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Conference Abstract

Predicting performance in sub-10s f200 m male track sprint cyclists

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Abstract: Maximal power output (P_{max}) and the ability to sustain power output close to P_{max} are primary determinants of track sprint cycling performance. Given P_{max} is achieved at a specific optimal cadence (F_{opt}) the importance of gear selection is paramount. To optimise gear selection for a specific event, individualised fatigue rates (i.e., fatigue rate per maximal pedal stroke) and field-derived Torque- & Power-Cadence profiles can be used in combination with physics-based model of track cycling. The aim of this investigation was to produce a model of track sprint cycling that can accurately predict performance times of the f200-m. The model utilised mechanical profiles derived from laboratory and field testing as the input variable to optimise f200-m gear selection and performance in elite and world-class track sprint cyclists. Six elite male track-sprint cyclists (P_{max} = 2146 ± 423W) completed two testing sessions to identify Torque-Cadence (T-C) and Power-Cadence (P-C) profiles, while fatigue rates were identified during maximal sprints performed at F_{opt}. The P-C and fatigue profiles were utilised to predict power output during a f200-m event and, in conjunction with a physics-based model of track cycling, predict performance times. This physics model was also utilised to simulate the f200-m performance with different gear ratios. The gear ratio that resulted in the fastest f200-m time was deemed to be theoretically optimal for each athlete. There was no significant difference between the modelled (10.23 ± 0.60s) and actual (10.23 ± 0.53s) f200-m times (p=0.9254). The model predicted that three of the athletes could theoretically improve f200-m performance by increasing the gear ratio, while three could theoretically benefit from a lower gear ratio. P-C and fatigue rate profiles in combination with a physics-based model of track cycling can be used to accurately predict f200-m times.

Keywords: Elite cyclists; Physics-based model; Maximal power output, Gear selection, Power-Cadence profiles, Field testing

1. Introduction

Track cycling as a sport, benefits greatly from performance analysis given the controlled environment of the velodrome and reliable technology used to quantify important variables (power, torque, cadence) (Gardner et al., 2007). Resultantly, modelling cycling has been an ongoing topic of investigation, with progressively comprehensive models being formulated to represent the forces acting on a cyclist, from riding a road bike in a straight line (Martin et al., 1998) to cycling around a velodrome (Fitton & Symons, 2018; Martin et al., 2006). Previous physics-based models however, been limited by the necessity of previously collected power data as input into the model

(Fitton & Symons, 2018; Martin et al., 1998). A recent investigation, (Dunst & Grüneberger, 2021) however, showed that predicted power output could be used as the input variable, enabling improved application within elite cycling. This methodological approach allows for theoretical changes in cadence and gear ratios to be factored into the model. The aim of this investigation was to produce a model of track sprint cycling to accurately predict f200-m performance times and optimize gear selection for this event.

2. Materials and Methods

Subjects - Six male (22.0±3.5 yr, 87.8±7.4 kg) world-class or elite track sprint cyclists, (McKay et al., 2022) volunteered for the study. The f200-m personal best time for the participants was between 9.53 and 9.975 s. Prior to participation all subjects provided written informed consent according to the Declaration of Helsinki and was approved by the Griffith University Human Research Ethics Committee.

Design- This project utilised a within-subject design where subjects attended one laboratory testing session at the Queensland Academy of Sport (Nathan, Queensland, Australia) or Adelaide Superdrome (Gepps Cross, South Australia, Australia) and one field-testing session at the Anna Meares Velodrome or Adelaide Superdrome separated by a minimum of 2 d.

Methodology - Two testing sessions established the cyclists' T-C and P-C profiles and investigated the decrement in power output during maximal sprints.

Session 1 was comprised of six, 5-s maximal sprints (three in standing position), an additional 5-s maximal standing sprint, and a maximal 15-s seated sprint, completed on a stationary cycling ergometer in the laboratory (Lode Excalibur Sport PFM, Lode B. V., Groningen, the Netherlands & custom SRM motor-driven ergometer, SRM, Jülich, Germany). The fatigue rate, expressed as a relative drop in power output per pedal stroke, was calculated from the 15-s optimised (F_{opt}) seated maximal sprint.

Session 2 consisted of six, 65-m maximal sprints (three in seated and standing position) and a f200-m sprint completed using a gear ratio selected by participants in conjunction with coaching staff. Data was collected utilising high frequency powermeters (PM9, SRM, Jülich, Germany (200 Hz) and Track InfoCrank 144BCD ISIS, VerveCycling, Berkshire, United Kingdom (256 Hz)). Torque-Cadence (T-C) and Power-Cadence (P-C) profiles were constructed utilising the method outlined in Wackwitz et al (2020).

Predicted power output was calculated by utilising participants' individualised fatigue rate to compress the seated P-C profile after each pedal stroke completed. The predicted power output was then used as the input variable into a physics-based model of track cycling to theoretically calculate cycling velocity and f200-m performance times.

Statistical Analysis - The de-identified data were analysed using IBM® SPSS® (v26 Armonk, New York, United States) and Prism software (v9 GraphPad, San Diego, California, United States). Descriptive analysis and tests of normality were calculated for all variables. Paired t-test analysis compared the variables (power output and f200-m performance time) between the predicted and actual f200-m trials. Bland-Altman plots with 95% limits of agreement were used to visually display the difference between the efforts whilst inspecting for systematic and proportional discrepancies.

3. Results

The predicted power output calculations produced values similar to the true power output during the f200-m effort completed in session 2 (0.6%±3.4 error; p= 0.8612, Figure 1).

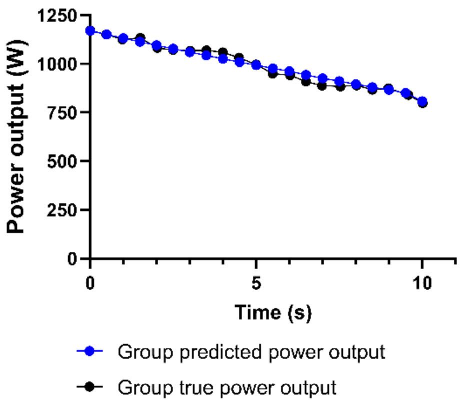

Figure 1. Group differences between predicted and true power output (W) during the f200-m event.

Similarly, the f200-m predicted velocity produced values similar to true event performance (-0.04%±1.4 error; p= 0.9254. A Bland–Altman plot (Figure 1) revealed good agreement between the predicted and true performance times and an absence of both systemic and proportional error.

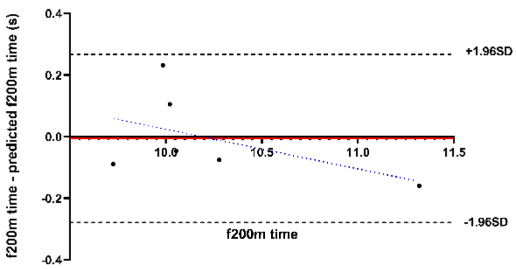

Figure 2. Bland-Altman plot displaying the differences between predicted and true f200-m performance.

4. Discussion

Findings from the present study suggest that f200-m performance time can be accurately modelled and predicted utilising field derived P-C profiles and laboratory-based fatigue rates in combination with a physics-based model of track sprint cycling. The methodological approach of this model permits changes in cadence and gear ratio to be accounted for and alterations in performance to be quantified. By simulating different gear ratios and their effect on performance we can establish the theoretical optimal gear ratio (minimizes f200-m time). The optimised gear ratio calculations revealed that none of the participants rode their theoretically optimal gear ratio during the f200-m efforts. Half of the athletes were under-geared, riding on a gear ratio that did not provide enough resistance, whilst the other half rode over-geared with gear ratios too large.

5. Practical Applications.

- This modelling approach can predict performance under different environmental conditions, track geometries, gear ratios etc.
- Theoretically quantify the impact of altering key performance variables such as CdA, power output, rolling resistance etc.
- Coaches could identify which factors and the degree of improvement needed to achieve a target time.

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

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