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Abstract

A Novel Submaximal Field Test of Fatigue Resistance in Professional Cyclists

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Abstract: Induced by a given amount of prior accumulated work, it should be possible to quantify fatigue resistance by measuring changes in perception of effort, not requiring a maximal effort from the athletes. The aim of the study was to investigate the impact of prior accumulated work on perception of effort during submaximal exercise in professional cyclists. Seven male professional cyclists performed a submaximal field test consisting of three 5-minute bouts at three different power outputs in both fresh and fatigued states. Heart rate (HR), ratings of perceived exertion (RPE), and power output (PO) data were collected. Before the submaximal test in the fatigued state total work done was 3244 ± 83 kJ. RPE and HR were higher in the fatigued state than in the fresh state ($p < 0.05$). Absolute and relative PO during the submaximal test were not different between fresh and fatigued states ($p > 0.05$). The main findings of the study are that both RPE and HR during submaximal exercise are sensitive indicators of the state of fatigue induced by more than 3000 kJ of work done in professional cyclists. Therefore, we proposed a feasible submaximal exercise protocol to test fatigue resistance in the field.

Keywords: cycling, endurance, fatigue, performance, professional, RPE.

1. Introduction

Fatigue resistance (also termed "durability") in the context of road cycling has been operationally defined as the reduction in performance indicators (e.g., mean power output in a 12-min time trial) induced by a given amount of prior accumulated work (Leo et al., 2022). However, the construct of fatigue includes both performance and perceptual dimensions (Enoka and Stuart, 1992), and perception of effort plays a major role in endurance performance (Marcora, 2019). Therefore, it should be possible to quantify fatigue resistance by measuring changes in perception of effort induced by a given amount of prior accumulated work. Furthermore, unlike measurements of performance, such measurements do not require a maximal effort from the athletes.

The aim of the study was to investigate the impact of prior accumulated work on perception of effort during submaximal exercise in professional cyclists.

2. Materials and Methods

Subjects — Seven male professional cyclists (age: 19 ± 1 yr; body mass: 64.1 ± 4.3 kg; stature: 1.75 ± 0.05 m) classified at Tier 4 (Elite/International Level) according to the Participant Classification Framework proposed by McKay et al., (2021) took part in the pilot study during a training camp held in February 2023.

Methodology — Based on a preliminary lactate threshold test performed 48 h prior to the intervention, all riders performed a submaximal field test consisting of three 5-minute bouts at three different power outputs (P1: 70% below lactate turnpoint; P2: lactate threshold; P3: lactate turnpoint) after a 60-min low-intensity warmup (*fresh* state), and after a 3-h race simulation including multiple high intensity interval exercise bouts (*fatigued* state). The submaximal test was performed in the same uphill road section of 1.93 km at 8.2% average grade. Heart rate (HR, Bryton heart rate monitor, Bryton Inc, Taipei City, Taiwan) and power output data (Favero Assioma Duo, Favero Electronics srl., Arcade, TV, Italy) were recorded using the same cycle computer (Bryton S800, Bryton Inc, Taipei City, Taiwan), and analysed using WKO5 Software (WKO5, Peaksware LLC, Lafayette, CO, USA). At the end of each bout of the submaximal test, participants were asked to rate their perceived exertion (RPE) using the modified CR-10 scale (Foster et al., 2001). Participants were instructed to adhere to an hourly carbohydrate intake of 90 g for the whole duration of the session.

Statistical Analysis — All data were checked for normality. Paired *t* tests were used to compare variables between states (*fresh*, *fatigued*). When the normality assumption was not met, Wilcoxon signed-rank tests were used. 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 submaximal test in the *fatigued* state was 3244 ± 83 kJ. RPE and HR were higher in the *fatigued* state than in the *fresh* state ($p < 0.05$). Absolute and relative power output during the submaximal test were not different between *fresh* and *fatigued* states ($p > 0.05$).

4. Discussion

We proposed a novel submaximal exercise protocol to test fatigue resistance in the field. The main findings of the study are that both RPE and HR during submaximal exercise are sensitive indicators of the state of fatigue induced by more than 3000 kJ of work done in professional cyclists. Moreover, the test was feasible and well tolerated by professional cyclists during a training camp. Further research is required to further validate and establish the reliability of this novel test of fatigue resistance in cyclists as well as in other endurance athletes. Further work is also required to establish the sensitivity of this test to changes in fatigue resistance induced by training and other interventions.

One limitation of this study is the lack of a performance measure (e.g., a time trial) to investigate whether changes in perceived effort during submaximal exercise are associated with changes in performance during a maximal exercise test.

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

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Table 1. Parameters measured during the submaximal test

	P1 (267 ± 23 W)			**P2 (319 ± 29 W)**			**P3 (376 ± 33 W)**		
	Fresh	**Fatigued**	***p***	**Fresh**	**Fatigued**	***p***	**Fresh**	**Fatigued**	***p***
Power output (W)	274 ± 19	270 ± 24	*0.279*	319 ± 30	316 ± 33	*0.134*	377 ± 30	371 ± 23	*0.115*
Power output (W/kg)	4.28 ± 0.26	4.21 ± 0.30	*0.281*	4.97 ± 0.39	4.92 ± 0.42	*0.136*	5.89 ± 0.42	5.81 ± 0.39	*0.093*
Heart rate (bpm)	143 ± 7	150 ± 5 *	*0.012*	155 ± 5	162 ± 4 *	*0.001*	168 ± 7	172 ± 5 *	*0.008*
RPE (0-10; A.U.)	2.4 ± 0.9	3.9 ± 1.4 *	*0.033*	4.2 ± 0.7	5.7 ± 1.3 *	*0.001*	7.0 ± 1.2	8.5 ± 1.0 *	*0.004*

Data are presented as mean ± standard deviation. * denotes significant differences between conditions ($p < 0.05$).