Similarity between the 3-minute and traditional measure of critical power in a track cyclist: A case study

Normand A Richard [1] **and Michael S Koehle** [2 3]

[1]Richard Physiological Services,[2]University of British Columbia, School of Kinesiology, Vancouver, Canada, and [3]University of British Columbia, Division of Sport & Exercise Medicine, Vancouver, Canada

Cycling | Critical Power | Case study

Headline

Critical power (CP) delineates the boundary between sustainable and unsustainable exercise [1]. Exercise intensity can be broadly categorised into three domains. The severe domain incorporates all work rates above CP. Exercise in this domain will lead to maximal oxygen uptake and/or exhaustion and is limited by a fixed capacity of work (kJ) called the W prime (W'). Progressive perturbations in metabolic environment such as low [PCr] and pH are characteristics of the severe domain [2]. The work rates between rest and the gas exchange threshold (GET) is called the moderate domain. Exercise in the moderate domain is well tolerated, swiftly reaches steady state $\dot{V}O_2$ and appears limited by muscle glycogen availability and central fatigue. In between the GET and CP, or the moderate and severe domain, is the heavy domain. During exercise in the heavy domain there is a sustained (but not progressive) increase in lactate. Oxygen uptake, despite a slow component (lag), eventually reaches steady-state. Time in the heavy domain may be influenced by muscle glycogen depletion and lowering of [PCr] and pH [2].

Track cycling is an Olympic sport and takes place within the banked oval track of a velodrome using a fixed-gear bicycle. With the advancement of portable power meters, the work demands of track cycling can now be quantified. Track cycling is a relatively "sterile" sport as velodromes are not subject to wind, can be temperature controlled, and the distance and surface remains constant. A common paradox exists in sports science. Laboratory studies have precision but lack "real-life feel" whereas field-based studies are ecologically valid but are prone to external variants; track cycling nicely bridges this gap. Critical power is usually measured in the laboratory with cycle ergometry by plotting the inverse of time versus power with a series of time trials lasting <20 minutes (TRAD), or by using a single all-out maximal 3 minute test (3MIN). Field studies have examined the determination of CP power using power meters on road bicycles using a series of time trials [3]. However, to our knowledge, CP has yet to be reported on a track bicycle within a covered velodrome. As the TRAD method is relatively time consuming, the rationale for this case study was to conduct a preliminary trial to investigate if measures of CP utilising the 3MIN method would provide similar measures to TRAD, and consequently lead to time savings and less disruption to training programmes.

Aim

The aim of this case study was to report the measure of CP measured on a track bicycle using the 3MIN and the TRAD method.

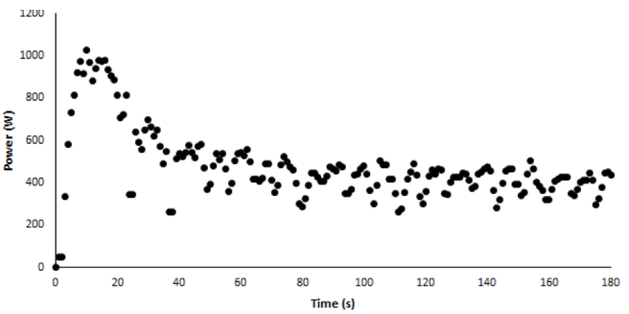

Fig. 1. Power profile of the 3-minute test

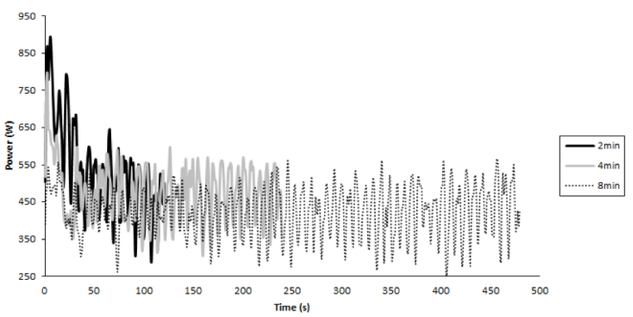

Fig. 2. Power profile of time trials used for the traditional method test

Table 1. Power outputs (watts), speed (m·s^{-1}) and gearing used for all trials.

	3MIN*	TRAD 2 MIN	4 MIN	8 MIN
Trial 1	395	537	465	425
Trial 2	390	519	476	422
Gearing	52x14	52x14	51x14	50x14
Speed	12.52**	13.56	13.08	12.67

*Values denote the average of the last 30 seconds of the test
**Average speed of the last 30 seconds of trial 1

Methods

Athletes

The participant was a 30-year old well trained amateur cyclist [4], participating in track and road cycling with an approximate training volume of 15hr·week^{-1}, and a 20 minute power of 411 watts. The participant is the first author, was informed of the benefits and risks of the investigation and consents to his data being published. All testing was conducted in accordance with the Declaration of Helsinki.

Design

This research report utilised a case study design to determine the feasibility of utilising the 3MIN method to determine CP in track cycling. All tests were performed twice on separate non-consecutive days. The test with the highest value for each trial was used for analysis. Training was standardized throughout the study period by an experienced cycling coach.

Methodology

The covered velodrome used for this study measures 200m in length, and is situated 190m above sea level. A Power2Max™track crank-based power meter installed on the participant's track bike was used to measure power output and zeroed according to the manufacturers' direction before each trial, and shows similar intra class correlation and standard error estimate compared to other commercially available power meters [5]. A standardised warmup of 20 minutes was performed before each test, and followed by a warm-down of 10 minutes spinning a light gear on rollers. The participant ensured his nutrition habits were also standardised. The 3MIN test has been described in detail elsewhere [6]. We modified it for the purpose of this study as such. From a standing start (as it is commonly used in track racing for the kilo (1km) and individual pursuit (4km)), the participant accelerated his bike as fast as possible avoiding any energy conservation or pacing tactics. Being on a velodrome, the participant was aware that his speed would decline but maintained a maximal effort for the duration of the 3 minutes. Timing feedback was provided as was verbal encouragement. Critical power was determined as the average power of the last 30 seconds of the test and the W' as being any work done above CP. Tests were considered maximal if the subject's heart rate (HR) was within 10 b·min^{-1} of his known maximal HR (HRmax) and a rate of perceived exertion (RPE) of 10/10 was reached by tests' end. Gearing (i.e. front chain ring and rear cog) used was 52x14. For the TRAD test, power was plotted against the inverse of time for three separate time trials on the track; the intercept of the line representing CP and its slope W' [7,8,9]. These efforts were paced to allow the highest power distribution during the chosen time. Time feedback, lap time, and verbal encouragement were provided by an experienced track attendant. Times of 2-, 4-, and 8-minutes were chosen and gearing used was 52x14, 51x14, and 50x14 respectively.

Results

The participant reached a HR of within 10 b·min^{-1} of his HRmax at the end of all trials and a maximal RPE of 10/10 each time. The 3MIN test yielded a critical power of 395 W and a W' of 18 kJ, while the TRAD test yielded a critical power of 394 W and a W' of 17 kJ. Figure 1 shows the power profile of the 3MIN test. Power outputs for the time trials used for the TRAD method were of 537, 479, and 425 W for durations of 2-, 4-, and 8-minutes (figure 2). All power outputs, gearing, and speeds can be seen in table 1. Of note, the power outputs in both the 3MIN test and the TRAD had some fluctuations as compared to stationary ergometer testing where it would be fairly linear. This is due to the centrifugal forces exerted when cycling in a velodrome; power outputs are higher in straight sections and decrease upon exiting a corner.

Discussion

This case study sought to compare the measure of CP and W' using the field based test of 3MIN and TRAD. Our case study shows that in a trained amateur, CP and W' were highly similar using the 3MIN and TRAD method. Our findings contrast a recent study examining six international caliber track cyclists. Utilising a stationary cycle ergometer Bartram *et al.*, found that the 3MIN CP was higher than the TRAD method [10]. However being that only one subject was tested in this study and that we did not use a stationary ergometer some caution is warranted in comparing these results. Regarding the TRAD method, agreement exists between field and laboratory-based measures of CP [11]. To our knowledge an attempt to compare the 3MIN method between a laboratory and field setting has yet to be done. Upon analysis of all power data we noticed that average speed over the last 30 seconds of 3MIN could perhaps be used for a measure of critical speed (CS) for those who do not have access to a power meter. Plotting the average speed of the three TRAD time trials versus the inverse of time yielded a very similar CS to the last 30 seconds of 3MIN. Therefore assuming no major equipment or position change, CS could be used in training programmes as is done in other sports such as swimming. Further research is required to support or reject this observation.

Limitations

- The study design in and of itself is a limitation. A larger sample size of international level track cyclists would confirm or reject these preliminary findings.
- Neither cadence nor resistance were constant and the 3MIN test was modified to begin from a standing start.

Practical Applications

- In a track-specific setting, shorter time trials (such as the kilo, which lasts one minute) are performed frequently by sprint specialists whereas time trials in the four-minute range are often undertaken by endurance specialists to prepare for the individual and team pursuit. It is rare, to our knowledge, for track cyclists to regularly perform time trials of longer duration (i.e. 8-20 minutes). As such, utilising the 3MIN method could be a time-efficient practice to determine CP and W', with minimal perturbations to training programmes.
- Based on our findings, we cautiously state that field-based measures of CP and W' utilising either the 3MIN or TRAD method appear similar.
- For those without access to a power meter, CS could also be used as a training tool.

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Dataset

Dataset available on SportPerfSci.com.

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