Optimal cycling time trial position models

D.M. Fintelman[1], F-X. Li[1], M. Sterling[2] & H. Hemida[2]

1: School of Sport and Exercise Sciences, 2: School of Civil Engineering, University of Birmingham

Introduction

Every cyclist has to overcome air resistance. At cycling speeds of 50 km/h, approximately 90% of the total power is used to overcome air resistance [1]. This resistance is strongly influenced by the torso angle [2] and increases with cycling speed. Therefore, to minimise air resistance, cyclists adopt a time trial (TT) position and lower their torso angle to become more aerodynamic. However, the cyclists' power output and gross efficiency (GE) drops accordingly [3]. Consequently there should be a trade off between gaining aerodynamics and losing power output.

The aim of this study is to predict the optimal torso angle for different speeds by using TT position models.

Method

Optimal position models

Power Output Model

Maximizing the difference between the peak power output and the power losses due to air and rolling resistance.

Metabolic Energy Model

Minimizing the required cycling energy, based on workload and GE.

Main input parameters

Experimental data of 19 trained competitive TT cyclists (peak power output, GE, frontal area of cyclist) in 4 different torso angles, β: 0, 8, 16 and 24°.

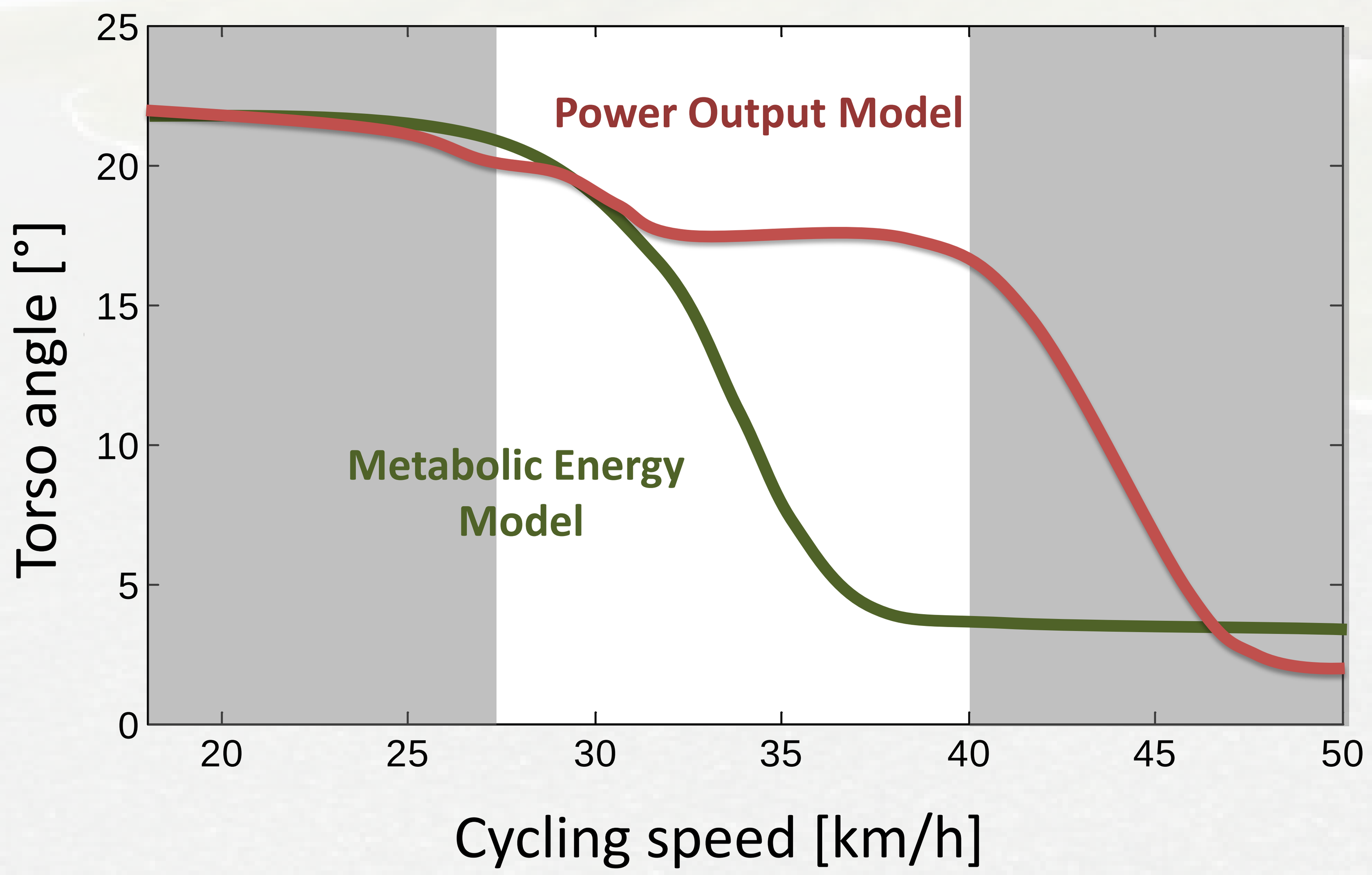
Model predictions

Based on physics laws, the models predict the optimal torso angle for speeds between 28-40 km/h. Outside this range the data is extrapolated (shaded area in result Figure).

Main assumptions

Cycling on flat road, no wind and constant cycling speed.

Results



- Optimal torso angle is dependent on cycling velocity.
- The Power Output Model curve is shifted to a higher velocity, which could be explained by the different approach of the models.
- Air resistance outweigh the power losses for velocities above 45km/h.
- A fully horizontal torso is not optimal.

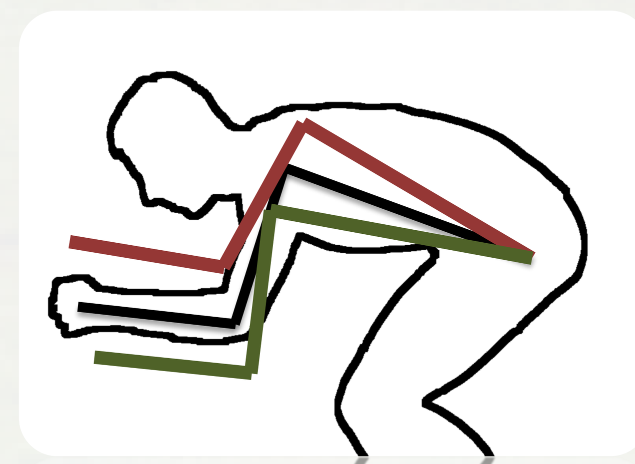
Model applications

The Metabolic Energy Model could be applied for endurance events, while the Power Output Model is more suitable in sprinting or in variable conditions (wind, undulating course, etc).

Conclusion & recommendations

Despite some limitations, the models give valuable information about the optimal TT cycling position at different speeds.

- For speeds < 30 km/h: ride in a more upright position
- For speeds of 32-40 km/h in **endurance event**: decrease the torso angle. In **sprinting** or in **variable conditions**: more upright position.
- For speeds > 40 km/h: decrease the torso angle.



Future research

Measurement of the air resistance of all participants in a windtunnel and implementing the effect of side wind.

References

[1] Belluye, N., et al. (2001). Science & Sports, **16**: p. 71-87
[2] Chowdhury H., et al. (2012). Sports Eng., **15**(2): p. 73-80.
[3] Jobson S.A., et al. (2008). Journal of Sports Sciences, **26**(12): p. 1269-1278