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Conference Abstract

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The Influence of Prior Accumulated Work on the Torque-Cadence Relationship in Junior Cyclists

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Abstract

Understanding the torque-cadence-power relationship in fatigue is crucial for assessing cyclists' performance potential. The aim of the study is to investigate the impact of prior accumulated work (like a junior cycling road race) on the power duration and torque cadence relationship. Results showed that race simulation workload induces reductions in Critical Power (CP: fresh = 301 ± 41; fatigued = 282 ± 46; $p = 0.021$), work capacity (W': fresh = 12497 ± 2846; fatigued = 9780 ± 2396; $p = 0.009$), 15 seconds, 3 minutes and 12 minutes all out efforts along with lower cadences ($p < 0.05$). On the other hand, torque values did not change under fatigue across all out efforts. These findings highlight that accumulated work influences the torque-cadence-power dynamics showing that drop in power output is mainly driven by declines in cadence rather than torque.

Keywords

cycling; endurance; fatigue; torque; cadence

1 Introduction

In recent years, it has been acknowledged that elite road cyclists exhibit the capability to generate substantial power output even under conditions of fatigue (Spragg et al., 2024). This attribute, referred to as durability, is essential for achieving success in competitive cycling, and numerous studies have examined both during races and training across various categories the decline in the power-duration relationship as riders experience fatigue (Gallo et al., 2022; Spragg et al., 2024). The parameters of torque and cadence are critical determinants of power output, and the capacity to sustain an optimal equilibrium between these factors can profoundly influence cycling performance (Leo et al., 2023). As fatigue affects power output, it is fundamental to recognize that its determinants are also influenced by prior exertion.

Despite the significance of these components, a limited number of studies have thus far described the relationship of the torque-cadence in road cyclists. In this context, Sanchez-Jimenez et al. (2023) showed that reductions in cadence, as opposed to torque, under conditions of fatigue have an effect on the sustainability of power output in non-elite road cyclists. Moreover, Leo et al. (2023) described that the torque production influences the power output differences between different cyclists categories. Within this framework, this pilot study aims to describe the impact of fatigue on power output and torque-cadence relationship after a simulated junior race.

2 Material and Methods

2.1 Participants

Ten junior cyclists (age: 16 ± 1 yr; body mass: 59.9 ± 5.1 kg; stature: 1.74 ± 0.5 m) took part in the pilot study during a training camp held in January 2025.

2.2 Methodology

The riders performed two days of CP test both in fresh and fatigue condition. The CP test consist of performing from a rolling start one all-out effort of 15 s, 3, and 12 min for both fresh and fatigued conditions with 10 min active recovery RPE 2 out of 10 between the 15 s and 3 min effort and 30 min active recovery between the 3- and 12-min effort. In the 3- and 12-min trials participants were asked to maintain a cadence between 80 and 100 revolutions per minute (rev·min^{-1}). The CP protocols both in fresh and fatigue condition have been performed in two different days interspersed by one day of rest. During both CP tests, participants were instructed to ingest carbohydrates at a rate of 90 grams per hour. In the period preceding the evaluations and throughout the days of the CP tests, participants refrained from the consumption of ergogenic supplements. The three efforts both in fresh and fatigued conditions have been performed in the same traffic-safe roads with an average gradient of 5.5%. Before performing CP test in fatigued condition participants performed a ~60-minute warm-up at 40% to 50% of their CP and then performed 3-minute repetitions at ~115% of their CP interspersed by 3-minute rest periods at 50% CP until an accumulation of an amount of 1100 kilojoules similar to a junior race workload as reported by Gallo et al., 2022, so they started the CP test in fatigued conditions. Power output data (Favero Assioma Duo, Favero Electronics srl., Arcade, TV, Italy) were recorded using the same cycle computer (Garmin Edge 530, International, Inc., Kansas, USA), and analysed using WKO5 Software (WKO5, Peaksware LLC, Lafayette, CO, USA). For the CP tests the inverse of time model, using the least sum of squares linear regression analysis, was used to derive the power-duration parameter estimates from 15 s, 3 min and 12 min efforts. The intercept of the regression line represented CP and the slope W′ according to the following equation 1:

$$P(t) = W' \times \frac{1}{t} + CP$$

Equation (1)

where, P – power output (W), t – duration of effort (s), CP – critical power, W' – work above CP.

For torque analysis, the power and cadence data of 15 s, 3 min and 12 min efforts were processed using the following equation 2:

$$\text{Torque (Nm)} = \frac{Power\ (W)}{\left(\frac{(Cadence\ \times\ \pi)}{30}\right)}$$

Equation (1)

where π (Pi) – ratio of a circle's circumference to its diameter.

2.3 Statistical Analysis

All data were checked for normality. Paired t tests were used to compare variables between states (fresh, fatigued). Statistical analyses were performed using JASP 0.16.3 (JASP, Amsterdam, Netherlands). Statistical significance was set at $p < 0.05$.

3 Results

Full disclosure of the results can be found in Table 1. Total work done before the CP test in fatigue condition was 1153 ± 147 kJ (range: 959-1500 kJ) and relative work was 19 ± 2 kJ/Kg (range: 15-24 kJ/kg). Absolute and relative power output of 15 s, 3 min and CP were lower in fatigued condition than in fresh condition ($p < 0.05$). W' were lower in fatigued condition than in fresh state ($p < 0.005$). Absolute and relative torque during the CP test were not different between fresh and fatigued states ($p > 0.05$). Cadence was lower in the fatigued state than in the fresh state ($p < 0.05$).

Table 1. Results. Data are presented as mean ± SD. * denotes p < 0.05. ** denotes p < 0.01. *** denotes p < 0.001

	Fresh	Fatigue (after 1153 ± 147 kJ)	p
15 s power output (W)	885.80 ± 146.14	784.30 ± 187.31**	0.001
3 min power output (W)	396.00 ± 48.32	352.60 ± 55.40***	<.001
12 min power output (W)	316.70 ± 41.47	294.60 ± 47.85**	0.008
15 s power output (W/kg)	14.43 ± 2.28	12.29 ± 2.55**	0.004
3 min power output (W/kg)	6.49 ± 0.72	5.78 ± 0.66***	0.001
12 min power output (W/kg)	5.20 ± 0.62	4.84 ± 0.63*	0.049
CP (W)	300.90 ± 40.72	281.90 ± 46.25*	0.022
CP (W/kg)	4.94 ± 0.44	4.63 ± 0.62*	0.021
W' (KJ)	12497.00 ± 2845.97	9780.40 ± 2396.32**	0.009
15 s Torque (Nm)	79.71 ± 14.16	75.71 ± 19.71	0.100
3 min Torque (Nm)	38.24 ± 5.88	36.57 ± 6.61	0.075
12 min Torque (Nm)	31.18 ± 5.08	32.00 ± 6.31	0.302
15 s Torque (Nm/kg)	1.33 ± 0.18	1.26 ± 0.26	0.089
3 min Torque (Nm/kg)	0.63 ± 0.08	0.59 ± 0.08	0.075
12 min Torque (Nm/kg)	0.52 ± 0.07	0.53 ± 0.08	0.328
15 s cadence (rpm)	106.40 ± 5.01	99.60 ± 5.56**	0.006
3 min cadence (rpm)	99.60 ± 5.56	92.50 ± 5.15 ***	<.001
12 min cadence (rpm)	97.13 ± 4.67	88.50 ± 4.77***	<.001

4 Discussion

The main finding of this study is that a prior accumulated work similar to a junior road race event induces a decline in power output both in short and long efforts in junior cyclists and this decay seems mainly influenced by a cadence drop. A combined effect of peripheral and central fatigue alter the pedalling dynamics shifting the power output production towards greater reliance on torque than cadence to sustain power in fatigued condition (Dunst et al., 2024; Leo et al., 2023; Sanchez-Jimenez et al., 2023). These observations suggest that optimizing cadence is critical for sustaining performance in fatigued condition.

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

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