

Performance Demands of Completing a First Grand Tour: A Case Study from the Giro d'Italia 2025

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Received: 2 March 2026

Accepted: 24 March 2026

Published: 29 October 2026

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Keywords

power output; external load; intensity distribution; elite cycling

1 Introduction

Grand Tours are the highest-demanding format in professional road cycling, requiring riders to compete across 21 stages over three consecutive weeks. Previous research has characterized the mechanical and physiological demands of different stage types within Grand Tours, showing substantial variability in exercise intensity, workload, and power output profiles depending on stage characteristics (Sanders & Heijboer, 2019). However, while stage-specific demands have been relatively well described, less attention has been paid to the cumulative workload experienced across the entire three-

week competition, particularly from the perspective of a Grand Tour debutant.

Understanding these demands is particularly relevant for debuting riders, as preparation strategies must account not only for peak performance requirements but also for durability under prolonged accumulated fatigue, a factor increasingly recognized as a key determinant of performance during Grand Tours (Lamberts et al., 2024; Muriel et al., 2022). Quantifying total work performed, relative intensity, and effort distribution across three weeks of competition may provide valuable applied insight for coaches and performance staff preparing athletes for stage racing at the World Tour level.



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Therefore, the purpose of this study was to characterize the external load and performance demands associated with completing a first Grand Tour, using a single-case analysis of a UCI World Tour cyclist during the 2025 Giro d'Italia.

2 Material and Methods

A single-case descriptive observational study was conducted on a 22-year-old male UCI World Tour cyclist during his debut at the 2025 Giro d'Italia. Anthropometric characteristics assessed in May 2025 included body height (183 cm), body mass (65.8 kg), body mass index ($19.7 \text{ kg}\cdot\text{m}^{-2}$), and sum of eight skinfolds (40 mm). Performance characteristics from May 2025 included a functional threshold power (FTP) of 395 W ($6 \text{ W}\cdot\text{kg}^{-1}$). The power-duration profile comprised 5 s: 1077 W ($16.4 \text{ W}\cdot\text{kg}^{-1}$), 1 min: 662 W ($10.1 \text{ W}\cdot\text{kg}^{-1}$), 5 min: 493 W ($7.5 \text{ W}\cdot\text{kg}^{-1}$), 10 min: 440 W ($6.7 \text{ W}\cdot\text{kg}^{-1}$), 20 min: 416 W ($6.3 \text{ W}\cdot\text{kg}^{-1}$), 60 min: 367 W ($5.6 \text{ W}\cdot\text{kg}^{-1}$), and 90 min: 341 W ($5.2 \text{ W}\cdot\text{kg}^{-1}$). Maximal oxygen uptake ($\text{VO}_{2\text{max}}$) was estimated at $83 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ using a prediction equation (Sitko et al., 2021).

General race characteristics (stage distance, duration, elevation gain, and average speed) and stage-specific performance data, including power output, cadence, workload, and intensity metrics, were extracted from the athlete's publicly available Strava profile. The power data were recorded using a Shimano Dura-Ace FC-R9200-P power meter (Shimano Inc., Osaka, Japan), with a manufacturer-declared measurement accuracy of $\pm 1.5\%$. According to the athlete, the power meter was calibrated prior to each stage following manufacturer guidelines. Activity files were collected daily by the primary investigator on the same day each stage was completed, ensuring that the files were retrieved shortly after upload. In addition, the researcher

confirmed with the athlete that the uploaded activities corresponded to the original power files recorded during each stage.

External load variables included total duration (h:mm:ss), distance (km), work (kJ), energy expenditure (kcal), elevation gain (m), normalized power (NP, W), average power (AP, W), and maximal power (W). Relative intensity was quantified using intensity factor (IF), percentage of FTP, and $\text{W}\cdot\text{kg}^{-1}$ values. Time-in-zone distribution was calculated across seven predefined power zones. Descriptive statistics (mean $\pm$ SD) were used to characterize stage demands and variability across the three-week competition. Stage durations were calculated based on the complete activity files recorded by the athlete, which included neutralized sections at the beginning of stages; therefore, small discrepancies with official race times may occur.

3 Results

The cyclist completed all 21 stages of the Giro d'Italia 2025, accumulating a total race duration of 88 h 59 min 53 s over 3,533.8 km, with 51,691 m of elevation gain. Total mechanical work performed during the event was 79,031 kJ, corresponding to an estimated energy expenditure of 57,596 kcal. Mean mechanical work per stage was $3,763 \pm 1,449$ kJ, while mean energy expenditure per stage was $2,743 \pm 1,074$ kcal.

Mean stage duration was $4:14:47 \pm 1:26:27$ (h:mm:ss), with an average distance of 168.3 ± 53.5 km and elevation gain of $2,461 \pm 1,456$ m per stage. Mean stage speed was $40.4 \pm 4.2 \text{ km}\cdot\text{h}^{-1}$.

Across stages, normalized power (NP) averaged 291 ± 28 W, corresponding to $4.43 \pm 0.42 \text{ W}\cdot\text{kg}^{-1}$, while average power (AP) was 251 ± 36 W ($3.82 \pm 0.55 \text{ W}\cdot\text{kg}^{-1}$). Maximal power achieved during stages was 967 ± 117

W. Relative intensity was characterized by a mean intensity factor (IF) of 0.81 ± 0.08 and a mean percentage of FTP of $64 \pm 9\%$. Average cadence across the competition was 89 ± 5 rpm.

Time-in-zone analysis demonstrated a predominantly pyramidal intensity distribution across seven predefined power zones based on FTP (395 W). Zone 1 (0-198 W; active recovery) accounted for $36 \pm 13\%$ of total race time. Zone 2 (199-276 W; endurance) represented $14 \pm 3\%$, Zone 3 (277-356 W; tempo) $15 \pm 4\%$, and Zone 4 (357-415 W; threshold) $16 \pm 9\%$. Higher-intensity efforts were less prevalent, with Zone 5 (416-474 W; VO₂max) accounting for $9 \pm 3\%$, Zone 6 (475-593 W; anaerobic capacity) $7 \pm 2\%$, and Zone 7 (> 593 W; neuromuscular power) $3 \pm 1\%$ of total time.

4 Discussion

This case study characterizes the external load and performance demands required to complete a first Grand Tour. The findings indicate that successful completion was achieved through sustained high submaximal intensity rather than prolonged supra-threshold effort. Despite the considerable cumulative workload accumulated across three consecutive weeks, relative intensity remained predominantly below FTP, with a clear pyramidal distribution across predefined power zones. The cyclist accumulated a total mechanical workload of 79,031 kJ across 21 stages, corresponding to a mean workload of $3,763 \pm 1,449$ kJ. These values are consistent with previous reports describing the energetic demands of Grand Tours. For example, Van Erp et al. (2020) reported mean stage workloads ranging from approximately $3,530 \pm 1,192$ to $3,770 \pm 1,359$ kJ in a general classification contender across multiple Grand Tours. The mean mechanical work

observed in the present case therefore falls within the upper range reported for riders competing for overall classification positions, highlighting the substantial cumulative energetic demands imposed during three-week stage races.

The mean intensity factor observed across stages suggests that the principal challenge of a Grand Tour debut lies in repeatedly tolerating substantial volumes of moderate-to-high-intensity submaximal work amid progressive fatigue levels. The predominance of time spent in Zones 1 to 4, combined with comparatively limited exposure to higher-intensity zones, supports the notion that durability may be more decisive for completion than maximal aerobic or anaerobic capacity alone. This intensity distribution is consistent with previous investigations of professional cycling races, which have shown that cyclists spend the majority of completion time at low-to-moderate intensities despite the overall high workload imposed by stage racing (Sanders & Heijboer, 2019). Similarly, Padilla et al. (2008) reported that uphill segments during three-week races typically involve prolonged efforts close to threshold intensity, emphasizing the importance of sustaining high submaximal power outputs over extended durations.

In this context, the importance of maintaining performance despite accumulated fatigue has increasingly been highlighted in the scientific literature. Recent research suggests that durability, defined as the capacity to sustain high power outputs despite progressive fatigue, is a key determinant of performance during Grand Tours (Lamberts et al., 2024; Muriel et al., 2022). In addition, comparisons between competition levels indicate that World Tour cyclists accumulate greater workloads and

spend more time at higher-intensity power outputs than Pro Team cyclists, with performance differences becoming more evident as the race progresses (Muriel et al., 2021). These findings reinforce the idea that successful participation in a Grand Tour depends largely on the ability to maintain performance stability across consecutive stages rather than solely on peak physiological capacities.

Finally, the physiological profile of elite cyclists provides additional context for interpreting the present results. Previous research describing the physiological characteristics of a multiple Tour de France winner reported exceptionally high aerobic capacity together with elevated gross efficiency, two characteristics that enable cyclists to sustain high submaximal power outputs during prolonged competition (Bell et al., 2017). In the present study, maximal oxygen uptake was estimated using a power-based prediction equation originally validated in recreational-to-trained cyclists (Sitko et al., 2021); therefore, although the resulting value appears physiologically plausible for an elite World Tour cyclist, its applicability to riders competing at the highest level should be interpreted with caution, as the equation has not yet been fully validated in elite professional cyclists.

5 Practical Applications

The present findings provide practical insight for coaches, sport scientists, and performance staff preparing cyclists for Grand Tour participation. The results suggest that preparation strategies should emphasize the development of durability and the ability to sustain prolonged submaximal workloads rather than focusing exclusively on maximal physiological capacities. Training programs should therefore prioritize high-volume endurance

work combined with repeated moderate-to-high-intensity efforts that mimic cumulative fatigue experienced during multi-stage races. In addition, monitoring external load metrics such as normalized power, accumulated mechanical work, and intensity distribution may help practitioners better understand the performance demands imposed during Grand Tour competition and optimize training and recovery strategies accordingly.

6 Conclusions

Completing a first Grand Tour requires the ability to tolerate extremely high cumulative workloads while sustaining elevated submaximal power outputs across three consecutive weeks of racing. The predominantly pyramidal intensity distribution observed in this study suggests that the principal challenge of Grand Tour competition lies in repeatedly performing large volumes of moderate-to-high-intensity work rather than prolonged supra-threshold efforts. These findings highlight the importance of fatigue resistance as a key determinant of performance during stage racing and provide applied insight into external load demands experienced by riders making their Grand Tour debut.

Funding: This research was funded by the Spanish Ministry of Science, Innovation and Universities (FPU24 predoctoral fellowship, reference FPU24/02003) and the Basque Government (grant number IT1726-22).

Conflicts of Interest: The authors declare no conflict of interest.

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