The effect of time-trial duration on aerodynamic drag

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Keywords: cycling position, aerodynamic drag, power output, time-trial.

Purpose: Aerodynamic drag is the main resistance (80-90 %) among the total resistive forces (R_T, N) opposing motion on level ground in cycling (Debraux et al. 2011). To reduce air resistance, cyclists adopt a characteristic time trial (TT) position on the bicycle to decrease the frontal area. The bike frame and the components only accounts for about 30 % of the total drag of the cyclist-bicycle system. Thus, the cyclist position has a great importance in the performance on flat terrain to overcome at the maximum the air resistance (Oggiano et al. 2008). Many research have studied the effect of the aerodynamic position or equipment's on the air resistance but to the best of our knowledge, no study has yet reported the effect of the duration of the exercise on aerodynamic drag. The aim of this study was to analyse the effect of time-trial duration on aerodynamic drag. We hypothesized that the more the duration of exercise is long the more the fatigue increases involving an alteration of the effective frontal area (AC_d, m^2) and accordingly a decrease of performance.

Methods: 9 elite road cyclists performed all testing session with their personal TT bike on a 200 m covered velodrome (Bourges, France). The bicycle was fitted with a rear wheel composed of a Powertap G3 hub (CycleOps, Madison, USA) for the measurement of speed (V, $m.s^{-1}$) and power output (PO, W). Firstly, the cyclists performed a discontinuous incremental exercise at different V to determine the rolling resistance coefficient (Cr) from the R_T-V^2 linear regression method (Grappe et al. 1997). Then, the Cr was fixed to compute the AC_d during three TTs of different durations according to the cyclists' categories (table 1). The effects of TT duration and time on AC_d, V and PO were tested using a two-way analysis of variance (ANOVA).

Table 1: *TT durations (min) according to the categories.*

Categories	TT1	TT2	TT3
U17 Men / U19 Women	3	8	15
U19 Men / U23 Women	4	10	20
U23 + Elite Men / Elite Women	5	15	30

Results: There was no significant effect of TT duration and time on AC_d. The largest decrease in AC_d was during TT1 (-2.9 %). PO and V were significantly influenced by TT duration ($p < 0.001$). The mean V was significantly different ($p < 0.001$) in all TT durations whereas the mean PO was significantly higher ($p < 0.001$) in TT1 compared to TT2 (+20.5 %) and TT3

(+28.2 %). A significant correlation was measured between V and the PO/AC_d ratio in TT1 ($r = 0.94$, $p < 0.001$), TT2 ($r = 0.95$, $p < 0.001$) and TT3 ($r = 0.97$, $p < 0.001$).

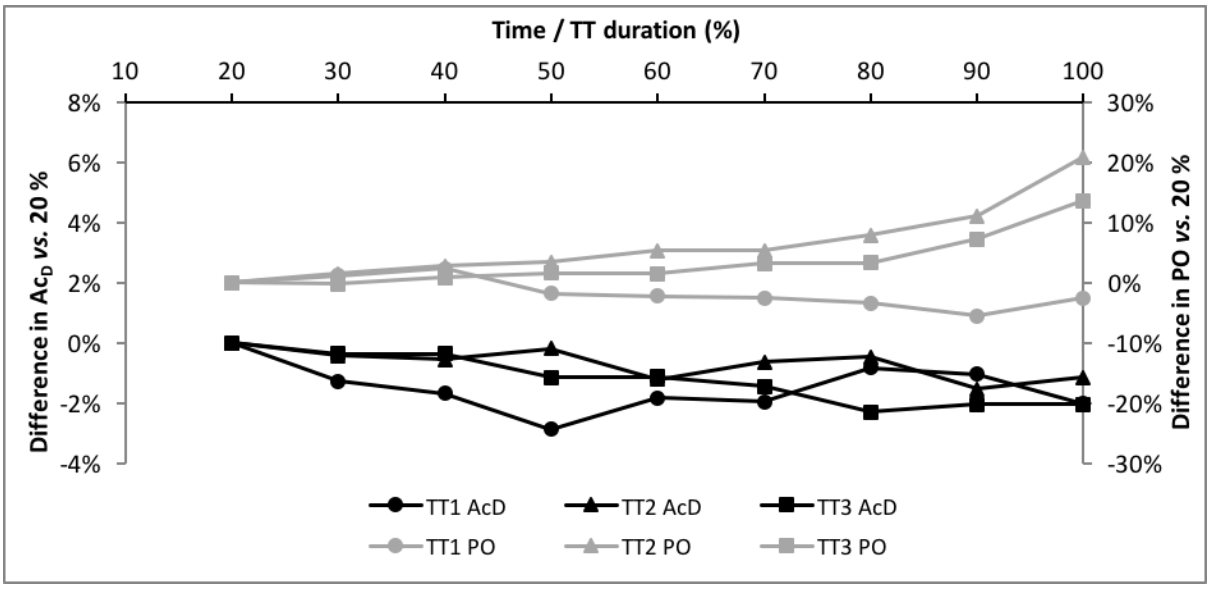

Figure 1. Mean changes (%) in AC_d and PO during the three time-based cycling time trials.
**The standard deviations don't appear to simplify the figure.*

Conclusions: The main results show that the mean AC_d decreased non-significantly over time for all the TT durations suggesting that the position of the cyclists was not altered during the three events. According to unpublished studies conducted in our lab, wind tunnel sessions have demonstrated that the AC_d decreases by a mean of 0.5 % per 1 $km.h^{-1}$ for speeds between 40 and 60 $km.h^{-1}$. Even more, by applying a correction coefficient on AC_d, the lowest value (-2.9 %) will be reduced to -2.3 % which reinforces the fact that AC_d remains relatively stable during the effort. The strong correlations between V and the PO/AC_d in the three TTs demonstrate that the more the PO/AC_d was high, the more the V was high and the performance was improved (Peterman et al. 2015). Thus, the balance between PO and AC_d is a parameter that must be optimised taking into account both the training process and aerodynamic resistance. To be efficient in a TT, the cyclist will find the better aero-position on his bike being able to develop the most important level of PO.

References:

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