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The Effects of Varied Terrain and Bicycle Fitting on Aerobic Power Production: Test methodology

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Abstract

Background: Elite cycling occurs over varied terrain and distances, within all of these events the need to maximise performance is of paramount importance. This can be in the form of specific training, nutrition plan or optimal bicycle fit (Faria et al., 2005: Sports Medicine, 35(4), 313---337). Currently there are recommend setups published for maximising anaerobic power, aerobic economy and injury prevention (Silberman et al., 2005: Clinical Journal of Sport Medicine, 15, 271---276; Bini et al., 2011: Sports Medicine, 41(6), 463---476). However, none take into account the effects of varied terrain and no recommendation exists for aerobic power.

Purpose: The aim of this study was to develop a process to identify an optimal bicycle fit for aerobic power production for varied terrain.

Methods: The testing protocol involved 4 separate trials conducted on a custom--- made ergometer within the Sports Technology Institute at Loughborough University (Lugo et al., 2014: Journal of Science and Cycling, 3(2), 27). During the first trial the subjects performed a 20---minute time trial from which their Functional Threshold Power) and Functional Threshold Heart Rate (FTHR) are obtained. Current bicycle fit (i.e. saddle height, handlebar reach) and anthropometric (i.e. 25º knee flexion, inseam) measurements were also recorded during the first trial. The FTP and FTHR magnitudes were used on subsequent trials to set the intensity and torque values. On the remaining 3 trials the subject pedalled against a load chosen to simulate a specific terrain (see Table 1). Within each trial the subject performed a 5---minute effort at 80% FTHR for each of 9 possible bicycle setups (see Table 2). Electromyography (EMG) surface electrodes were placed on both the left and right legs for the Vastus Lateralis (VL), Biceps Femoris Long Head (BF) and Medial Head of the Gastronemius (G). Power and muscle activity were measured for the whole 5--- minute effort however, the analysis was focused on the last minute of the effort.

Results: Paired t---tests comparing the net power output for the original setup and all the other 8 alternative positions were carried out, a significant difference was found for positions 2, 3, and 8 (see Table 3). The most significant difference was found for position 8 (p---value = 0.011). Using the average power observed for each setup, the time difference for a simulated 10 --- mile time trial when compared to the original setup was calculated following the mechanistic model presented by Dahmen et al., 2---11 (see Figure 1). For the positions with significant differences (i.e. 2, 3, 8) the largest improvement was seen for position 8 while the largest deterioration occurred for position 3. The power across the pedal cycle shows that for the right leg the difference between the 8th position and the original position is small (mean difference = 0.20 W) however for the left leg the difference is considerable (mean difference = 4.49 W), starting at 200º and reaching a maximum at 300º (see Figure 2). The increase in net power observed during the second phase of the upstroke occurs due to an increased right leg Vastus Lateralis (VL) activity (see Figure 3).

Discussion: The used ergometer allows automated alteration of the setup while the rider is cycling, therefore several positions can be tested in a single trial. This capability also reduces the errors associated with EMG electrode placement between trials and longitudinal effects due to subject variability observed when current ergometers are used (Hug F. and Dorel S. Journal of Electromyography and Kinesiology: 2009 19, 182 --- 198). Comparison between the original and alternate setups from mechanical (i.e. power) and biomechanical (i.e. EMG) points of view allow identifying the effect of bike setup changes and the mechanisms behind them for different terrains. Currently only 2 subjects have completed all trials however, a larger number of subjects are being recruited and results will be reported in the future.

Conclusion: The proposed methodology together with the ergometer capabilities can be used to identify optimal bicycle setups for different terrains based on maximal aerobic power production. The corresponding muscle activation patterns allow a greater understanding of pedalling mechanics and the how terrain and bicycle set up affects them.

Table 1. Torque settings used for terrain simulation.

	Session	Torque Value	Terrain Simulation
1		FTP Torque	Flat
2		150% FTP Torque	Uphill
3	50% FTP Torque	Downhill	

Table 2. Tested bicycle fit setups.

Setup	Saddle height	Handlebar reach
1	Current	Current
2	Current	+5%
3	25 ° knee flexion	+5%
4	25 ° knee flexion	Current
5	25 ° knee flexion	-5%
6	Current	-5%
7	109% inseam	-5%
8	109% inseam	-5%
9	109% inseam	+5%

Table 3. Paired t-test results for net power between alternative and original setup. Effect of the setup on simulated 10-mile time trial performance.

Setup	Average power (Watts)	p-value	Significant	TT difference (min)
2	205.7	0.013	YES	-3.51
3	196.7	0.013	YES	4.45
4	200.4	0.227	NO	1.13
5	202.7	0.281	NO	-0.94
6	202.5	0.330	NO	-0.76
7	203.0	0.227	NO	-1.19
8	205.8	0.011	YES	-3.54
9	204.3	0.102	NO	-2.25

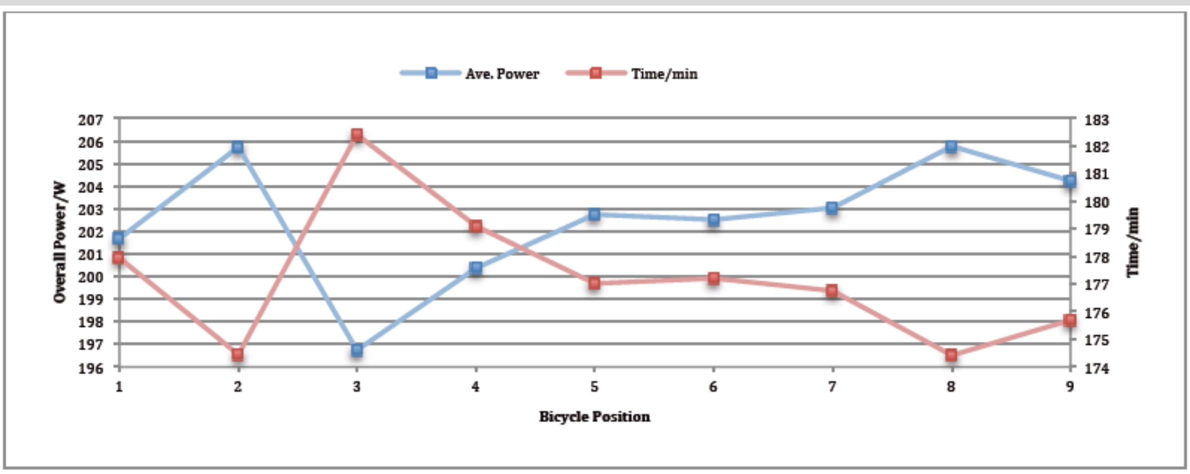


Figure 1: Comparison of aerobic power production and the Corresponding effects on a 10mile uphill TT simulation for flat riding

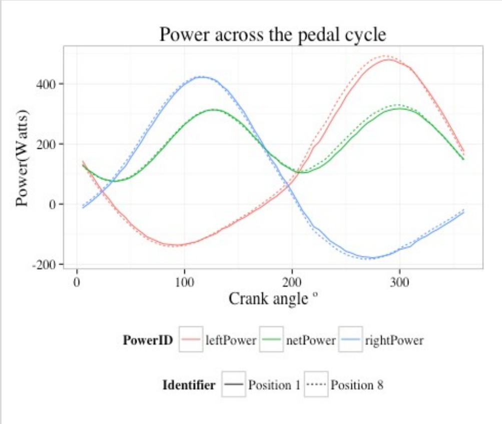
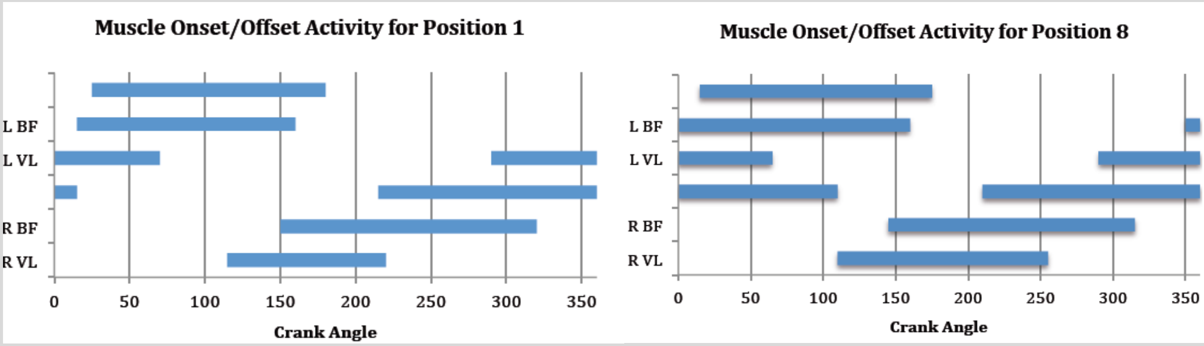


Figure 2. Power across the pedal cycle. The top dead centre position is located a 0º.



3A. Muscle onset/offset activity for position 1. **3B.** Muscle onset/offset activity for position 8.

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