests. Dependent variables (stage distance, TEG, and average speed) were compared between stages WON, LOST, and DROPPED using a 1-way analysis of variance (ANOVA). Distance from the front of the bunch and number of teammates at 60, 30, and 15 s of the race remaining were compared between WON and LOST using a mixed-model ANOVA. Where significant effects were observed, a Fisher least-significant-difference test was performed. Where violations of assumptions of sphericity were observed, the degrees of freedom were corrected using Greenhouse-Geisser or Huynh-Feldt corrections where appropriate. Critical level of significance was established at $P < .05$. Results are presented as mean \pm SD unless otherwise stated.

Results

The cyclist in this study became professional at the age of 22, winning 75 professional road races at the end of the 2011 cycling season. This cyclist has twice won the general points classification in a Grand Tour. In his professional career, he has completed 79 ± 9 professional races/y, riding approximately 12,000 km/y (only in races). The 2nd to 5th competitors rode an average of 80 ± 10 races/y and also raced over approximately 12,000 km/y (cqranking.com).

In the 4 cycling seasons analyzed, the subject started 9 Grand Tours (ie, 3 \times Giro d'Italia, 4 \times Tour de France and 2 \times Vuelta a España) and finished 52 stages (out of 79 won by sprinters). The cyclist WON 58% ($n = 30$), LOST 29% ($n = 15$), and was DROPPED on 12% ($n = 6$) of these stages, and in 1 stage he was involved in a sprint accident. There was no significant difference in the average speed of the last kilometer ($P = .51$) or the sprint duration ($P = .33$; Table 1) between WON and LOST. The subject's position in the bunch and the number of teammates at 60, 30, and 15 s were significantly different between WON and LOST stages ($P < .05$; Table 1).

In DROPPED stages, TEG was significantly higher than both WON and LOST ($P < .01$ and $P = .02$; Table 2). TEG for WON and LOST was not significantly different ($P = .85$). Stage length and average speed were not different between WON, LOST, and DROPPED ($P = .49$ and $P = .85$; Table 2).

Table 3 shows the performances during head-to-head competitions between the subject and his closest competitors. The cyclist's ability to reach the finish line to be in contention for the sprint (sprint chances) was lower than that of the 4 other successful sprinters (77% vs an average of 89%). However, he won over 60% of stages in which he was in contention to sprint (win ability), while his competitors won less than 15%.

Discussion

The purpose of this study was to examine the race results of a professional world-class sprinter performing in

Table 1 Average Speed, Sprint Duration, Position in the Bunch, and Number of Teammates of the Subject Determined From Video Analysis of Won and Lost Sprints (N = 31)

	Average speed in last km, km · h ⁻¹	Sprint duration, s	Position From the Front of the Bunch			Number of Teammates in Front of the Subject		
			60 s to the finish	30 s to the finish	15 s to the finish	60 s to the finish	30 s to the finish	15 s to the finish
Won (n = 19)	60.6 ± 4.2	11.3 ± 1.7	6 ± 2*	3 ± 1*	2 ± 0*	2 ± 1**	1 ± 1*	1 ± 1**
Lost (n = 12)	59.6 ± 4.2	10.4 ± 3.2 ^a	9 ± 5	8 ± 5	5 ± 4	0 ± 1	1 ± 1	0 ± 1

*Significantly different ($P < .05$) from lost sprints. **Significantly different ($P < .001$) from lost sprints.

^a n = 9.

Table 2 Distance, Total Elevation Gain (TEG), and Average Speed of Stages the Subject Won, Lost, and Was Dropped Before the Finish (N = 45)

	Stage distance (km)	TEG (m)	Average speed (km · h ⁻¹)
Won (n = 28)	179 ± 30	574 ± 394*	41.9 ± 2.5
Lost (n = 11)	173 ± 39	601 ± 423*	41.8 ± 2.1
Dropped (n = 6)	193 ± 28	1089 ± 465	42.4 ± 2.0

* Significantly different ($P < .05$) from dropped stages.

Table 3 Performance of the Subject Relative to the Second to Fifth Most Successful Competitors

	2nd		3rd		4th		5th	
Number of stages with subject	39		139		92		104	
Number of sprint stages with subject	11		57		39		44	
	S	C	S	C	S	C	S	C
Sprint chances (number of sprint stages in the top 20)	8	11	51	49	28	35	33	35
Sprint chances (% of sprint stages in the top 20)	73	100	89	86	72	90	75	80
Wins	6	1	29	5	17	8	19	5
Win/sprint ability (victories relative to sprint chances, %)	75	9	57	10	61	23	58	14

Note: Only stages competed by both the subject and competitor were compared. Abbreviations: S indicates subject; C, competitor.

Grand Tours to explore methodology and identify key factors responsible for winning sprint performances. Our case study reveals methodology that can be used to evaluate tactical aspects of road-cycling sprint finishes and documents that bunch position and teamwork are associated with successful outcomes. In addition, data collected from a highly successful sprint cyclist indicate that in addition to team support and position in the bunch, stage characteristics (TEG) can influence overall sprint performance.

Despite his young age, the cyclist examined is one of the most successful sprinters in the history of cycling (<http://www.cyclingnews.com/features/the-top-ten-sprinters-of-all-time>). At the time of this investigation, he had won 58% of the Grand Tour sprint stages that he completed. Whereas previous case studies describe

physiological characteristics of cyclists who have repeatedly won Grand Tours,^{12,13} our investigation focused on a road sprint cyclist and tactical aspects of his winning performances.

It is well accepted that team tactics are extremely important for winning a sprint finish in cycling; however, we are unaware of research that has directly examined the implementation, execution, and success of team tactics during a sprint finish in a Grand Tour. In road cycling, teammates or team members of a sprinter will often lead the cyclist through the final kilometers of the event to allow the sprinter to conserve energy and be well positioned for the final sprint. Broker et al¹⁴ characterized the effect of drafting in team-pursuit cyclists riding at 60 km · h⁻¹ on a velodrome, a speed that is relevant to the road sprint lead-out. For team-pursuit cyclists the power

output required to ride at $60 \text{ km} \cdot \text{h}^{-1}$ was reduced by 29% while riding in second position and by 36% while riding in third position. Martin et al³ also used a theoretical model to explore the relevance of drafting in road sprint cycling, showing that a cyclist sprinting from the second position can win by 1 m compared with other strategies. Video analysis in the current study indicates that in stages resulting in a win, this subject had strong team support, as indicated by the presence of 1 or 2 teammates leading the subject out at 60 s from the finish (ie, approximately the last kilometer). Typically, this team support was maintained until the final 15 s, when 1 teammate was still in front of the subject in stages resulting in a win. This team organization may be responsible for the subject's positioning and smooth progression through the bunch in the last minute of each stage. Indeed, the subject in this investigation was significantly better placed at 60 s from the finish in the stages that resulted in a win, compared with stages resulting in a loss (ie, in 5th–6th vs 9th–10th position). Furthermore, he rarely had teammates in front of him in the last 60 s (approximately 1 km) of the race in the stages that resulted in a loss. These results highlight the significant importance of team tactics in successful road sprint performance. Further research adopting the novel methodology used in this study is needed to examine the importance of team tactics to other professional sprint cyclists and in other aspects of road cycling (ie, hill climbing). Such research may provide valuable information on the importance of team support to different professional cyclists performing various road-cycling tasks. Indeed, some professional sprinters appear to have the ability to excel in the road-cycling sprint with little team support.

We adopted a performance-analysis technique similar to the approach published by Bullock et al,¹⁰ who examined bunch position in elite short-track speed skating. Similar to their observations with skaters, it appears that position in the lead bunch over the final kilometer of the race is important to sprint-cycling performance. If the sprint cyclist is too far back or too close to the front, the odds of winning are diminished. More specifically, we observed that the winning sprints never occurred if the cyclist was more than 9 positions back from the front of the race at 60 s remaining. The ideal position in the peloton toward the end of the race for sprinters appears to be somewhere between second and ninth behind the leaders and could be influenced by terrain and technical aspects of the race (narrow roads, turns, etc).

Road sprint cycling is a unique cycling discipline requiring cyclists to have high aerobic and anaerobic capacity.^{15–17} Improving strength and anaerobic capacity may improve sprint performance^{18,19}; however, in some stages of Grand Tours, sprinters are required to cycle over high mountain passes to reach the finish line.²⁰ The ability to win such stages, some of which may last more than 7 hours, requires high aerobic qualities (ie, maximal oxygen uptake and metabolic thresholds). In this study there was a significant difference in the total elevation change between stages in which the subject was dropped

during the stage ($1089 \pm 465 \text{ m}$) and stages in which he was in contention for the sprint ($582 \pm 397 \text{ m}$). The influence of elevation on race dynamics is important to not only the sprinters but also the entire peloton. Indeed, we observed a logarithmic correlation ($R^2 = .53$) between the TEG of stages and the number of riders reaching the finish line in the first main bunch (data not shown). In particular, 70% of the stages with less than 1000 m of TEG finished with a sprint. Only 20% of the stages with a TEG between 1000 and 2000 m finished with a sprint, and none of the stages with a TEG over 2000 m was won by a specialized sprinter. The performance of a sprinter during Grand Tours is therefore highly dependent on not only sprint capacity but also other physiological attributes related to hill-climbing capacity. Supporting this, the cyclist in the current study had fewer sprint chances than his most successful competitors, presumably due to lower hill-climbing capabilities (ie, aerobic capacity). However, if he made it to the finish line in the leading group, this cyclist was much more likely to succeed in the final sprint, winning over 60% of the stages in which he was in contention to sprint. These differences occurred despite the fact that the number of races completed and total kilometers cycled during competitions were similar between the cyclist in this study and his closest rivals. Such results highlight the fact that physiological characteristics might be different among the various specialty sprinters. Future research aiming to classify and describe different kinds of sprinters (eg, flat- or hilly-terrain sprinters, long- or short-sprint sprinters) is recommended. Knowing the sprinters' climbing ability (sprint chances) and their likelihood to succeed in the sprint (win ability), together with a careful evaluation of the rivals' characteristics, may be important in the development of training programs or the selection of events that may best suit particular athletes. Noticeably, external factors other than TEG, such as the position of the elevation gain within a stage, are extremely important to race dynamics. Despite this, data from this study provide some indication of the influence race profile has on outcomes of the event. Additional valid methods to describe the elevation gain and altimetric profile of road-cycling events therefore appear important when describing stage characteristics. With such data, it will be possible to analyze the whole race and different sections of competition to improve the understanding of technical and tactical issues relevant for race outcomes.

Practical Applications

This case study outlines methodology that can be used by sport scientists to quantify key aspects of road sprint cycling. Positioning in the bunch appears to influence the probability of winning; thus, athletes may benefit by team support or training to position themselves wisely. Sprinters with good climbing ability will get more opportunities to sprint, compared with relatively poor climbers, and possibly get a chance to sprint against a less competitive field because others sprinters (ie, flat-terrain sprinters) are dropped before the finish. However, training choice (ie, to

improve the climbing ability or the sprint ability) should be guided by a careful evaluation of the characteristics (sprint chances and win ability) of the cyclist and the cyclist's competitors.

Conclusions

In conclusion, this study examined the race results of a professional world-class sprinter performing in Grand Tours. The results indicate that the position of this cyclist in the bunch and the number of teammates leading into the finish are important factors in stage-racing sprint performance. Furthermore, compared with his closest competitors, this subject was less likely to reach the finish line in the leading group during stages that contained a high TEG. However, when arriving at the finish line in the leading group, this cyclist was considerably more successful than his closest competitors.

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