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Communication

MMP and Torque – duration profiles from u19 cyclists and WT cyclists.

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Abstract: Performance in cycling is often defines by the power produced by an athlete (i.e., power profile). Studies have tried to identify the differences between categories and levels. It has been showed that world tour cyclists have better qualities than the others. Moreover recently, it has been showed that power profile is mainly depend on the torque production capacities. The aim of our study was to investigate the torque at Mean Maximal Power – duration relationship by i) testing the fitting of the relative torque used in MMP from different durations ii) determine the differences between world tour cyclists (WT) and under nineteen cyclists (U19), because of the development strakes of this category. 17 u19 cyclists and 20 world tour participated in this study. Relative Power, cadence and relative torque data from one full season were used to determine the relative mean maximal power and relative mean torque relationships, for 10s, 1min, 2Min, 5min, 10min, 20min and 30min, and critical power was determined with the 3-parameter cp model. The goodness of fit was excellent (r^2 = .98 [.91-1). Significant differences were found from 5min to 30min and cp were found between the groups for relative power and relative torque data. No differences were found for the cadence. Torque duration relationship can be modelled and use to track performance of cyclists. Differences between world tour cyclists and under nineteen cyclists are mainly due to differences in torque capacities.

Keywords: Mean Maximal Power; torque-cadence relationship; critical power; torque profile.

1. Introduction

Performance in cycling is often defines by the power produced by an athlete (i.e., power profile), and different profiles of cyclist could be defined by it. MMP profiles provide information to train cyclists, analyze performance or also to calibrate performance indicators as FTP, CP, MAP, etc. (J. Spragg, 2020; Pinot & Grappe, 2014; Quod et al., 2010; Sanders et al., 2020).

Beside power profiles, the ability to produce the highest level of power has been studied in sprints since several decades (refs). Power is mechanically the product of the crank torque in $N.m^{-1}$ and angular velocity in $rad \cdot s^{-1}$ (eq. 1) the latter being usually expressed in cadence (rpm). During maximal efforts, a polynomial relationship exists between power and cadence:

$$(1)\quad P(c) = \left[C_0 \cdot (1 - (\frac{C}{C_0}))\right] \cdot C$$

with P being the power, C_0 the maximal cadence a null torque and T_0 the maximal torque at null velocity. A maximal power production being possible only with an optimal cadence (C_{opt}) and torque (T_{opt}) being

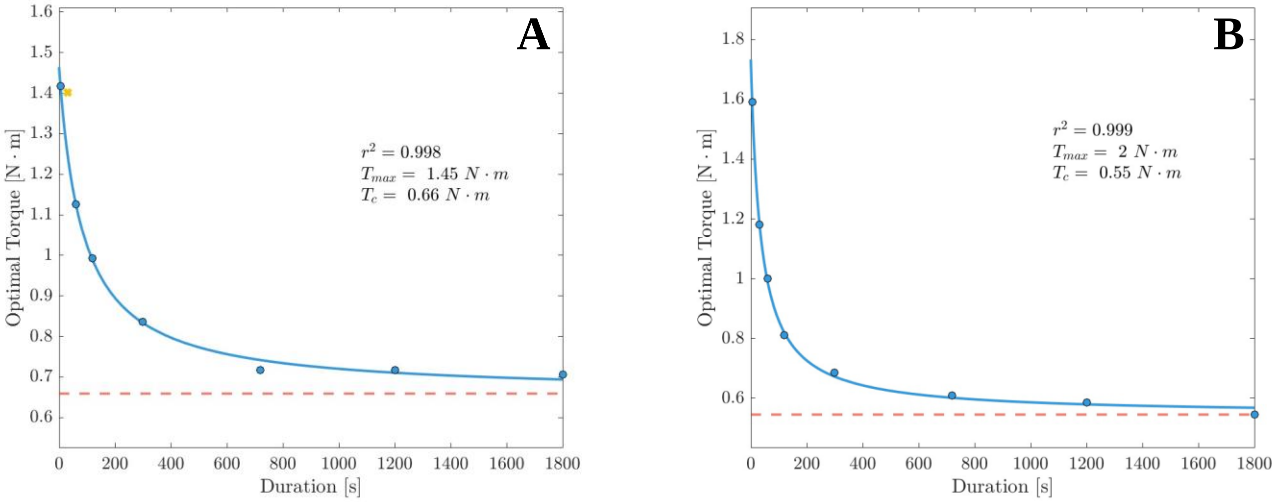

Figure 1. Examples of relative torque at MMP over durations for a World Tour cyclist (A) and for a under nineteen cyclist (B). Relative torque date are in $N.m^{-1}.kg^{-1}$ and durations are in seconds. Red dotted line is the relative torque at critical power.

respectively half of C_0 and T_0 (Dorel, 2018; Vandewalle et al., 1987) .

Recently, a study have showed that the power profile is influenced more by the calculated torque capacities than the cadence used for maximal efforts (Leo et al., 2022), and it could differentiate athletes by their category and by their specificity. The aim of this study was to i) test the fitting of the relative torque used in relative MMP from different durations ii) determine the differences between world tour cyclists (WT) and under nineteen cyclists (U19).

2. Materials and Methods

Subjects — Seventeen male under 19 (U19) national level cyclists participated in this study, (17 ± 1 years, 66.9 ± 6.1 kg, 11h00min ± 2h30min of training/week) and twenty male world (WT) cyclists (26 ± 1 years, 66.9 ± 6.0 kg, 23h00min ± 4h30min). This is a retrospective study which uses existing data. This is a retrospective study which uses existing data. The database was collected and declared accordingly to the European General Data Protection Regulation.

Design— The present study proposes a retrospective analysis of the data recorded during one complete season of national under 19 level and a complete season of world tour cyclists with time, power, cadence data registered by the participants mobile power meter (Quarq Dzero, West Fulton Market, Chicago, USA for the U19 and Ngeco, Power2max, Waldhufen, Germany) and head unit (Wahoo Wahoo BOLT, West Wieuca Rd NE, Atlanta, USA). Data were stocked into a database and then treated on Matlab software ®(R2022a).

Methodology— We computed the MMP and torque at MMP for a duration of 5-s, 30-s, 1-min, 2-min, 5-min, 12-min, 20-min and 30-min and for each mean cadence between 60 and 120 rpm and for each training session or race. Torque data were calculated from power and cadence data. Critical power (CP) and estimated torque at critical power (tCP) were calculated from the 3 parameters CP model (Hugh Morton, 1996).

Statistical Analysis— Data consistently passed the normality test (the Shapiro-W ilk's test), therefore results were expressed as mean. Goodness of the fit will be tested by reporting median and quartiles of the coefficient of determination (R^2). A two-way ANOVA (GROUP X DURATION) as well as post-hoc analysis when necessary was performed for both MMP and torque at MMP and torque at CP with JASP.

3. Results

3.1. Figures, Tables and Schemes

Relative torque inside MMP data have been modelled with a 3 parameter CP model to determine the torque at critical power (fig. 1). The goodness of the fit was excellent (r^2 = .98 [.91-1]) for the torque used in MMP and tCP.

Table 1. Mean relative torque values for WT group and U19 group for typical durations and relative torque used at CP. Values are expressed $N.m^{-1}.kg^{-1}$. *: significant differences (p<0.05) between WT group and U19 group.

Duration	Relative torque WT (n = 20)	Relative torque U19 (n = 17)
5s	1.62	1.68
30s	1.31	1.31
1min	1.12	1.13
2min	0.91	0.89
5min	0.78	0.70*
12min	0.68	0.60*
20min	0.64	0.59*
30min	0.60	0.54*
CP	0.60	0.55*

Significant differences were found between the groups from 5min to 30min durations and for the relative torque used at CP intensity ($p<0.05$), with U19 group significantly lower than WT group. Significant differences were also found in the MMP profile from 5min to 30min and CP ($p<0.05$), with U19 significantly lower than WT group for these durations.

4. Discussion

The objective of this was to first test the fitting of the relative torque from different duration in the severe exercise intensity domain and to determine the differences between the groups in terms of MMP and relative torque in MMP and CP. The main observation was that the fitting of relative torque was excellent and the main result was that differences in relative MMP was linked with differences in the torque used in MMP values.

The fitting of the relationship was excellent, which means that the study of torque at MMP could be used to estimate performance capacity in the torque production from the cyclists. The importance of torque capacities in the ability to produce power has been well demonstrated (Leo et al., 2022; Taylor & Deckert, 2022).

The differences observed between the two groups are in line with the study from Peter Leo *et al.* (Leo et al., 2022) with no significant differences for the short durations, and from 5min to 1h durations, the world tour group was significantly higher than under 23, so U19 was expect to have lower capacities than WT because of the lower MMP values. These differences could be explained by a lower percentage of muscle mass in juniors cyclists (Alejo et al., 2022) and/or a lower gear ratio due to UCI rules applied during the season used (UCI rules restricted the gear ratio availability).

5. Practical Applications.

The modelization of tCP could be useful in order to prescribe exercises in the severe exercise intensity domain to improve torque capacities of the cyclists. The assessment of the torque duration relationship could also help in the gear selection for under 19 cyclists to help them to select the gear ratio that suits their capacities the most.

6. Conclusions

Torque duration relationship can be modelled and use to track performance of cyclists. Differences between world tour cyclists and under nineteen cyclists are mainly due to differences in torque capacities.

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

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