Is cycling time trial power output higher on uphill than on flat road conditions?
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Introduction
Bicycle power monitoring devices use is spreading among cyclists. Some experienced or professional athletes adopting mechanical power output (PO) to target training zones, refers that, during high intensity efforts lasting several minutes, while climbing they are able to sustain 20-30 W higher PO than pedalling on flat road. The work of Welbergen and Clijsen (1990) supports this hypothesis. To date, especially for workloads at or above the anaerobic threshold, 20-30 W are empirically added by some coaches when climbing exercises are scheduled. Smith et al. (2001) found the same PO in a 40 km time trial performed in laboratory and on the road. In our knowledge, no study supports a difference between flat and climbing maximal PO. The aim of the present pilot study was to evaluate if, during efforts lasting several minutes, experienced cyclists are able to sustain higher PO on uphill than pedalling on flat road.

Methods
Six experienced cyclists (VO2max 68.8 ± 8.4 ml·kg⁻¹·min⁻¹; weight 65.3 ± 6.9 kg; height 176.3 ± 7.3 cm; age 22.3 ± 6.0 yrs; body fat .60 ± 2.0 %; 15.000 km/year average training) were involved in the study. In a random order, after a standardised warm-up, they performed three 15 min ‘all-out’ time trial: one trial (Ergo) was performed in the laboratory, on an adjustable riding position stationary cycloergometer (SRM Training System PC IV, Schoberer, Germany). The other two trials were performed on a 10 km flat road circuit (FR), and on a 7% slope uphill (UH). Between each test session, three days of easy training and usual food intake regimen were recommended. In all the trials, power was measured by a SRM Science Powermeter (accuracy ±0.5%), after a dynamic calibration (Ergometer Calibrator 17800, VacuMed, Ventura CA). Pedalling cadence, heart rate, final lactate accumulation data were also collected.

Results
Average power output in the climbing time trial was not significantly higher than on flat road conditions (347.3 ± 25.4W vs. 333.3 ± 34W respectively) but showed a trend (P=0.06) in being higher. To note, only one subject had less PO while climbing. Other results are summarised on Table 1.

Table 1. Average values (means ± SD) in the three experimental conditions. * = P<0.05; ** = P<0.01; *** = P<0.001,**** = P<0.0001.

<table>
<thead>
<tr>
<th></th>
<th>Ergometer (1)</th>
<th>Flat road (2)</th>
<th>Uphill road (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power output (W)</td>
<td>317.9 ± 21.4</td>
<td>333.3 ± 34.0</td>
<td>347.3 ± 25.4</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>178.7 ± 11.6</td>
<td>177.7 ± 11.3</td>
<td>177.7 ± 11.3</td>
</tr>
<tr>
<td>Final lactate (mmol/l)</td>
<td>9.1 ± 2.2</td>
<td>8.7 ± 1.1</td>
<td>8.4 ± 1.2</td>
</tr>
<tr>
<td>Cadence (rpm)</td>
<td>102.5 ± 9.9</td>
<td>90.9 ± 3.3</td>
<td>74.6 ± 7.0</td>
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</tbody>
</table>

Discussion/Conclusion
The lowest PO found in Ergo vs. FR disagrees with the data reported by Smith et al. (2001), which found the same PO in an ergometer 40 km time trial simulation vs. actual road conditions. This inconsistence could be due to the lack of gear ratios resulting in an optimal cadence around the average PO in our Ergo trial (indeed cadence is higher than usually reported in literature for similar conditions). Several hypothesis can be formulated concerning the trend (P=0.06) for higher PO in UR vs. FR. It could be explained by factors related to: i) the body position on the bike (upright position advantages while climbing; the possibility to pedal also standing); ii) the lower cadence (which affects effectiveness, efficiency, blood hemodynamics). ii) Possible power measure distortions - due to the within crank cycle angular inconstant speed, and the lack of the angle encoder on the marketed power monitor devices – should also be investigated. In conclusion, the present pilot study shows a trend for a higher PO in cycling 15 minutes “all-out” time trials, when they are performed on uphill than on flat road. This agrees with the anecdotal experiences referred by some experts or professional cyclists. Due to the practical consequences of this difference, both for performance modelling, and for power training monitoring, further research in these directions are recommended.

References